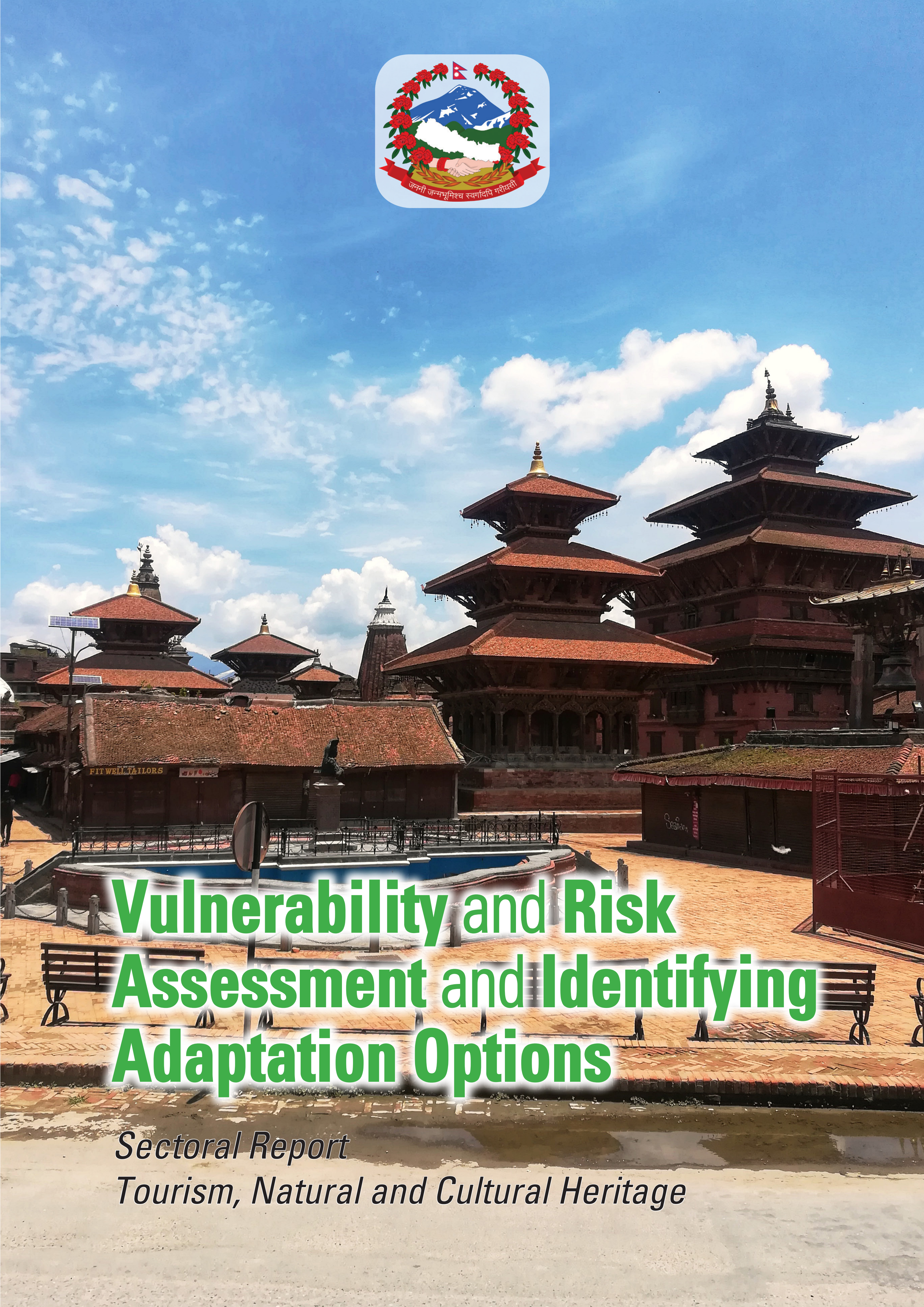


Vulnerability and Risk Assessment and Identifying Adaptation Options

Sectoral Report

Tourism, Natural and Cultural Heritage

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

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

Editorial Team
Dr Kalyan Gauli, Dr Bimal Raj Regmi, Apar Paudyal, Regan Sapkota, and Pratik Ghimire

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

Thematic Working Group (TWG)
Ghanashyam Upadhyaya, Pradeep Kumar Koirala, Laxmi Kumari Basnet, Durga Prasad Bhurtel, Mukesh Dangol, Nasib Acharya, Dipesh Joshi, Basanta Hamal, Shilshila Acharya, Binod Aryal, Mira Acharya, Ajaya Dhakal, Shishir Khanal, and Uttam Babu Bhattarai

Citation
MoFE. (2021). Vulnerability and Risk Assessment and Identifying Adaptation Options in Tourism, Natural and Cultural Heritage. Ministry of Forests and Environment, Government of Nepal. Kathmandu, Nepal.

Cover page photographs credits: Regan Sapkota

Design and Print: Worldwide Print Solution (WPS), tel 01-5550289, email wpsnepal@gmail.com

Foreword

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

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

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

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

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

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

Acknowledgment

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

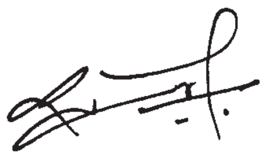
A National Adaptation Plan (NAP) needs to be developed based on a strong scientific foundation and reliable evidence. This includes data and information about how the climate has evolved in the recent past and how it may further change in the future. To realise this, the MoFE has carried out detailed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

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

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

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

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



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

List of Acronyms

CAA	Civil Aviation Authority of Nepal
CA	Conservation Area
CBS	Central Bureau of Statistics
CCA	Climate Change Adaptation
DHM	Department of Hydrology and Meteorology
DNPWC	Department of National Parks and Wildlife Conservation
DoA	Department of Archaeology
DoR	Department of Road
DoS	Department of Survey
DoT	Department of Tourism
GDP	Gross Domestic Product
GESI	Gender Equality and Social Inclusion
GLOF	Glacier Lake Outburst Flood
GPS	Global Positioning System
HAN	Hotel Association of Nepal
HCI	Himalayan Climate Initiative
HR	Hunting Reserve
HRA	Himalayan Rescue Association
HSN	Heritage Society of Nepal
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel for Climate Change
L&D	Loss and Damage
MoCTCA	Ministry of Culture, Tourism and Civil Aviation
MoFE	Ministry of Forests and Environment
MoHA	Ministry of Home Affairs
MoITFE	Ministry of Industry, Tourism, Forest and Environment (Provincial)
NAP	National Adaptation Plan
NATHAM	Nepal Academy of Tourism & Hotel Management
NATTA	Nepal Association of Tour and Travel Agents
NARA	Nepal Association of Rafting Agents
NCA	Nepal Canyoning Association
NHA	Nepal Heritage Association
NMA	Nepal Mountaineering Association

NMA	Nepal Mountain Academy
NP	National Park
NRCA	Nepal Rafting and Canoeing Association
NTB	Nepal Tourism Board
NTNC	National Trust for Nature Conservation
OPML	Oxford Policy Management Limited
PA	Protected Area
RCP	Representative Concentration Pathway
TAAN	Trekking Agents Association of Nepal
Tavg	Average Temperature
Tmax	Maximum Temperature
Tmin	Minimum Temperature
TWG	Thematic Working Group
TNCH	Tourism, Natural and Cultural Heritage
UNFCCC	United Nations Framework Convention on Climate Change
VRA	Vulnerability and Risk Assessment
WR	Wildlife Reserve
WTTC	World Travel and Tourism Council

Executive Summary

The tourism sector in Nepal is considered a vehicle for socio-economic development and prosperity because of its significant potential for earning foreign exchange, creating employment, reducing income and employment disparities, strengthening linkages among economic sectors, and helping alleviate poverty. The sector was able to earn foreign currency equivalent to USD 670.6 million in FY 2017/18 and generated more than one million jobs. Tourism activities in Nepal were only limited to mountaineering in the past, but now are much more diverse with options for mountain climbing, trekking, bird watching, mountain flights, rock climbing, rafting, bungee jumping, paragliding, jungle safaris, and pilgrimage.

Despite its potential, the sector faces numerous hurdles and has lagged in capitalizing on existing potential. With an increasing number of tourists, every established destination faces water shortage, water pollution, and land pollution. Furthermore, bad infrastructure, such as limited road coverage and poor road quality, as well as unreliable domestic air services, raises costs and reduces value for tourists.

The effects of climate change in recent decades have magnified the challenges in Nepal's tourism, natural and cultural heritage (TNCH) sector. Climate extreme events, extreme weather variabilities and hazards, such as receding snow lines, melting glaciers, increased frequency of cloudbursts, floods, Glacier Lake Outburst Flood (GLOF), and landslides have negatively affected the sector. Climate change has also affected both tourists and tourism-dependent people. Without diverse economic, physical, political, and social capital, even areas with high levels of tourism may suffer from the brunt of climate change. This study assessed the context of climate vulnerabilities and risks and identified feasible short, medium, and long-term adaptation options in the TNCH sector.

The study followed the vulnerability and risk assessment (VRA) framework proposed by the Government of Nepal, which was developed based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The IPCC framework considers risk as a function of hazard, exposure, and vulnerability. The framework assumes that the risk of climate-related impacts results from the interaction of climate-related hazards with the exposure and vulnerability of human and natural systems. The assessment approach used in this study included impacts that have already occurred as well as the risk of future climate change impacts, and especially the way such risks are anticipated to change with climate change and with investments in adaptation. The Observed Climate Trend Analysis of Nepal (1971-2014) conducted by the Department of Hydrology and Meteorology and the Climate Change Scenarios for Nepal conducted by MoFE and ICIMOD (2019) were used to characterize both the past trends and future scenarios of climatic hazards for the TNCH sector.

The study followed nine methodological steps that included scoping, developing the VRA framework, identifying indicators, exploring data sources, collecting data, and analysing data to identify impacts and risks. Finally, adaptation options were identified based on analysis of results, a literature review, and expert consultations. The study divided the TNCH sector into two sub-sectors i.e., natural heritage (for which the Protected Areas (PAs) were used as a proxy) and cultural heritage. Before computing the analysis, indicators were given weightage based on the importance of the indicators. The secondary data were collected from different sources, such as governmental organizations, developmental organizations, and projects. The data were tabulated, filtered, and normalized. The normalized data were used to calculate exposure index, sensitivity index, adaptive capacity index, and hazard intensity index. The vulnerability index was calculated by subtracting the adaptive capacity index from the sensitivity index. Finally, the risk was calculated as a function of exposure, vulnerability, and hazard intensity. Based on the identified vulnerability and risk, the adaptation options were proposed.

Like many other economic sectors in Nepal, the tourism industry is also highly sensitive to climate change. A recent study by the government of Nepal shows that an increase in the maximum temperature of the country leads to an increase in total tourism-related GDP and vice versa in the case of a decrease in minimum temperature. This means there is a tendency of tourists to go out for recreational activities when the temperature is high. However, other consequences of increased temperature on the TNCH sector, such as scarcity of water, diminishment of the aesthetic value of tourist sites because of forest fires, and glacier melting, cannot be ignored. Tourism activities in Nepal are largely nature-based and concentrated in PAs that are at high risk from landslides, floods, glacier melts, avalanches, and GLOFs. Furthermore, the spread of invasive plant species has negatively impacted the habitats of the wildlife, a popular tourist attraction.

Similarly, cultural heritage sites are impacted because of consecutive rainy days, as such structures are generally made out of mud and stone/bricks. Seepage in monuments and damage to their wooden structures and walls are common. Besides, climate change has put the lives of trekkers, mountaineers, and associated human resources at risk. Climate-induced hazards, such as GLOFs, avalanches, and landslides can kill people and destroy their properties. Unexpected weather conditions adversely impact the mobility of tourists and the tourism supply chain. Furthermore, scarcity of water, resulting from long droughts, seriously affects the quality of services delivery. Water scarcity also increases the workload of women as they are the de facto managers of many hospitality businesses, particularly in rural areas.

Tourism infrastructure, nature, tourists, and tourism-dependent people and their livelihoods are the key elements exposed to climate extreme events and climate-induced hazards. Among the 20 PAs in Nepal, Annapurna Conservation Area (CA) has the highest exposure index, followed by Chitwan NP, Sagarmatha NP, and Langtang NP. All three PAs receive the highest number of tourists and have more infrastructure available compared to the other PAs, raising their level of exposure. On the other hand, the Kanchenjunga CA, Manaslu CA, Khaptad NP, and Shuklaphanta NP have very low exposure because of their smaller size, smaller number of visitors, and less infrastructure. However, the exposure scenarios of these low-exposure PAs will change in the future if they begin to attract a large number of tourists. In the case of cultural heritage sites, Mustang, Kathmandu, Kapilbastu, and Rupandehi districts have higher numbers of such sites, increasing their level of exposure.

This study found that most of the PAs located in the mountainous area are either very highly or highly or moderately sensitive. The Kanchenjunga CA has the highest sensitivity, followed by Makalu Barun NP, Gaurishankar CA, Sagarmatha NP, Annapurna CA, and Manaslu CA. This is because of the sloppy terrain, soil fragility for landslides, and past occurrences of hazards in these areas. Additionally, most of these PAs consist of rivers that can potentially be impacted by GLOF. There are 47 potentially dangerous glacier lakes in the Koshi, Gandaki and Karnali basins. Among the three river basins, the Koshi basin contains the highest number (42) of such lakes. The sensitivity of PAs is also influenced by changes in glacier and snow cover areas. Furthermore, limited opportunities to pursue alternative sources of livelihood for the tourism-dependent people living in these PAs make the area more sensitive. In the case of cultural and heritage sites, the sites in hilly and high mountain districts are generally sensitive to climate change as they are situated mostly on hills or along riverbanks, which makes them sensitive to landslides and soil erosion.

The adaptive capacity of Bardiya NP is the highest, followed by Chitwan NP Shivapuri Nagarjun NP, Banke NP, and Annapurna CA. The high adaptive capacity of these PAs is due to their revenue regeneration capacity, access to airports, access to places for food and accommodation, availability of financial institutions, and availability of health facilities. In contrast, although the Sagarmatha NP and Annapurna CA do have good revenue collection, their adaptive capacity is relatively low because they are located remotely and have limited access to strategic roads, smaller food and accommodation facilities, and poor health services. In the case of cultural heritage, most of the mountainous districts of western regions have the comparatively less adaptive capacity, mainly because of less early warning coverage and a smaller number of health facilities available.

This study found that the Kanchenjunga CA is the most vulnerable, followed by Makalu Barun NP, Manaslu CA, and Gaurishankar CA. This level of vulnerability is due to their very high to high levels of sensitivity and low to very low levels of adaptive capacity. PAs in the southern plain area and close to Kathmandu have low to very low levels of vulnerability mostly because of their accessibility and availability of basic tourism services. In the case of cultural heritage, the sites in most of the mountainous districts are very highly or highly vulnerable. This is mainly because these sites are generally situated on sloped terrains or at riversides, leaving them vulnerable to soil erosion and landslides.

Risk assessment of the TNCH sector showed that among the PAs, the Sagarmatha NP and Makalu Barun NP have the highest level of risk. Additionally, all the other PAs in the mountainous regions of Province 1 and Bagmati Province are in moderate and high risk ranks. Due to the very high to high level of adaptive capacity of the Chitwan NP, Shivapuri Nagarjun NP, Paras NP, and Koshi Tappu WR and their very high to moderate level exposure and very low level of sensitivity, these PAs are in the low and very low risk ranks. Regarding future risk scenarios, the findings revealed that risk increases under both RCP 4.5 and RCP 8.5 scenarios in the future. The PAs with moderate risk in the baseline, such as Annapurna CA, Sagarmatha NP, and Gaurishankar CA, are likely to be at very high risk under both RCP 4.5 (2030) and RCP 4.5 (2050). Furthermore, the future scenario of RCP 8.5 (2030) is quite similar to RCP 4.5 (2030), except in Kanchenjunga CA, Chitwan NP, and Parsha NP which are likely to be at more risk under RCP 8.5 (2030) compared to RCP 4.5 (2030). However, the future scenario of RCP 8.5 (2050) is alarming. Almost all the PAs in the mountain areas are likely to be in very high to high risk ranks, except Rara NP, Khaptad NP, and Shivapuri Nagarjun NP, which are likely to be in moderate risk rank.

The baseline risk ranks of cultural heritage sites show that districts such as Kavrepalanchok, Kaski, Pyuthan, Gorkha, Mustang, Myagdi, Kapilbastu, and Bajhang are in the very high and high risk ranks. The sites in these districts are characterized by moderate to very high levels of vulnerability and exposure and moderate to very low levels of adaptive capacity. Despite the very low vulnerability of the cultural heritage sites in Rupandehi districts, they are in moderate risk rank due to their high level of exposure. Regarding the future scenario, mixed results were revealed under RCP 4.5 (2030 and 2050) compared to baseline. The cultural heritage sites in the Kavrepalanchok, Kapilbastu, and Gulmi districts, which are at high risk in the baseline, are likely to be at very high risk in RCP 4.5 (2030) and RCP 4.5 (2050). Similarly, the sites in the Rasuwa district that are at moderate risk in the baseline are likely to be at high risk under both RCP 4.5 (2030) and RCP (2050) scenarios. The RCP 8.5 (2030) scenario is almost similar to the RCP 4.5 (2030) scenario. However, the Gulmi and Kapilbastu districts which are at high risk at both baseline and under RCP 4.5 (2030), are likely to be at very high risk under RCP 8.5 (2050). Similarly, Dadeldhura, Jumla, and Dailekh, which are at low risk in the baseline and under RCP 4.5 (2030) and RCP 8.5 (2030), are likely to be at moderate risk under RCP 4.5 (2050) and RCP 8.5 (2050).

The risks and vulnerability findings suggest that it is important for the TNCH sector to increase its adaptive capacity in the future to be able to respond to the impacts of climate change. This study identified adaptation options for the short, medium, and long terms. Short-term adaptation options include revision of tourism policies and acts to include climate change issues; enforcement of implementation of building codes while constructing tourism infrastructures; enforcement of GPS tracking system, particularly for mountaineers and trekkers; educational and awareness programs on climate change targeting tourism value chain actors; and priority interventions targeted to women and marginalized people.

Medium-term adaptation options include the establishment of research stations at all the major tourist destinations to understand how climate change is happening and impacting the tourism sector; increasing hydrological and metrological stations, particularly in mountainous regions; identifying hazard hotspots and discouraging construction of infrastructure through legal enforcement; and allocating adequate, dedicated, trained and equipped human resources for rescue operations at strategic points of the tourism destinations. Finally, the long term adaptation options include demarcation of buffer zone areas for potential damage by GLOFs, floods, and landslides and putting a restriction on the construct of infrastructures; relocation of existing tourism facilities to low-risk areas; assessment of the physical condition of cultural and heritage sites; and documentation of festivals and cultural practices.

This study concludes that the TNCH sector is highly vulnerable to climate change. Most destinations in mountainous areas are highly vulnerable, compared to those in the hilly and plain areas. However, this study suffered from a lack of sufficient data. Hence, there is a need for developing a system of data generation at the local level and consolidating and analysing that data at the provincial and national levels.

Contents

List of Tables

List of Box

List of Figures

List of Annex

Chapter 1

Background and Sectoral Context

Nepal is endowed with rich natural and cultural diversity and heritage. Its altitudinal variations make it rich in biodiversity and landscape diversity. Furthermore, it is a multilingual and multicultural country that harbors cultural heritages of historical importance and where more than 100 ethnic people reside and 123 languages are spoken. Nepal is known throughout the world as the home of Mount Everest and Lord Buddha (CBS, 2014). Its natural and cultural diversity is a big attraction for travelers from all over the world. In 1951, the country opened its doors to international tourists (Dhakal, 2015) and gained international recognition in the 1950s after two climbers reached Mount Everest in 1953. By 2019, 6,509 climbers had conquered the peak (MoCTCA, 2020a).

Since the formulation of the first five-year growth plan (1956-1960), the tourism industry has received the government's full attention. Popular tourist activities include mountain climbing, trekking, bird watching, mountain flights, rock climbing, rafting, bungee jumping, paragliding, mountain biking, and jungle safaris. Tourism is considered a vehicle for socio-economic development because of its potential to earn foreign exchange, create employment, reduce income and employment disparities, strengthen linkages among economic sectors, and help alleviate poverty (Kurk, 2009). The sector generates employment and income for youths who can work as mountain guides or porters (K.C. & Thapa Parajuli, 2015) and creates opportunities for enterprise generation through the operation of gift shops, groceries, tea houses, and lodges along the trails (Sherpa, 2006).

The tourism sector was able to earn foreign currency equivalent to USD 670.6 million in FY 2017/18 (MoCTCA, 2020b). This figure represents 24.8% of the total foreign currency earned through the total export of goods and services, 5% of the total foreign currency earned overall, and 2.2% of Gross Domestic Product (GDP) (MoF, 2019). The earning is in increasing trend (Figure 1).

Figure 1: Fiscal year-wise foreign exchange earnings from tourism

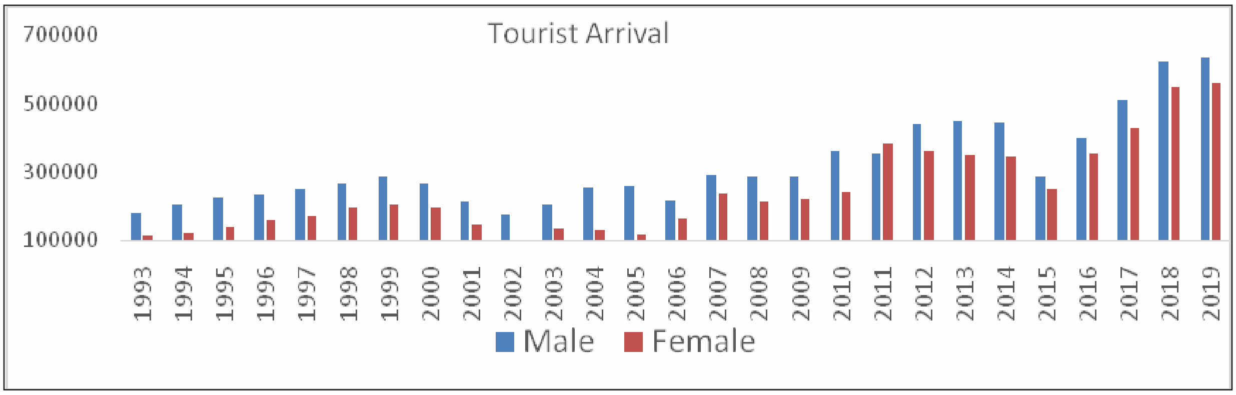
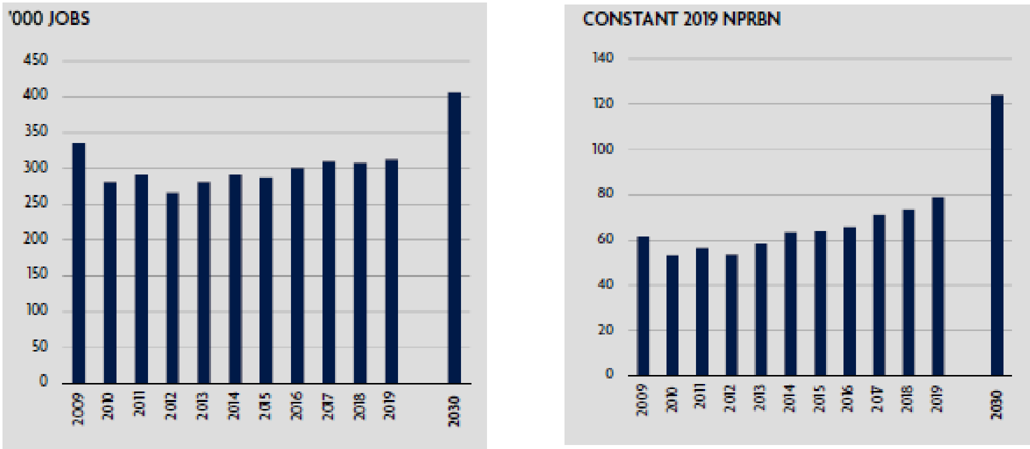


Figure 2: Tourist arrival in Nepal

The number of tourists arriving in Nepal has been steadily increasing (Figure 2; Shrestha & Shrestha, 2012). A report by the World Travel and Tourism Council (WTTC) shows that the total contribution of travel and tourism to the employment generation was 1,034,000 jobs in 2019 (6.9% of total employment; WTTC, 2020). By 2030, the travel and tourism sectors are likely to support 1,326,000 jobs (7.2% of total employment), which is an increase of 2.6% per annum over nearly a decade (Figure 3). Besides, the report shows that the total contribution of travel and tourism to GDP was NPR 231.0 billion in 2019 (6.7% of GDP) and is projected to rise by 4.2% per annum to NPR 359.5 billion by 2030 (6.8% of GDP).

According to the Tourism Employment Survey 2014 conducted by the Ministry of Culture, Tourism and Civil Aviation (MoCTCA, 2014), a quarter (24%) of the total number of employees in the sector were seasonal workers. In addition, 80% were male and about one-third (32%) had a second job as well. In the tourism sector, economic growth and financial development are co-integrated because of an increase in international tourism revenues by 1%. Nepal's GDP is projected to grow by an average of 0.2% in the long run (Kumar, 2019). Furthermore, the tourism sector has the potential to make a major contribution to the green economy through more sustainable practices, climate change mitigation, and ecotourism (Reddy & Wilkes, 2015).



(a) (b)

Figure 3: Number of jobs created by the tourism sector (a) and its contribution to the GDP (b)

Sustainable tourism development is an important vehicle for poverty alleviation in Nepal (Kafle, 2011). Tourism is one of the largest industries in the country, which creates multi-structural and multi-layered opportunities for poverty reduction. The country has comparative advantages in terms of cultural heritage, natural properties, climatic diversity, and traditional activities. The diversified nature of tourism enabled through nature/biodiversity, adventure, culture, historical, religious, and other segments will allow the sector to meet the potential tourism demand and sustain itself.

However, despite having promise, the tourism sector is faced with many challenges related to the country's changing geopolitical context as well as health, environment, and climatic change crisis, and political unrest and instability. Some key challenges are described below.

- **Land and water pollution:** Along with the increasing number of tourists, major tourist destinations, such as the Phewa Lake—a signature attraction of Pokhara—faces problems with water pollution, solid waste disposal, eutrophication, and siltation. The Chitwan National Park is one of the major tourist attractions that has issues arising from invasive plant species, forest fires, and habitat degradation. In Kathmandu, which is popular for its historic sites, poorly managed and unplanned urban development and poor waste management is an obstacle to attracting tourists. The gateway to Everest, Lukla, has faced massive challenges with waste management and insufficient water availability (Jones, 2013).
- **Poor access to information:** A prominent challenge for tourists, particularly those visiting the mountain regions, is difficulty getting (easy) access to weather forecasts and early warning information. Many tourists and the people associated with the tourism industry have lost their lives because of hazards like snowstorms and avalanches. A recent example is an avalanche in Annapurna Conservation Area in 2019 where seven people including four Korean tourists lost their life (THT, 2019).
- **Poor infrastructure and services:** Poor coverage and low quality of roads, and unreliable domestic air services increase the costs and reduce the economic value acquired from tourists. Services, such as electricity and sanitation, are too costly to provide adequate tourism facilities and services, especially in the more remote parts of the country.

- **Lack of recreation facilities and alternative destinations:** In the last 34 years, the average length of stay of tourism in Nepal has been between 10 and 13 days (MoCTCA, 2020a). Despite an increase in the number of tourists from less than 0.1 million in 1975 to more than 1.1 million in 2019, their length of stay could not be increased much. This is mainly because of limited recreational activities and alternative destinations. Tourism in Nepal is concentrated in a few cities and Protected Areas (PAs) such as Kathmandu, Pokhara, Chitwan National Park, Annapurna Conservation Area, and Sagarmatha National Park. Therefore, the government needs to focus on building and promoting alternative destinations.

The effects of climate change in recent decades have magnified the challenges in the tourism sector. Temperature and precipitation are the climatic variables that create major havoc in the sector, while the microclimatic variables including fogs, mists, and storms, and other extreme weather conditions are also responsible for the creation of adverse conditions. Different climate extreme events and hazards including receding snow lines, melting glaciers, increased frequency of cloudbursts, floods, and landslides have the potential to change the nature and quality of tourism resources, and therefore, the appeal of the tourism areas (Sharma, 2012). Outdoor activities of tourists are in particular very sensitive to precipitation changes and other climatic extremes. Most of these activities in Nepal start from the last week of September, after the withdrawal of the monsoon or from February. But, at present, the withdrawal date of monsoon is in an upward shift toward October and as a result, is severely impacting outdoor activities (Sharma, 2012).

Climate-induced hazards affect both tourists and service providers in several other ways as well. The hazards increase the travel and operational cost of tourism activities and are also responsible for the loss of lives (of both tourists and service providers), and properties (roads, hotels, airports, trekking routes, pilgrimage sites, historical sites, etc.). Additionally, poor visibility days, due to haze and fog, during the winter season have been significantly increasing over the Indo-Gangetic Plains, with serious impacts on air and road travel, as well as on tourism (ICIMOD, 2019). Naturally, the livelihoods of the mountain-based communities also suffer as climate change impacts the tourism potential of their region.

Chapter 2

Objectives and Scope of the Study

2.1 Objectives and rationale of the study

The National Climate Change Policy 2019 considers the tourism, natural and cultural heritage (TNCH) sector as climate-sensitive (MoFE, 2019). However, since information about the exposure, vulnerability, and adaptive capacity of the sector is lacking, it is difficult to create an appropriate adaptation plan to improve the resilience of the sector. Besides, the current TNCH sectoral plans and policies still have a long way to go when it comes to integrating climate change issues. To fill this sector-specific knowledge gap, this study aimed to assess climate vulnerabilities and risks and identify adaptation options in the TNCH sector. The specific objectives were to:

- Assess the vulnerability of the TNCH sector to climate change through applicable frameworks, and rank/categorize associated climate risks and vulnerabilities.
- Identify and prioritize adaptation options according to the identified risks and vulnerabilities.

The task also involved integrating the outcomes of the Vulnerability and Risk Assessment (VRA) from the National Adaptation Plan (NAP) Thematic Working Group of the TNCH sector.

2.2 Scope of the study including limitation

The scope of the study was to carry out a VRA of the TNCH sector using the available data and other evidence and explore potential adaptation measures to address the identified risks and impacts. The TNCH sector contains two main sub-sectors—i) nature and ii) cultural heritage—both of which incorporate tourism. Nature, in this study, is represented by the Protected Areas (PAs) of Nepal, where nature-based tourism activities like trekking, wild safari, bird watching, and mountaineering are concentrated. On the other hand, cultural heritage is represented by temples, monuments, monasteries, rituals, and practices. Hence, the study assessed the vulnerability and risk of PAs as tourism destinations and cultural heritage sites as both tourism destinations and in terms of cultural and historical values.

Using primarily secondary information, the assessment was carried out at a national level with tourism destination, i.e., PA, as a unit of analysis for natural heritage and district as a unit for cultural heritage sites, and later this information was categorized at the levels of the province and physiographic region. However, it is important to note that the COVID-19 pandemic had restricted possibilities for collecting data and meeting with experts and stakeholders even at the national level. Although efforts were made to collect data related to tourism destinations and cultural heritage sites, very few destination-wise data were available, and most of them were at the district level. Since, for this assessment, the district-level data were transformed into destination-level, it is important to note the limitation that some destinations may not represent a whole district or that some destinations are located in more than one district.

Chapter 3

Methodology

3.1 Framework

The government of Nepal has developed a framework for Vulnerability and Risk Assessment (VRA) using IPCC-AR 5 as a base (Figure 4). The proposed framework unpacks the elements of risk and customizes them to the needs of and applicability to the national context. The framework assumes that the risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the exposure and vulnerability of human and natural systems.

Changes in the climate system (trends and scenarios), biophysical system, and socioeconomic processes (including governance and adaptation and mitigation actions) are drivers of hazards, exposure, and vulnerability.

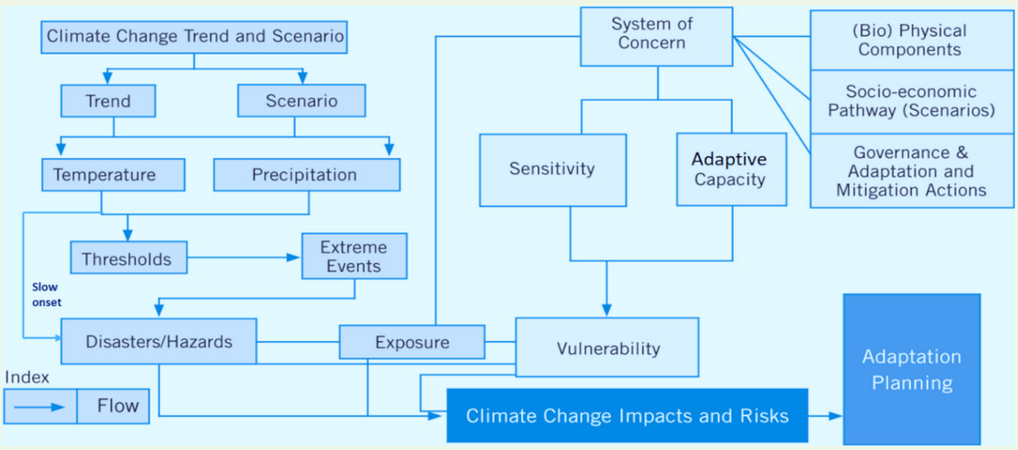


Figure 4: Climate change vulnerability and risk assessment framework (MoPE, 2017)

Although there are various ways of calculating vulnerability and risk, the framework proposed by Nepal is mostly based on the IPCC Fifth Assessment Report (AR5). The IPCC framework considers risk as a function of hazard, exposure, and vulnerability. Nepal's VRA framework has used climate scenario analyses, emission scenarios, and socio-economic pathways available from national, regional, and international research centres to characterize broad future climate risks and levels of uncertainty.

3.2 Approach

This assessment took both top-down and bottom-up approaches. The top-down approach was guided by the technical guidelines agreed in the Paris Agreement developed by the Least Developed Country (LDC) expert group (LEG), in line with the Cancun Adaptation Framework, to facilitate the country-led adaptation initiative. Indicators were chosen for the analysis based on the VRA framework and indicators developed by GoN for the NAP formulation process and literature review. Data was collected at the national level for the identified indicators for assessing vulnerability and risk. The outcomes of the top-down vulnerability assessment can be used to reduce harmful impacts by reducing exposure or by implementing adaptation options that reduce sensitivity or enhance adaptive capacity.

To complement the top-down approach, this study also used a contextual or bottom-up approach. Preliminary results and findings of the VRA were shared with the local communities and relevant stakeholders in provincial and local level workshops. Additionally, the workshops were useful platforms to get input and feedback on the assessment's results and possible adaptation measures as well as to record local experiences of climate change impacts. Following this, focus groups were organized with selected local communities, tourism professionals, and stakeholders to capture their perceptions, experiences, and observations on climate change and adaptation measures. This approach was not just intended for one-way sharing of experiences and validating identified adaptation measures but was also used for empowering local communities and stakeholders.

Furthermore, mixed approaches were also followed for data collection and analysis, i.e., the destination approach and the political boundary approach. For the tourism activities that are generally concentrated in specific natural heritage areas, particularly in PAs, the study followed the destination approach. For cultural heritage sites that are spatially distributed all over the country, the study followed the political boundary (district and province) approach.

3.3 Methodological Steps

The assessment was carried out in nine steps with a reiterative, participatory, and consultative process and was guided by the overarching VRA assessment framework discussed above. A simplified version of the step-wise methodological framework that was prepared for the VRA process for the TNCH sector is presented in Figure 5.

Figure 5: Steps of Vulnerability and Risk Assessment

Step 1: Scoping Vulnerability and Risk: The scoping task was an important step to set the boundaries for the VRA methodology. This process involved stocktaking of existing methodology, approaches, and frameworks for undertaking VRAs. It also helped in understanding the various concepts methodologies and terminologies used by the IPCC, NAP technical guidelines, and UNFCCC reference documents. The scope of this study was to carry out a VRA for Nepal's TNCH sector by doing separate assessments for natural heritage (through looking at PAs) and cultural heritage. The VRA for PAs was limited to the PA level itself, whereas that for cultural heritage was done at the district and provincial levels.

Step 2- Developing the VRA Framework: The NAP technical guidelines allow countries to develop their country-specific frameworks for assessing vulnerability and risk. This study used the VRA framework developed by Nepal to assess and illustrate the logical linkages between hazard, exposure, vulnerability, and risk.

Step 3- Identifying Key Indicators for Hazard, Exposure & Vulnerability (sensitivity and adaptive capacity): This step was the entry point of the assessment, whereby relevant indicators of exposure, sensitivity, and adaptive capacity concerning the TNCH sector were identified based on the VRA Framework and Indicators for NAP Formulation Process in Nepal (MoPE, 2017), extant literature, available facts, scientific studies, and journal articles. The identified indicators were organized according to two broad sub-sectors i.e., natural heritage and cultural heritage. To characterize the exposure, sensitivity, and adaptive capacity-related indicators, the assessment used both biophysical (intrinsic) attributes and socio-economic dimensions.

Step 4 - Exploring Data Sources: The main data sources were government and development agencies, private sector associations, individual experts, and researchers (see Table 2). Most of the data were collected from annual reports, research studies, policy briefs, periodic plans, and strategy documents. Some data was also collected from peer-reviewed articles and journals.

Table 1: Data types and sources

Data source	Name of organizations	Data collection documents (Source types)
Government organizations	MoCTCA, MoFE, MoF, DoA, DoT, DNPWC, CBS, CAAN, NPC, DoA, DHM, NATHAM, NMA, Provincial MoITEF	Reports (Periodic, annual, and progress report), study reports, Policy brief, Policy, strategy, peer review articles, grey literature
Development organizations	ICIMOD, WWF, NTNC, IUCN	
Private sector associations	HAN, TAAN, Nepal Mountaineering Association, NATTA, NARA	

Step 5 - Data Collection, Tabulation, Filtering, and Normalisation: The data needed for the assessment was collected through various means. The types and sources of data are provided in Table 2 below.

Table 2: Data types and sources

Data Types	Sources
Data related to PAs such as the number of visitors, area of PAs, and revenue of PAs	Department of Tourism (DoT), Nepal Tourism Board (NTB), and Department of National Parks and Wildlife Conservation (DNPWC)
Spatial distribution of hotels and restaurants in PAs, including campsites in PAs	trekking maps developed by Himalayan Map House Pvt. Ltd. and Nepal Map Publishers Pvt. Ltd
Glacier lakes and Ramsar sites in the PAs	International Center for Integrated Mountain Development (ICIMOD) and DNPWC
Geological information, such as the slope of the area, soil types, and soil fragility	Department of Survey (DoA) and MODIS
Hazards and rescue system	Ministry of Home Affairs (MoHA) and the Himalayan Rescue Association (HRA).
Strategic roads in and to the PAs	Department of Road (DoR)
Number of airports and number of airlines operating in an airport	Civil Aviation Authority Nepal (CAAN)
Hotels and restaurants	Central Bureau of Statistics (CBS) and Hotel Association of Nepal (HAN)
Cultural heritage sites	Department of Archaeology (DoA)
Other data	Nepal Academy of Tourism and Hotel Management (NATHAM), Nepal Mountaineering Academy (NMA), Nepal Mountaineering Association, Trekking Agencies Association of Nepal (TAAN), and Nepal Association of Tour and Travel Agents (NATTA)

Every effort was made to identify and rely on high-definition downscaled data and projection models, to ensure that the resultant VRAs and hazard maps are highly relevant to operationalize adaptation options on the ground, based on the expected climate impacts.

The list of indicators identified in step three of this methodology was reviewed based on the data availability. The data collected were tabulated in MS Excel, filtered, and normalized. It was taken into consideration that the more the data is grounded in specific ecosystems, human settlements, and critical infrastructures at risk, the more relevant the VRAs and adaptation option results would be.

Normalization was done to a scale of 0 to 1 using the min-max normalization method as follows:

$$Z_{i,j} = \frac{X_{i,j} - X_i^{min}}{X_i^{max} - X_i^{min}} \qquad \text{.......Equation I}$$

Where,

$Z_{i,j}$ = normalized value of the indicator of type i

$X_{i,j}$ = value of the indicator of type i

X_i^{min} = minimum value of the indicator of type i

X_i^{max} = maximum value of the indicator of type i

Step 6 and 7- Weightage and Composite Value, and Analysis: The normalized data was given weightage by using pair-wise comparisons (Uribe et al., 2014) as indicated in the Analytical Hierarchy Process (AHP) model, to prioritize the related decision indicators. For this, scores of importance/priorities were given on a nine-point Saaty Scale (Saaty, 1984), as shown in Table 3. To this end, a set of questionnaires was designed and sent to 20 respondents including members of the Thematic Working Group (TWG) experts, representatives from the governments, I/NGOs, and the private sector. The respondents were requested to respond to each possible pair of criteria and rate one relative to the other. In total, responses were received from nine respondents.

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

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

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

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

$$AC = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \qquad \text{.......Equation II}$$

Where;

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

The most preferred alternative was the one with the minimum value of AC.

Indicator-wise weightage for exposure, sensitivity, and adaptive capacity is given in Tables 4 and 5 for PAs and cultural heritage sites respectively.

Table 4: Indicators related to PA and their weight

Exposure	Weight	Sensitivity	Weight	Adaptive Capacity	Weight
Strategic Road	0.196	Soil fragility (flood)	0.146	Black top road	0.148
Trekking trails	0.214	Soil fragility (landslides	0.348	Alternative trekking trails	0.22
Airports	0.189	The slope of the area	0.332	Airport in access	0.161
Basecamp/campsites	0.207	Hazard severity (loos and damage) for Tourism Infrastructure	0.174	Number of airlines in operation	0.146
The place for food and accommodation	0.194	Length of non-paved road	0.192	Access to place for food and accommodation	0.167
Coverage of protected areas	0.26	Hazard Severity for nature	0.282	GLOF prevention activities in place	0.159
Glacier/snow-covered areas	0.247	Change in snow cover area	0.263	Revenue collected from the protected areas	0.152
Glacier lakes	0.247	Length of river potentially impacted by GLOF	0.263	Diversity of key flora and fauna	0.295
Lakes (Ramsar sites)	0.247	Female-headed household (%)	0.487	Management Plan available	0.145
People living in and around the protected area	0.493	Engagement of female in agriculture works (%)	0.513	Early warning system coverage	0.234
Tourists visiting PAs	0.506			Disaster Preparedness and Response Plan available	0.174
				Financial institutions available	0.333
				Sanitation coverage	0.239
				Health facility available	0.428

Table 5: Indicators related to cultural heritage and their weight

Exposure	Weight	Sensitivity	Weight	Adaptive Capacity	Weight
Cultural and Archeological sites	1	Soil fragility (flood)	0.184	Early warning system coverage	0.4
		Soil fragility (landslides)	0.277	Health facility available	0.6
		The slope of the area	0.255		
		Hazard severity	0.284		

Step 8: Calculation of the Vulnerability and Risk Index: According to IPCC-AR5, vulnerability is a function of Sensitivity and Adaptive Capacity. The vulnerability of each sub-sector and aggregate of both sub-sectors (protected area and cultural heritage) was analysed with the aggregated value of sensitivity and adaptive capacity as shown in equation III and Figure 6. Figure 6 illustrates a typical process and analysis of the chain of vulnerability and risk with the indicator-wise data of sensitivity, adaptive capacity, and exposures.

$V = S - AC$ ………………………………………………………….. Equation III

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

Similarly, the sub-sector-wise and cumulative risk of the TNCH sector were estimated as a function of Hazard Intensity, Exposure, and Vulnerability as shown in equation (IV).

$R = H_{intensity} \times V \times E$ ……………………………………………. Equation IV

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

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

$scale = R/max(R),\ R \in \{admin\ units\}$ ……………………………….. Equation V

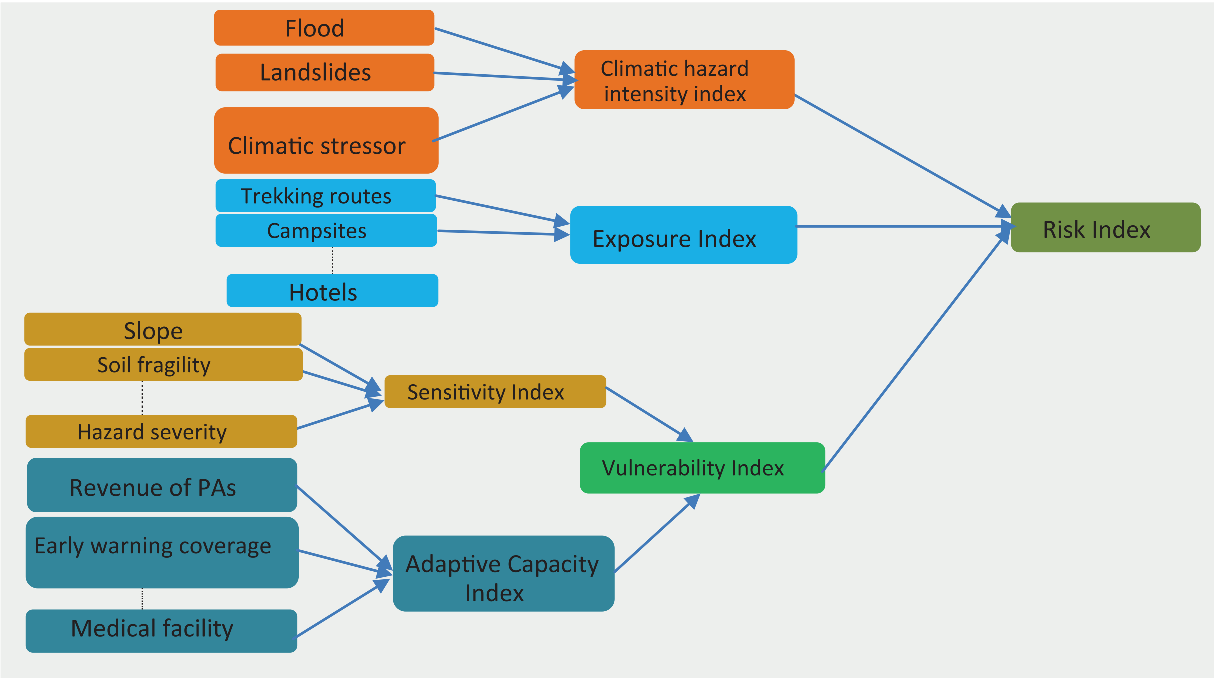


Figure 6: A Process to compute aggregation of weighted indicators to vulnerability & risk indices

The calculated sub-sector and sector-wise aggregate vulnerability and risk indexes across protected areas, and the districts and provinces in case of cultural heritage sites, were ranked into five classes: (a) very low (b) low (c) moderate (d) high, and (e) very high; based on the Jenks natural break method. The result of the risks and vulnerability of different districts, provinces, and physiographic regions is also presented in the form of maps. The purpose of this ranking was to help the decision-makers in setting priorities for the selection of adaptation interventions and investments at the national, provincial, and local government levels. The rankings are also likely to be useful to policymakers for the formulation of the climate finance strategy across three government levels.

Spatial Multi-Criteria Errors (SMCE) were introduced in all phases of the analysis. Errors such as preference uncertainty were introduced throughout the analysis processes i.e., standardization, prioritization, and aggregation, since these errors are inevitable due to the challenges that arise from subjective and judgment-based information. This is particularly true for information obtained from the stakeholders. To take such errors into account, the study constantly assessed the stability of the obtained indexes.

Step 9: Identification of Adaptation options: Based on the information generated from ranking vulnerabilities and risk, relevant adaptation options that address problems through the management and operating strategies, infrastructure changes, policy adjustments, capacity development, and generating awareness were identified. This identification was done using criteria that are in line with national goals and targets as well as national and sectoral policies relevant to climate change.

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

Chapter 4

Observed Climate Change Impacts in the TNCH Sector

Like many other economic sectors in Nepal, the TNCH sector is also highly sensitive to climate change and is being impacted both directly and indirectly. Direct impacts on the sector include the changing length and quality of climate-dependent tourism seasons, while indirect impacts include loss of biodiversity, reduced landscape aesthetics, damage to infrastructure including cultural heritage sites, and the presence or appearance of new water-borne diseases (Simpson et al., 2008). Furthermore, high mountains are projected to be more exposed to avalanches and Glacier Lake Outburst Floods (GLOFs); hills to landslides, flash floods and debris flows; and the Terai lowlands to floods; affecting the TNCH sector as a whole (Nyaupane & Chhetri, 2009).

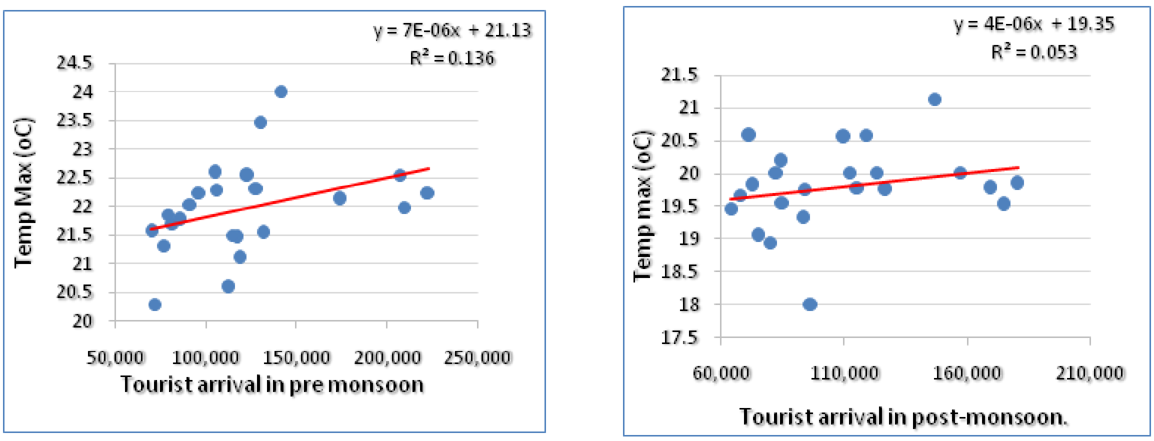
A report by the DHM (2017) shows between 1971 and 2014, Nepal experienced a rapid increase in temperature and extreme variability in precipitation patterns, which directly affected the tourism industry. During this period, the surface maximum temperature increased by 0.056°C per year while the minimum temperature increased by 0.002°C. The increasing rate of surface temperature was reported to be higher in the Himalayas with 0.086°C per year, compared to the Terai lowland with 0.021°C per year. The increasing rate of temperature triggers and accelerates the melting rate of ice in the Himalayan region, which further triggers the rate of avalanches and other mountain disasters that directly affect the tourism industry (MoCTCA, 2018).

The climate-related hazards—such as increasing rates of precipitation—destroy infrastructures related to the TNCH sector, including roads, bridges, trails, hotels, resorts, temples, and monuments. Furthermore, damageability is high in the non-engineering-designed infrastructure, such as roads and trekking trails. The fragility of and inaccessibility to the high mountain areas increase the impacts and reduce the ability to recover from them, and make the areas more vulnerable (Bhandari, 2014). The following sections describe the impacts of climate change on the national economy, natural heritage, cultural heritage, livelihoods, and socio-economic prosperity.

4.1 Impact on the national economy

The tourism sector is a key contributor to Nepal's national economy and foreign exchange. Climate variation has a strong relationship with tourism activities and thus by extension with the national economy. A study conducted by the MoCTCA shows that a one percent increase of average maximum temperature leads to an increase in total tourism GDP by 9.36%; while the same level of decrease of minimum temperature leads to a decrease in total tourism GDP by 3.66% (MoCTCA, 2018). The report further shows that a one % increase in average maximum temperature leads to an increase in leisure and recreational tourism GDP by 34.45%; whereas the same level of decrease of minimum temperature leads to a decrease in leisure and recreational tourism GDP by 11.7%. In contrast, the study showed that there is no significant relationship between precipitation and tourism activities. This could be because the monsoon season is the off-season for tourism activities in Nepal.

The results of the correlation analysis between tourist arrivals, and annual average temperature (Figure 7) also support the abovementioned findings of the MoCTCA (2018). To carry out the analysis, tourist arrival in two seasons–pre-monsoon and post-monsoon, the most touristic seasons in Nepal—was correlated with maximum temperature. The result shows that there is a positive relationship between maximum temperature and tourist arrival in both seasons. This could be because the popular seasons are the warmer seasons and tourists want to go outside when the temperature is high. The results also show no relationship between precipitation and tourist arrivals in both seasons (pre-monsoon and post-monsoon,), which could be because precipitation is not common during these seasons in the country. However, during the monsoon and winter seasons the relationship between the weather and the tourist's arrival were observed which could be related to the weathervfactors such as flight cancellation due to fog and heavy rain, or the rising number of consecutive rainy days. Although there is an increase in tourism arrivals with the increase in maximum temperature, we cannot ignore the consequences of increased temperature—such as scarcity of water, diminishment of PAs' and cultural landmarks' aesthetic value because of forest fires and glacier melts—on tourism activities



(a) (b)

Figure 7: Relations between tourist arrival and maximum temperature in pre-monsoon (a) and post-monsoon seasons (b)

Weather and climate affect tourist demand, comfort, satisfaction, natural resources and other tourism-related industries important for the tourism, meaning that climate change can substantially influence this climate-sensitive and economically important sector (Dawson & Scott, 2013). Most of the nature-based tourism activities in the Himalayas are weather-sensitive, so rain and foggy conditions significantly decrease the quality of the trekking experience in the region. Tourists can opt for a change in the destination if the weather continues to disappoint them (Rayamajhi, 2012), hurting the region's tourism-derived economic prospects.

A significant reduction in tourist arrivals will have serious impacts on employment and undermine the livelihood of people and the private market entities dependent on the sector. The tourist flow, diversity of tourist visits, and spending are dictated by weather conditions, disaster events, and other climatic stressors like heatwaves and cold waves. Overall, there is a close relationship between tourism and climate in ecosystem tourism, mountain tourism, and nature-based tourism (Anup & Thapa Parajuli, 2014).

4.2 Impact on natural heritage

The tourism activities in Nepal are largely nature-based and include trekking, wildlife safari, and mountaineering. The literature review shows that climate change has impacted tourism infrastructures and nature itself, which are key for nature-based tourism in multiple ways. Trekking and mountaineering in Nepal are concentrated in PAs, which are at high risk from landslides, glacier melt, avalanches, and GLOFs (ICIMOD, 2011). The intensive monsoon rains, together with the fragility of the landscape, make the mountains of Nepal one of the most landslide-prone regions in the world. Climate change in the form of heavy precipitation and temperature variations has increased the frequencies of rainfall-induced landslides. Additionally, the shifts in the timing and the intensity of the monsoons triggers landslides and floods (Nyaupane & Chhetri 2009). Other adverse effects from monsoons, in turn, also create serious consequences for tourism, such as blocking roads and trails. Moreover, tourism activities weather, such as trekking, mountaineering, and safari that depend on certain weather conditions to remain attractive are likely to be impacted by changing monsoon patterns since these determine when and where tourists travel.

The warming in the Himalayas has a great impact on the glaciers (Shrestha & Aryal, 2011), in the form of rapid deglaciation (Bajracharya et al., 2020). This could have a serious impact on mountaineering and river tourism activities like rafting and kayaking. Furthermore, the aesthetic value of mountains could diminish as the white snow-covered mountains gradually turn into black, rocky mountains (KC, 2017).

Nepal's pristine forests are among the tourist attractions, particularly because they provide viable and scenic trekking routes. A pronounced impact of climate change on forests, through changes in temperature, is the upward movement and shift of vegetation. Upward shifting of ecological belts has already been noticed (Gaire et al., 2017, Shakya, 2013) as in the case of high mountain tree species like Himalayan Fir *(Abies spectabilis)*, Taxus *(Taxus wallichiana)*, Cedar *(Cedrus deodara)*, and Bhojpatra *(Betula utilis)* in Nepal. Similar phenomena were observed in the *Pinus wallichiana* and *Abies spectabilis* species by Dhakal et al. (2016) in the Annapurna conservation area and the Shey-Phoksundo National Park area. The annual upward shifts of

Abies spectabilis were 2.4 m in the Kanchenjunga area (Bhuju et al., 2016) and 0.5 to 2.6 m in Sagarmatha National Parks (Gaire et al., 2017). All these phenomena change the aesthetic value of the destinations.

Wild animals are one of the tourist attractions in Nepal. Climate change poses notable impacts on all faunal species including mammals, herpetofauna, avians, and fish in the vertebrate group and butterflies and molluscs in the invertebrate group. During rainy seasons, rhinoceroses, calves, and other animals are highly susceptible to flash floods. For instance, a massive flood in Chitwan National Parks in 2017 killed four rhinoceroses and a wild buffalo; and ten rhinoceroses were swept away to India (DNPWC, 2018). Subedi and colleagues (2017) claimed that flash floods are one of the factors that can be attributed to the decline of rhinoceroses in Chitwan National Park. Additionally, the increasing numbers of forest fires are a threat to wildlife and their habitats (MoFSC, 2014).

Furthermore, the habitat degradation due to Invasive Plant Species (IAPS) (e.g., Mikania in Chitwan NP) in PAs in recent decades is of concern (Adhikari & Shah, 2020; Rai & Scarborough, 2012). An intensification of Mikania infestation between 2008 and 2011 was observed in all types of habitats except sub-tropical forests (Lamichhane et al. 2014; Murphy et al. 2013). The intensification of IAPS was found to be high in wetlands habitats (30.38%) and short grasslands (11.33%). As shown in Table 6, the rapid expansion of the *Mikania micrantha* has posed a threat of shrinking and destruction of rhino habitat in the Chitwan National Park (Lamichhane et al., 2014; Pant et al., 2020). Consistent with these findings, Adhikari and Shah (2020) projected a loss of suitable habitats of rhinoceros by 51.25% and 56.54% under RCP 4.5 for the years 2050, and 2070 respectively. This may lead to increased trends of rhinoceros deaths and human-wildlife conflicts in the buffer zone communities of the Terai PAs (DNPWC, 2019). An increasing trend of human wildlife-conflict incidences has also been observed in high-mountain PAs due to competition over resources between humans and wildlife (Aryal et al., 2014).

Table 6: Habitat-wise Mikania infestation change from 2008 to 2011

Vegetation type	% of the plots having high Mikania infestation (>50%)		% Increase from 2008 to 2011
	2008	2011	
Riverine Forests	26.02	27.03	1.01
Sal Forests	2.23	4.24	2.01
Short Grassland	**1.02**	**12.35**	**11.23**
Tall Grassland	19.86	20.17	0.31
Subtropical mixed Forests	51.33	14.71	-36.62
Wetland	**9.62**	**40**	**30.38**
Other	14.89	11.67	-3.23
Not specified	N/A	2.94	2.94
Grand Total	**15.12**	**17.95**	**2.83**

Source: Lamichhane et al. (2014)

4.3 Impact on cultural heritage

Currently, there is very little research looking at the impact of climate change on cultural heritage in Nepal. Nevertheless, the studies that do exist show that climate-induced hazards such as landslides and floods are damaging archaeological sites. Consultations in Gandaki Province, stakeholders also revealed the same: that climate change poses a threat to cultural and heritage sites because of landslides and floods. A problem of seepage has been observed in historic monuments, caused by consecutive rainy days, which has led to the damaging of wooden structures and walls made from mud and stones/bricks. A study conducted in Jomsom found a decrease in winter precipitation in the form of snow and an increase in rainfall after the winter months (Dahal, 2020), which affected traditional flat-roofed houses made of mud and stone. Locals experienced roof leakage and wall erosion problems in their homes, tea shops, and hotels. Furthermore, changes in the ecological characteristics of wetlands, lakes, and rivers can change their significance as cultural and religious tourism sites (ICIMOD, 2010).

Box 1: Impact of climate change on cultural practices

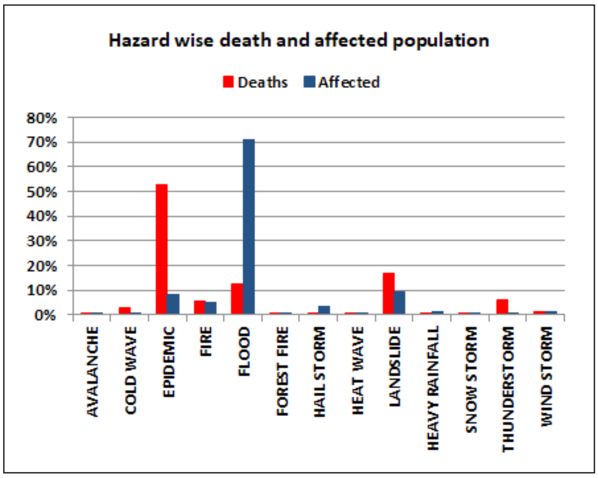
In Mustang, for centuries people of the region have been celebrating their main festivals, such as loshar and yartung. Each house contributes grains to make food and chang (local beer) and prepare a feast for the whole village. Whereas previously, eating, drinking, singing, and dancing used to be a big part of such festivals, now as food production is decreasing at an alarming rate due to uncertain weather conditions, villagers are finding it hard to continue their traditions. One of the most important festivals—Tiji, which is celebrated in Lo-Manthang involving all villages of the Lo-pa region—is losing its charm, simply because the villagers are not able to spare many grains for the festival (Devkota, 2013).

A study conducted by Devkota (2013) in Upper Mustang shows that the livelihood and survival of the people in the region are closely related to the lands and livestock they possess. If these possessions are affected by climatic variability, it will have serious consequences for the cultural aspect of life in Nepal (Box 1). Additionally, consequences of climate change events such as landslides and drought force households and communities to migrate from their original settlements. When people are displaced from places that they value, there is evidence that their cultures are diminished and, in many cases, even endangered (Adger et al., 2012).

4.4 Impact on people and livelihoods

Climate change impacts include major destruction of assets, disruption of economic sectors, loss of human lives, and loss of and detrimental effects to plants, animals, and ecosystem services. The human and economic impacts of climate-induced disasters were analysed using data from 1971 to 2019. On average, 647 people die from climate-induced disasters in Nepal each year, which is about 65% of the total number of deaths from all disaster events except road accidents (MoHA, 2018). The average economic loss per year is NPR 2,778 million, which is about 0.08% of GDP (at the current price) of FY2018/19. The maximum economic loss of NPR 63,186 million occurred in 2017 during the Terai floods (NPC, 2017), which is about 2.08% of GDP (at current price) of FY 2017/18 (MoF, 2018).

Floods, landslides, epidemics, and fires are the most devastating climate-induced disasters in Nepal. Figure 8 shows the percentage of deaths, affected population, and economic losses due to 13 types of climate-induced disasters in Nepal from 1971 to 2019. Hazard-wise comparison of a number of deaths, affected population and economic losses revealed that epidemics caused the most deaths (52.8%), followed by landslides (16.7%) and floods (12.7%). Floods affected about 71% of the total affected population, followed by landslides (9.5%) and epidemics (8.2%). Fires caused the most economic losses (56.6%), followed by floods (31%) and landslides (3.7%).



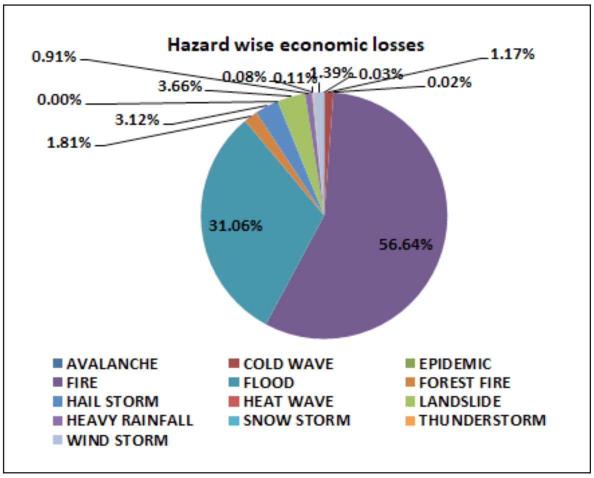


Figure 8 Hazard-wise comparison of deaths, affected people, and economic losses due to climate-induced disasters

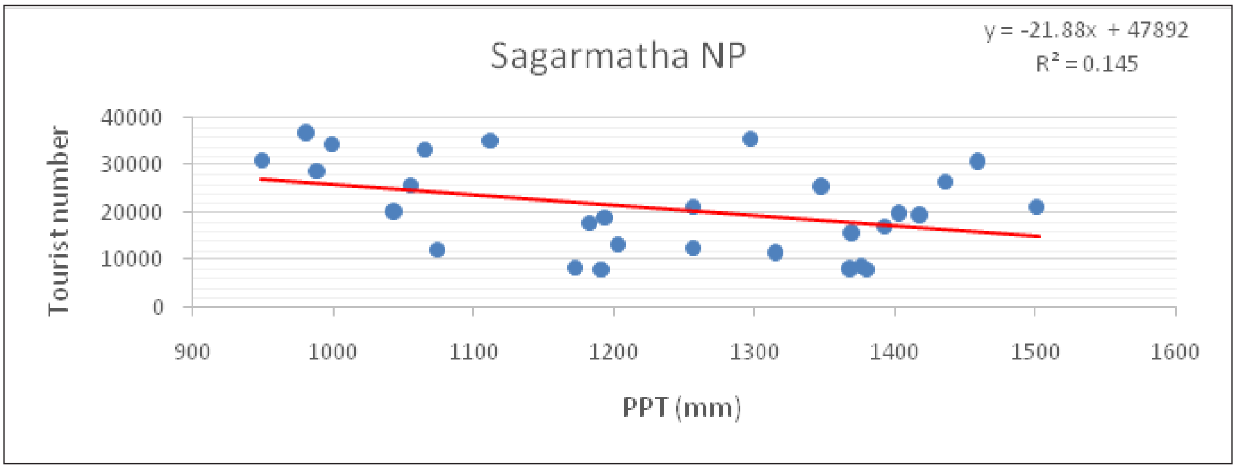
Climate change has also put the lives of trekkers, mountaineers, and associated human resources at threat. Hazards such as GLOFs, avalanches, and landslides are taking their lives, and destroying their properties. For instance, the Dudh Koshi GLOF was caused because of an outburst of the Dig Tsho glacier lakes on 4 August 1985, killing five people, destroying 30 houses and 14 bridges, and trekking trail networks (ICIMOD, 2011). The avalanches in the Khumbu and Kanchenjunga areas in 1995 killed 43 people, including foreign trekkers (MoHA, 2015). Similarly, in 2014, 12 Nepali guides died and four went missing in the Mt. Everest avalanche. In November 2014, unseasonal snowfall and avalanches resulting from the effects of cyclone *Hudhud* killed at least 43 trekkers and guides. During the incident, hundreds of trekkers were trapped at more than 5000m altitudes in the Thorong La Pass area. Many tourists were trapped by similar weather change phenomena in Manaslu Conservation Area at the same time.

Although an earthquake is not triggered by climate change, its consequences increase risks and vulnerability from other disasters. In April 2015, a devastating earthquake in Nepal caused snow avalanches in the Mt. Everest region at about 7000m altitude from mean sea level. More than 17 people, including tourists, died and 61 were injured. At the same time in 2015, a devastating earthquake caused avalanches in the Langtang region, burying 116 houses, (mainly hotels) and killing 308 people (176 residents, 80 foreigners, and 10 army personnel) (Callaghan & Thapa, 2015). Between 2005 and 2014, a total of 235 people were killed by inclement weather in the country, including avalanches and snowstorms (MoHA, 2015).

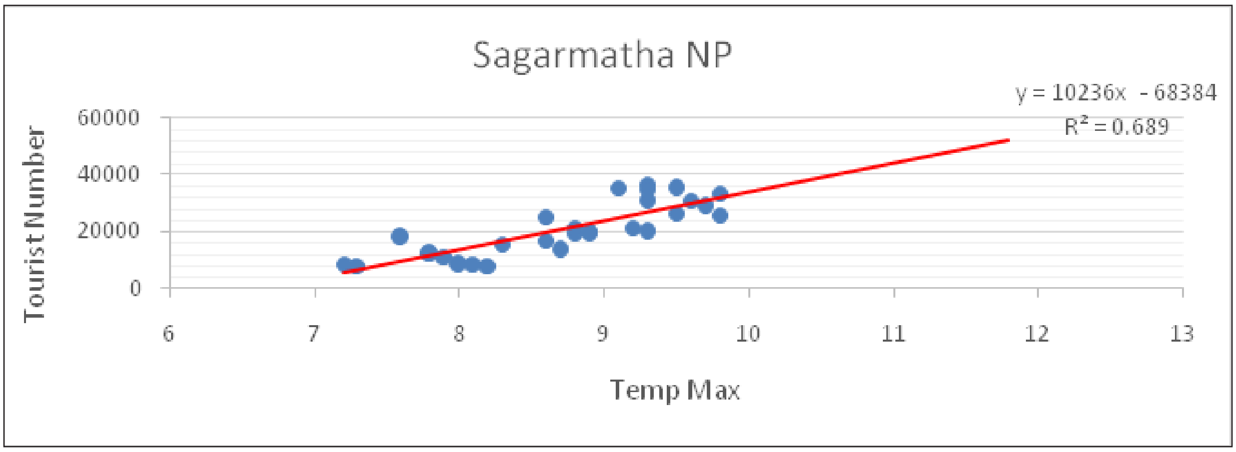
Unexpected weather conditions have adverse implications for the mobility of tourists (Sangraula, 2010). For instance, as Figure 10a shows, there is an inverse relationship between tourist arrivals and rainfall in Sagarmatha NP. This means that the number of tourists visiting the NP decreases as the rainfall increases. Such restriction in tourist mobility negatively impacts the tourism business as either tourist cannot reach the destinations in time or have to cancel the trip (Nyaupane & Chettri, 2009). Furthermore, the tourism supply chain is disrupted, leading to a lack of vital goods at destinations, raising the cost for travelers.

A study conducted by Faulon & Sacareau (2020) in the Everest region shows that the heavy interdependence of water and tourism, combined with uncertainty about how stream discharge could be affected by climate change, increases the inhabitants' vulnerability. Besides, the study shows that vulnerable groups include not only the poorest who rely on agriculture but also those who have invested heavily in welcoming tourists and equipping their guest houses with electricity. Additionally, access to and availability of water highly influence tourism activities. Water demand substantially increases due to tourism businesses such as hotels and restaurants, which may be challenging to sustain in water-scarce areas (Gössling et al., 2012).

Climate change has implications for gender-related issues in the tourism sector. Water crises increase the workload for women as they are the de facto managers of many hospitality businesses, including homestays, restaurants, hotels, and tea shops; and are responsible for providing basic facilities to tourists (Tenzin et al., 2019). Water scarcity also makes it difficult to provide improved services (Lama, 2010) and also has a direct impact on the sanitation of tourist locations, potentially causing health problems for tourists and tourism-dependent people (Nicholson et al., 2016).



(a)



(b)

Figure 9: Relation between tourist arrival in Sagarmatha NP, and rainfall (a) and temperature (b)

Furthermore, when the tourism season overlaps with the cropping cycle, it may increase the workload of women and marginalized groups (Rayamajhi, 2012).

Nonetheless, stakeholders in the Annapurna Conservation Area have noted some positive impacts of climate change, such as warmer temperatures making the trekking season slightly longer and more comfortable for a larger range of individuals (Rayamajhi, 2012). Similarly, an increase in temperature boosts visitor mobility. In Sagarmatha National Park, for example, there is a positive association between visitor arrival and maximum temperature (Figure 9b), meaning that tourist movement increases as the temperature rises. Remarkably, a one-percentage increase in maximum temperature boosts the tourism sector's contribution to national GDP by 9.36% (MoCTCA, 2018).

Observed and Projected Climate Change Hazards and Exposure

5.1 Climate change trend and scenarios

This study observed trends of two variables—temperature and precipitation—between 1971 and 2014, as shown in Table 7. The results show a negative trend in the average amount of rainfall in all seasons. The seasonal trend of the precipitation was observed to be decreasing with the highest decline (0.32 mm per year) during post-monsoon. However, pre-monsoon precipitation indicates a significant positive trend in the High-Himalayan region (MoFE, 2019). On average, Nepal's annual precipitation has declined by 1.3 mm per year over the observed period. In the last 40 years, the annual increment of Nepal's maximum and minimum temperature were observed to be 0.056°C and 0.002°C, respectively.

Table 7: Observed trend of the climatic variables in Nepal between 1971 and 2014

Climatic variables	Winter	Pre-monsoon	Monsoon	Post-monsoon	Annual
Precipitation (mm/year)	-0.072	-0.081	-0.085	-0.324	-1.333
Maximum temperature (°c/year)	0.054**	0.051**	0.058**	0.056**	0.056**
Minimum temperature (°c/year)	0.009	-0.003	0.014*	-0.005	0.002

*Note: **significant at 99% confidence level and *95% of confidence level. Source: DHM (2017)*

Physiographic region-wise, the analysis shows that the winter temperature of the Terai has declined annually by -0.004°C, whereas the change in annual and seasonal temperatures in all seasons is the highest in the High Himalaya region compared to other regions of the country. The annual positive change in the temperature of the Himalayan region is 0.086°C. The highest significant positive trend (0.092°C/year) is observed in Manang, while the lowest positive trend (0.017° C/year) is observed in the Parsa district (MoFE, 2019).

According to the MoFE (2019), the annual mean temperature will increase by 0.9°C to 1.1°C in the 2030s (near future) and by 1.3°C to 1.8°C in the 2050s (medium-term future), compared to the 2010s (baseline period). Likewise, the annual mean precipitation will also increase in the future by 2 to 6% in the 2030s and by 8 to 12% in the 2050s. This shows that the climate will be significantly warmer and wetter in the future. However, there will be seasonal variability, such as decreasing precipitation during pre-monsoon seasons and a likelihood of stronger monsoons which will increase the chances of extreme climate events occurring in the future. The stronger monsoons will increase the risks of monsoon-related disasters, such as landslides and floods/flash floods, in the future, which will directly affect tourist movement, tourism infrastructure, and cultural heritage sites.

5.2 Climate change stressors in the TNCH sector

The focus in this assessment was given to stressors or extreme events with a certain magnitude, frequency, and potential for having immediate consequences in the TNCH sector. For example, changes in extreme wet days may cause flood and landslide events, which in turn have direct impacts on tourism infrastructure and business operations. Depending on the geological structures of different destinations and their susceptibility to climate variabilities, impacts may register differently. Table 8 shows the main climate stressors identified in the TNCH sector based on the literature review, expert consultation, and expert weightage.

Table 8: Climate Change stressors/hazards in the sector and sub-sectors

Extreme Events	Expert weightage	Supporting Literatures
Protected Area related		• IPCC AR5, working group III (2014) • IPCC AR4, Impacts, Adaptation and Vulnerabilities (2007) • Climate Change Adaptation Policy for Industrial Area (GIZ, 2016) • Climate Resilient Planning (NPC, 2011) • Economic Impact Assessment of Climate Change (IDS, 2014) • Development and Climate Change in Nepal (OECD, 2003) • Climate Change Impact on Tourism (MoCTCA, 2018) • NSTS, 2015
Change in Precipitation (%)	20	
Change in Extreme Wet Days (%)	20	
Change in Temperature (0C)	10	
Change in Warm Spell Duration (%)	10	
Change in Consecutive Dry Days (%)	15	
Change in Cold Spell Duration (%)	10	
Change in Consecutive Wet Days (%)	15	
Cultural Heritage Sites related		
Change in Precipitation (%)	30	
Change in Extreme Wet Days (%)	30	
Change in Cold Spell Duration (%)	10	
Change in Consecutive Wet Days (%)	15	
Change in Consecutive Dry Days (%)	10	
Change in Warm Spell Duration (%)	5	

The section below presents the trend of climate extreme events that are most relevant to the TNCH sector, based on data from 1971 to 2014 provided by the Department of Hydrology and Meteorology (DHM).

5.2.1 Change in extreme wet days and precipitation

Figure 10 below shows the positive and negative annual average trends of extreme wet days and precipitation. The Syangja district is showing a positive trend. This means that every 10 consecutive years, there is likely to be an increase of one additional extreme wet day in the district. Among the total 77 districts, 29 districts show an increasing annual precipitation trend, and 48 districts show a decreasing one. The district-wise trend values of annual precipitation show a significant decreasing trend in Kaski (-11.44 mm/yr) and a significant increasing trend in Syangja (9.0mm/yr).

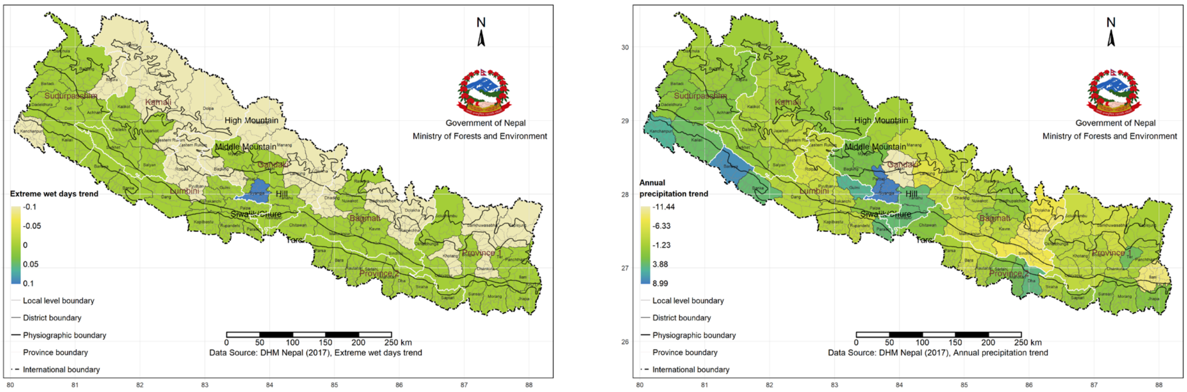


Figure 10: Extreme wet days trend and annual precipitation trend

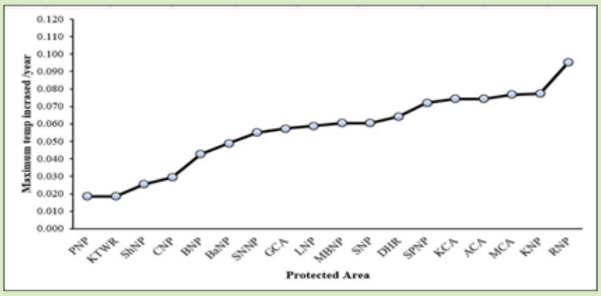
Climate change-related shifts in weather patterns might also cause significant disruption in mobility, infrastructure, and daily operation of the tourism business. Extreme precipitation increases the inundation of roads, collapse of infrastructure, increasing the operational cost. Thus, the positive trend in extreme wet days and precipitation in some districts may lead to an increase in the sensitivity of the TNCH sector.

5.2.2 Change in temperature

The maximum temperature trend is significantly positive and shows an increase of 0.056⁰C per year (DHM 2017). Additionally, the trends show that the Manang and Taplejung districts have a higher increasing trend in annual maximum temperature (i.e., 0.092⁰C/yr and 0.091⁰C/yr) respectively, whereas the Bara and Rautahat districts have the least increasing trend (Figure 11). Gradual shifts in long-term temperature trends might have resulted in glacier melts and GLOFs. This kind of change in maximum temperature might directly influence the gradual increment of possible future risks in the TNCH sector.

Box 2: Temperature change trend in Protected Areas

The PAs key tourism destinations of various bioclimate zones respond differently to climate stressors. Lowland PAs experience low temperature increase than in middle mountain and high mountain PAs. This indicates clearly that in the high Himalayas, the pace of increase in maximum temperature per year is high. Tsering and colleagues (2010) found in their assessment that in Nepal average annual temperature increased by 0.01°C in the foothills, 0.02°C in the middle mountains, and 0.04°C in the higher Himalayas.



The maximum temperature is observed the high positive trend in winter season in High mountains and High Himalayas and the highest positive trend in monsoon in Tarai, Siwaliks and Middle Mountains (DHM, 2017). An increasing rate of warming with elevation was also observed in encompassing the whole physiographic region of Nepal using climatological data from 1977 to 2000 (Shrestha et al., 1999)

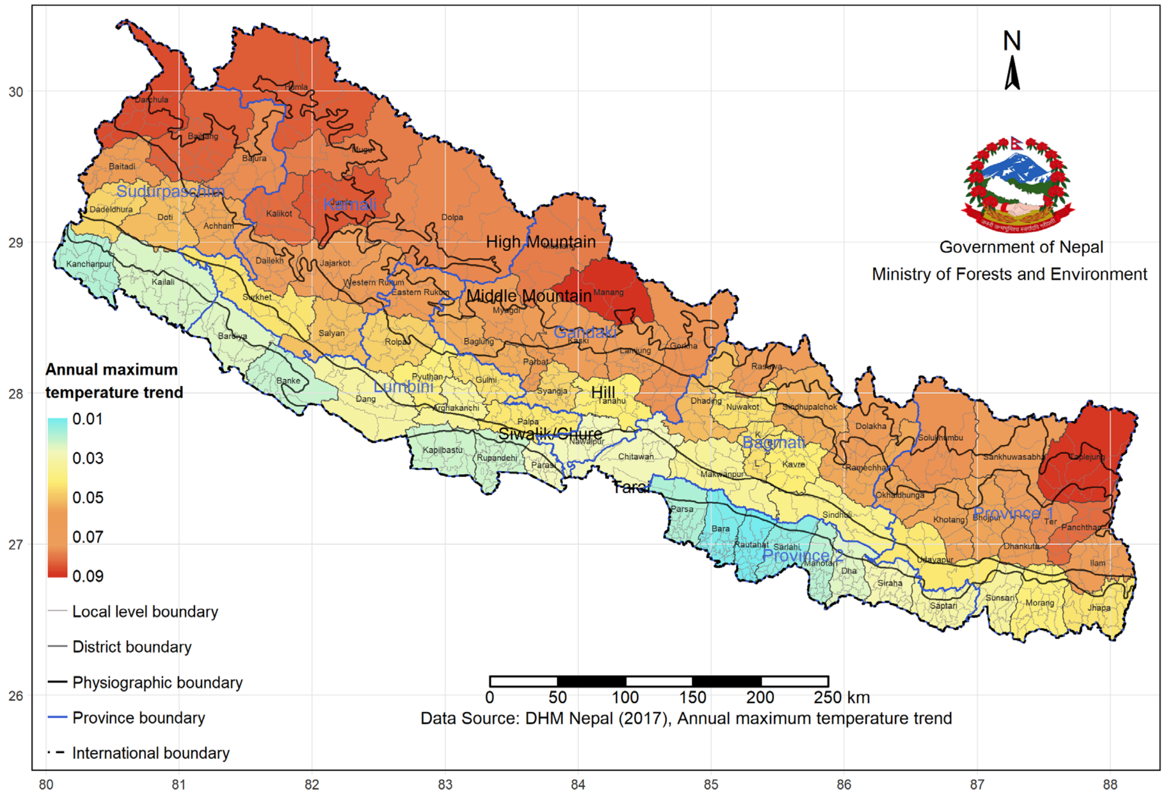
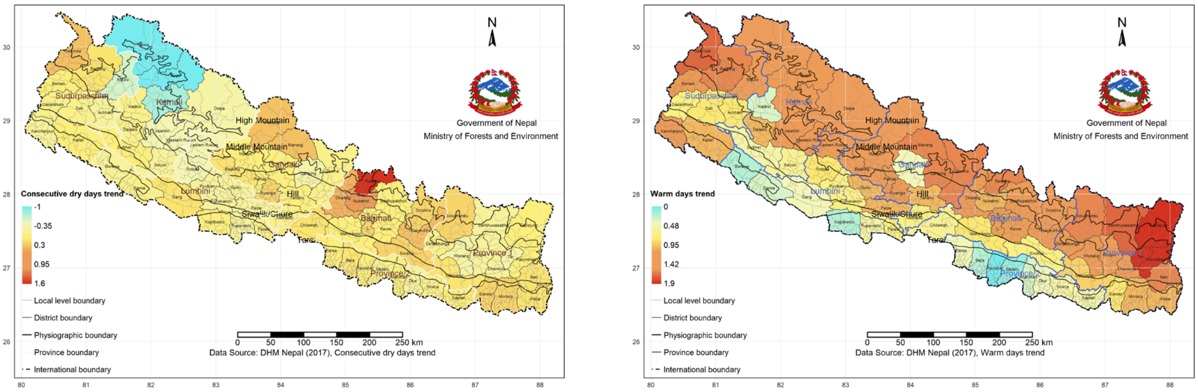


Figure 11: Annual maximum temperature trend

5.2.3 Change in consecutive dry days and warm days

Figure 12(a) shows the changes in the consecutive dry days in the country. The map shows that there is a trend of an increasing number of dry days in the Rasuwa district (1.6 days/yr), whereas the number of dry days in Humla and Mugu is in a decreasing trend. Moreover, consecutive dry days in the mountain districts, like Manang, Mustang, Dolakha, Solukhumbu, and Taplejung, are in an increasing trend. The increase in such days may result in scarcity of water in these districts and given that they host key tourism and pilgrimage destinations—both PAs and cultural heritage sites—the tourism business there stands to be substantially impacted. Furthermore, the increase in the number of dry days increases the risk of forest fires, which can destroy and diminish the aesthetic value of tourism destinations.

Figure 12(b) shows that warm days are in an increasing trend in most of the hill and mountain districts in the country. Such a trend is the highest in the Taplejung, Terathum, and Panchthar districts (1.9 days/yr), followed by the Sankhuwasabha and Solukhumbu districts. The increase in warm days accelerates the melting of glaciers, directly affecting mountaineering tourism. Moreover, glacier melting increases the risk of GLOFs as the area has many potentially dangerous glacier lakes (Bhajracharya et al., 2020).



(a) (b)

Figure 12: Consecutive dry days trend (a) and consecutive warm days trend (b)

5.3 Climate change hazards in the TNCH sector

Changes in precipitation and temperature are responsible for climate change extreme events and hazards, such as landslides, floods, avalanches, snowstorms, and cold waves. The trends of several climatic hazards in the last 49 years (1971-2019) indicate an overall increasing trend (MoHA, 2020). The trend analysis of the occurrences of 11 climatic hazards (thunderbolts, windstorms, epidemics, heavy rainfalls, landslides, floods, avalanches, hailstorms, heatwaves, cold waves, and snowstorms) revealed the same: that there is a significant increasing trend of climatic hazards, especially after 1990 (Figure 13).

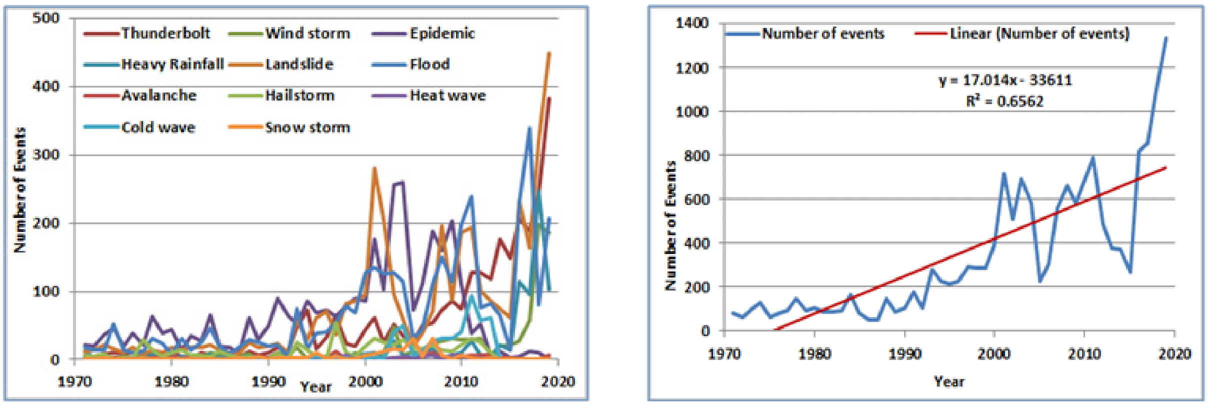


Figure 13: All Nepal trends of hazards based on historical data

Statistical analysis of the hazard data of the last 49 years shows that trends of all hazards are significant at a 5% level except epidemic, avalanche, and drought (Table 9)[1].

1 Statistical analysis was carried on data from MoHA between 1971 to 2019; and on forest fires data from 2001 to 2019, and drought data from 1981 to 2019, both obtained from ICIMOD, using Mann-Kendall Test and Sen's Slope Method

Table 9: Mann-Kendall test statistics for linear trend of climatic hazard events

Hazard	Z-statistic	P-value	Sen's Slope	Significance (5%)
Epidemic	1.63	0.10	1.16	No
Heavy rainfall	4.53	0.00	0.25	Yes
Landslide	6.62	0.00	2.70	Yes
Flood	5.43	0.00	2.64	Yes
Avalanche	1.61	0.11	0.03	No
Heat wave	2.18	0.03	0.00	Yes
Cold wave	3.70	0.00	0.00	Yes
Snowstorm	2.60	0.01	0.04	Yes
Forest fire	1.96	0.05	83.50	Yes
Drought	-1.73	0.08	-2.39	No

The section below describes the key climate hazards related to the TNCH sector and their relationship with climate stressors. These hazards directly or indirectly put the lives of tourists, tourism-dependent people, tourism infrastructures, and businesses at risk.

Avalanche: An IPCC report (2012) pointed out that at higher temperatures, more ice melts and the strength of the remaining ice becomes lower; as a result, the frequency and perhaps size of ice avalanches may increase. In Nepal, analysis of avalanche hazards shows an increasing trend in recent years in popular tourism destinations like the Solukhumbu, Kaski, Manang, and Dolpa districts. With an increase in temperature in the future, avalanches are expected to increase.

Floods: A change in the climate physically changes many of the factors affecting floods (e.g., precipitation, snow cover, soil moisture content, glacial lake conditions, and vegetation) and thus may consequently change the characteristics of floods. Pluvial floods may increase with an increase in heavy precipitation. In Nepal, the most flood-prone districts are Jhapa, Morang, Sunsari, Rautahat, Saptari, Sarlahi, and Nawalparasi. The Jhapa district is one of the most flood-prone districts, with the highest number of flood events from 1971 to 2019. Furthermore, flash floods have a serious impact on forests and biodiversity. During rainy seasons rhinoceroses, calves, and other animals are at risk due to flash floods and there have been multiple incidences of animal deaths resulting from this type of hazard (NTNC, 2020; Subedi et al., 2017).

Landslides: Generally, consecutive wet days induce landslides in sloppy terrains with fragile soil. In recent decades, unscientific development works, such as the construction of rural roads without engineering design, have also led to an increase in incidences of landslides. Analysis of the data shows that Dhading, Baglung, Sindhupalchok, Sankhuwasabha, Taplejung, Nuwakot, and Syangja are the most landslide-prone districts in Nepal. Most of these districts are key tourism destinations as they are home to popular PAs and cultural heritage sites. Figure 14 shows the trends of landslide events and monsoon rainfalls and their relationship in the Sindhupalchok district, one of the districts with the Gaurishankar CA. The landslide events appear to be in an increasing trend, whereas the monsoon rainfall is in a slightly decreasing trend. However, rainy days and consecutive wet days are in increasing trends in the Sindhupalchok district (DHM, 2017). This indicates that more landslides are occurring due to low-intensity continuous rainfall rather than high-intensity rainfall. The number of landslide events increases when the monsoon rainfall increases.

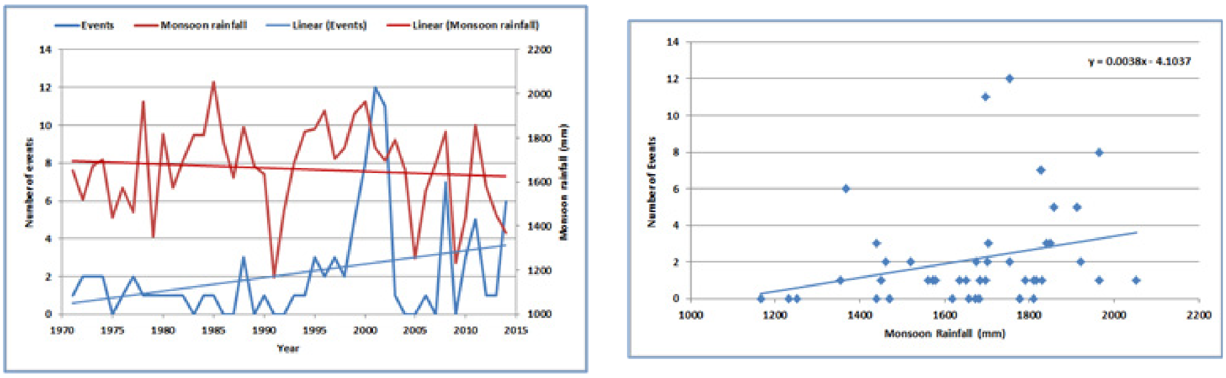


Figure 14: Trend of landslide events and monsoon rainfall in Sindhupalchok district

GLOFs: Receding glaciers are a sign of global climate change. With the melting of glaciers, glacial lakes are created in the lower sections. Several of these lakes have been broken in the past, leading to catastrophic floods (or GLOFs) that have destroyed infrastructure and taken human lives in the valleys downstream. Out of the 47 potentially dangerous glacier lakes in China, Nepal, and India, 42 are located in the Koshi basin (Bajracharya et al., 2020), where the world-famous tourism destinations, such as Sagarmatha NP, Makalu Barun NP, and Kanchenjunga CA are also located. The historical GLOF events in Nepal reportedly occurred about 450 years ago. A total of 24 GLOFs events have been reported so far, originating 14 GLOFs in Nepal's Himalaya region and another ten in the Tibetan part of China (Bajracharya et al., 2014).

Box 3: Potential impact of GLOF in rafting

The analysis of Desinventar data of MoHA from 1971 to 2019 shows that Dudh Koshi, Arun, Lower Sun Koshi and Bhote/Upper Sun Koshi experience high hazard severity as the areas are highly sensitive to GLOFs. For instance, there are 14 potentially dangerous glacier lakes in the catchment of Aurn river, and eight in Bhote Koshi (Bhajracharya et al., 2020). Moreover, the discharge of all 42 dangerous glacier lakes located in the Koshi basin reaches the Lower Sun Koshi, including the Bhote Koshi river. Trishuli river, the most popular destination for rafting, has two potentially dangerous glacier lakes in its catchment. These glacier lakes have made the rivers highly sensitive, as potential GLOFs could have devastating effects on the infrastructure, such as campsites, roads and bridges, for reaching the destinations, and hotels and restaurants.

Forest Fires: Prolonged drought with increased temperature generally make favorable conditions for a forest fire. The analysis of data from ICIMOD shows the number of forest fire events increases when the pre-monsoon rainfall decreases (Figure 15).

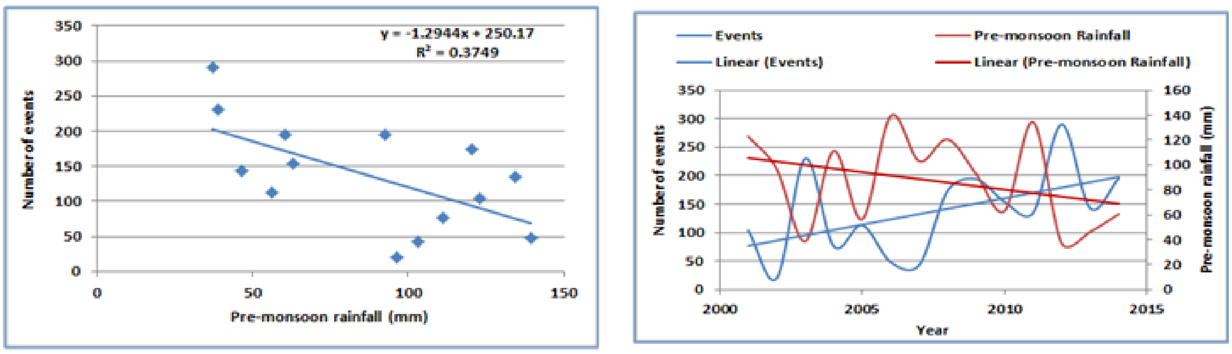


Figure 15: Trend of forest fire events and pre-monsoon rainfall and their relationship

The analysis further shows that forest fire hazards are increasing in recent years in the Bardiya, Chitawan, Parsa, and Surkhet districts, where key tourist destinations are located. The trend of the forest fire events in the Bardiya district was compared with the trends of pre-monsoon rainfall and annual maximum temperature (Figure 16). The figure shows that there is more forest fire when there is less rain.

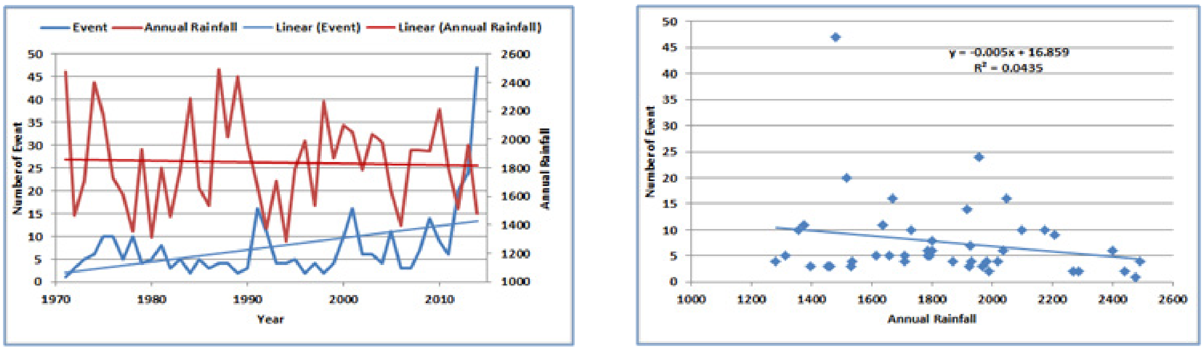


Figure 16: Trend of fire events and annual rainfall and their relationship in Bardiya district

A higher number of forest fires occurred in the lower elevation (below 1000m) areas and more than 30% of fires occurred in plain lands, indicating that the PAs in lowland were highly prone to fire events. Also, data from 2012 to 2016 showed a higher number of fire events in the Bardiya NP, Chitwan NP Parsha NP, and Shey Phokshudo NP in the lowland, and Langtang NP, Annapurna CA and Dhorpatan HR in the mountain PAs in Nepal (Lamsal et al., 2017).

The extreme events composite index of the PAs is calculated by using historic data of extreme events from 1971 to 2010 (DHM, 2020). Figure 17 shows that the PAs located in the eastern part of Nepal experienced more climate hazards in the past compared to the PAs located in the middle and the western part of Nepal. Among the PAs, Kanchanjenga CA experienced the highest climate extreme events, followed by Makalu Barun NP, whereas Shey Phoksundo experienced the least amount of climate hazards, followed by Rara NP.

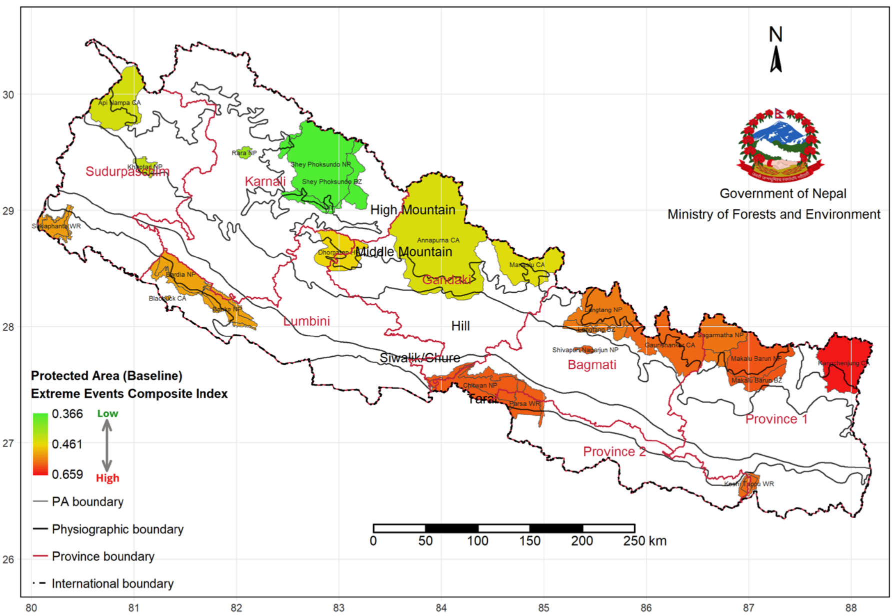


Figure 17: Extreme events composite index of protected areas (baseline)

The extreme event scenario analysis of the PAs shows that there is a likelihood of an increase in extreme events in both 2030 and 2050 under RCP 4.5 scenarios (Figure 18). The PAs that experienced fewer incidences of extreme events in the past, such as Shey Phoksundo NP and Rara NP, are also likely to experience more extreme climate events. Although under the scenario RCP 8.5 (2030), these PAs are likely to experience similar extreme events, there is a high likelihood that the PAs will experience the highest number of extreme events under RCP 8.5 (2050), compared to all other scenarios (Figure 19).

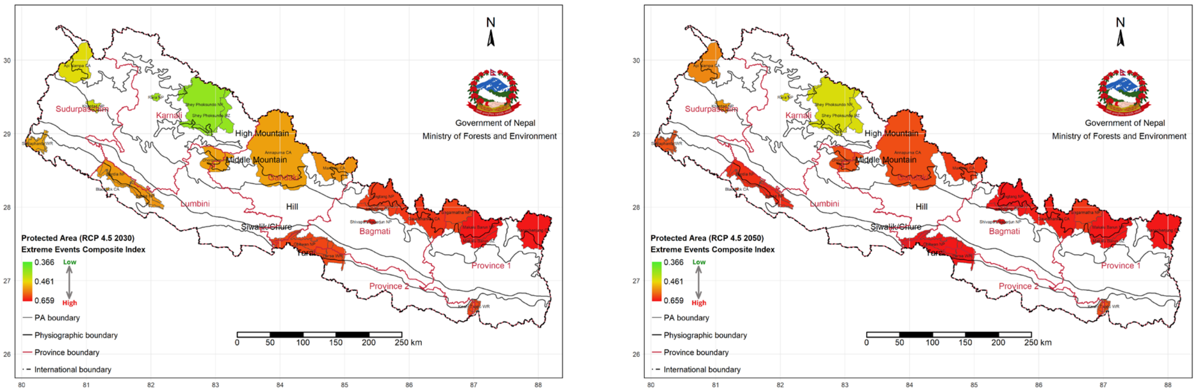


Figure 18: Extreme events composite index of protected areas in RCP 4.5 (2030 and 2050) scenario

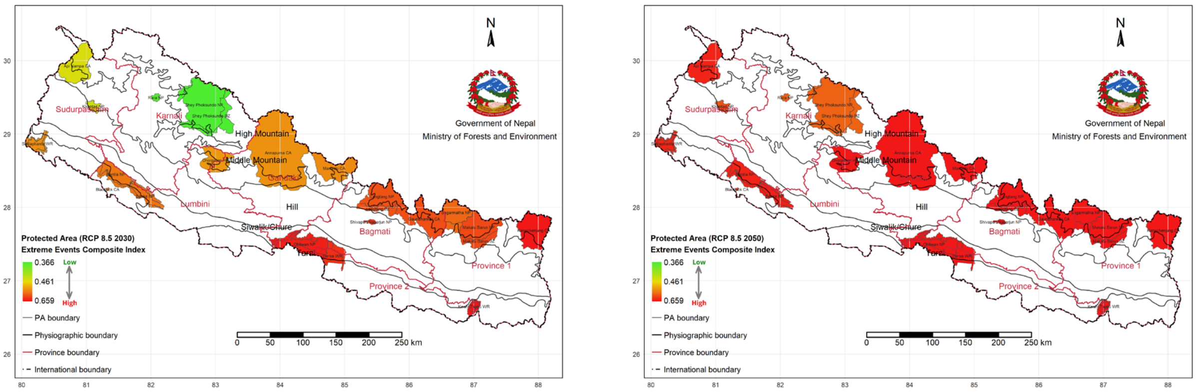


Figure 19: Extreme events composite index of protected areas in RCP 8.5 (2030 and 2050) scenario

Likewise, the extreme event composite index of districts related to cultural heritage sites includes the combined effects of changes in precipitation, extreme wet days, cold spell duration, consecutive wet days, and consecutive dry and warm days. Analysis shows that the cultural and heritage sites in the eastern districts of Province 1 and mountain districts of Bagmati province, such as Taplejung, Sankhuwasabha, Solukhumbu, Ilam, Jhapa, Dolakha, and Sindhupalchok, experienced more climate extreme events in past (Figure 20). As these districts experience high rainfall and also have potentially dangerous lakes, the districts are faced with a high possibility of landslides and GLOFs. Likewise, the hilly districts of Gandaki Province, such as Kaski, Syangja, Tahanu, and Lamjung, have had higher compositive extreme climate events in past. Almost all the districts in the Lumbini, Karnali, and Sudurpaschim provinces have relatively low compositive extreme events.

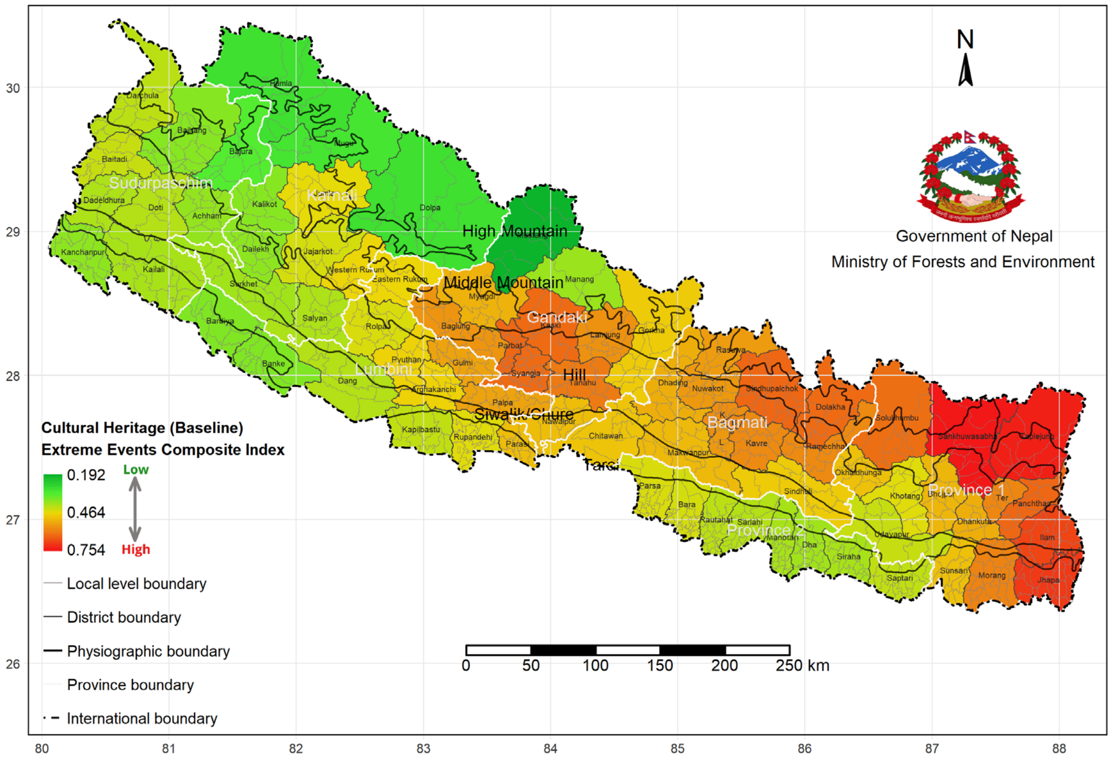


Figure 20: District wise compositive extreme events (baseline)

There is no substantial difference between the RCP 4.5 (2030) scenario and the baseline for cultural heritage sites in the western part of Nepal (Figure 21). However, there is a likelihood of an increase in extreme events in the central and eastern parts in RCP 4.5 (2030), compared to the baseline. This is mainly because these regions experience more rainfall. Moreover, there is a likelihood of an increase in extreme events all over Nepal under RCP 4.5 (2050), compared to the baseline and RCP 4.5 (2030) scenario. Additionally, there is the likelihood of an increase in extreme events under the RCP 4.5 (2050) scenario in the hilly and mountainous districts of the Gandaki Province. The mountain districts of the Gandaki Province and almost all eastern districts of Province 1 are likely to experience more extreme events compared to the baseline.

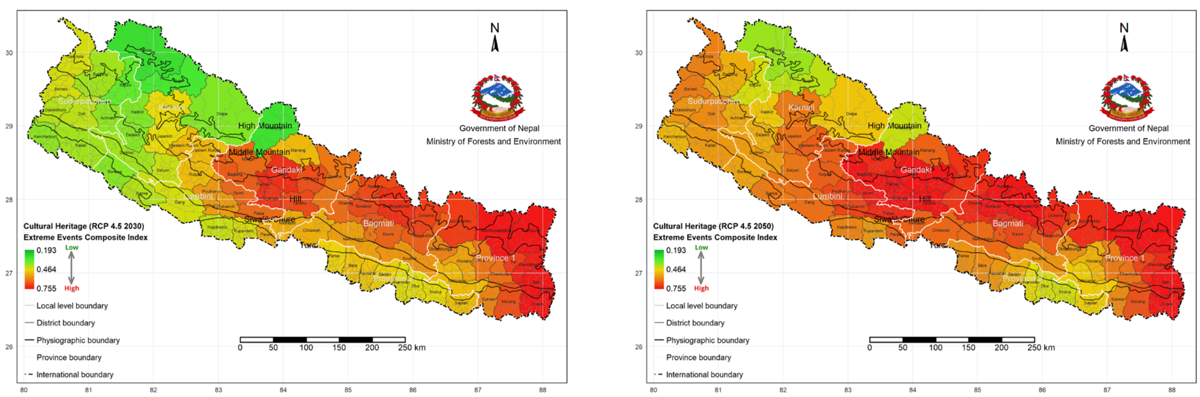


Figure 21: District wise compositive extreme scenario of cultural heritage sites in RCP 4.5 (2030 and 2050)

In the case of the RCP 8.5 (2030) scenario, there is a likelihood of more extreme events in central and eastern parts of Nepal, compared to the baseline (Figure 22). Furthermore, the analysis shows that under scenario RCP 8.5 (2050), there is a high likelihood of an increase in extreme events in almost all parts of the country.

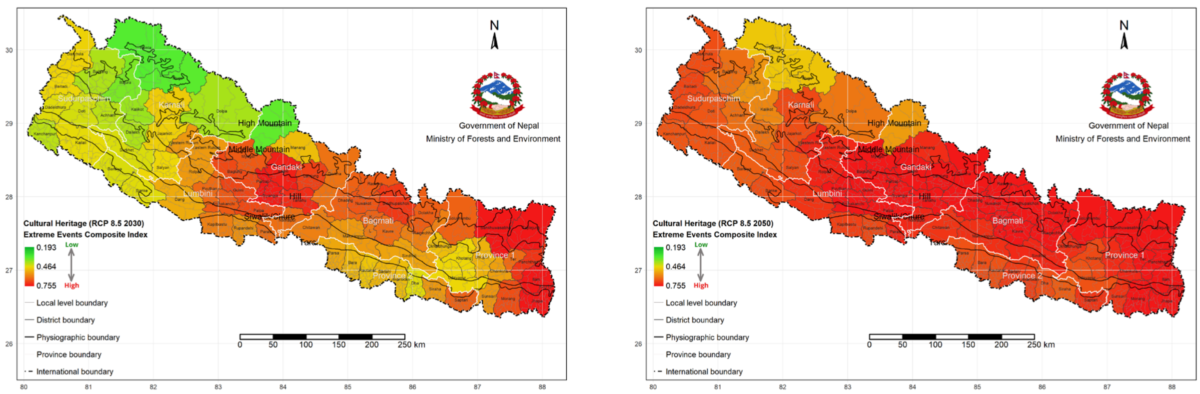


Figure 22: District wise compositive extreme scenario of cultural heritage sites in RCP 8.5 (2030, 2050)

5.4 Climate change exposure in the TNCH sector

Exposure in this study is defined as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or cultural assets in places and settings that could be adversely affected (IPCC, 2014). This study analysed the exposure of the PAs and cultural heritage sites separately.

Protected Areas

In PAs, tourism infrastructure, nature, tourists, and people, and livelihoods are exposed to climate change. The exposure elements related to tourism infrastructure include roads connecting to the destinations, trekking trails, airports, places for food and accommodation, and basecamp sites. Likewise, exposure elements related to nature are the coverage of the projected areas, glacier/snow-covered areas, glacier lakes, and lakes, including Ramsar sites. Similarly, the exposure elements of people and livelihoods are tourists visiting PAs and people living in and around PAs.

As can be seen in Table 8, findings show that Annapurna CA has the highest exposure index, followed by Chitwan NP, Sagarmatha NP, and Langtang NP, indicating that these PAs have the highest number of exposure elements. The number of people living in the CA and the buffer zone of the NPs is the highest in Chitwan NP (231,046), followed by Bardiya NP (133,792) and Annapurna CA (90,755). Likewise, these PAs receive the highest number of tourists compared with other PAs. For instance, Annapurna CA was visited by 181,746 tourists in 2019, whereas the number of tourists who visited Chitwan NP and Sagarmatha NP were 142,486 and 57,289 respectively (MoCTCA, 2020).

The higher exposure index of Chitwan NP, Annapurna CA, and Sagarmatha NP is due to the infrastructure density (which includes the road network in and to the PAs, and the trekking networks in the PAs). The districts of Chitwan NP have 1,363 km of strategic roads (DoR, 2018), whereas Annapurna CA has 2,627 km of trekking routes and Sagarmatha NP has 545 km of trekking routes (NMP, undated and HMP, undated). Although Chitwan NP does not have any campsites, Annapurna CA, Sagarmatha NP, and Langtang NP have 129, 63, and 36 respectively. Except for Api Nampa CA, Dhorpatan HR, and Manaslu CA, all other PAs have access to airports, and the Sagarmatha has the highest number—three—of airports (CAAN, 2020).

Table 10: Exposure index of protected areas

SN	Name of PA	Exposure Index	Rank	SN	Name of PA	Exposure Index	Rank
1	Annapurna CA	1	Very high	11	Koshi Tappu WR	0.524	Moderate
2	Api Nampa CA	0.321	Low	12	Langtang NP	0.625	Very high
3	Banke NP	0.505	Moderate	13	Makalu Barun NP	0.481	Moderate
4	Bardiya NP	0.61	High	14	Manaslu CA	0.245	Very low
5	Blacbuck CA	0.176	Very low	15	Parsa NP	0.399	Low
6	Chitwan NP	0.942	Very high	16	Rara NP	0.453	Moderate
7	Dhorpatan HR	0.432	Low	17	Sagarmatha NP	0.87	Very high
8	Gaurishankar CA	0.551	High	18	Shey Phoksundo NP	0.504	Moderate
9	Kangchenjunga CA	0.319	Very low	19	Shivapuri Nagarjun NP	0.474	Moderate
10	Khaptad NP	0.308	Very low	20	Shuklaphanta NP	0.255	Very low

The other key elements of exposure are area coverage of the PAs and snow cover area. Annapurna CA covers 7629 km^2 area with 685.4 km^2 of glacier/snow cover area, followed by Shey Phoksundo NP (4904 km^2 including buffer zone area) with 2106 km^2 of glacier/snow cover area. Despite being the second-largest PAs, Shey Phoksundo NP is a moderately exposed PA (Figure 23), mainly because of the small network of strategic roads, few places for food and accommodation, and few tourists visiting the park. Gaurishankar CA and Bardiya NP are highly exposed as Gaurishankar CA covers 2,179 km^2 with 7,040 people living there, and Bardiya NP has 1,295 km^2 of area (including buffer zone area) with 11,436 people visiting in 2019.

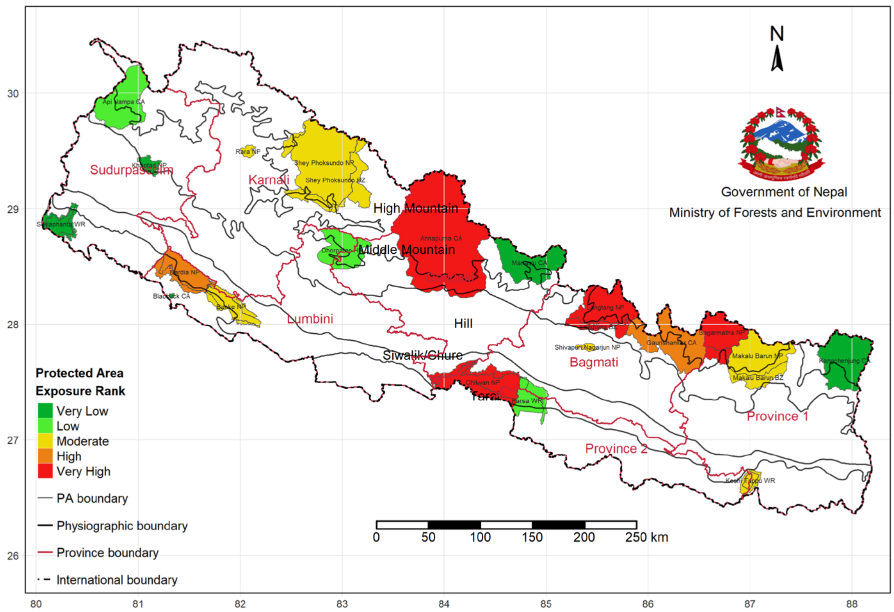


Figure 23: Exposure ranking of protected areas

Among the PAs, Kanchenjunga CA, Manaslu CA, Khaptad NP, and Shuklaphanta NP have very low exposure. This is mainly because of their smaller size, smaller networks of strategic roads and trekking routes, a smaller number of places for food and accommodation, and a smaller number of visitors.

Cultural Heritage

Cultural heritage sites are spatially distributed all over Nepal. According to a publication by the Department of Archaeology (DoA), there are 226 such sites in 72 districts of Nepal (DoA, 2007). These sites include temples, monuments, monasteries, and stupas. The Mustang (16), Kathmandu (16), Kapilbastu (11) and Rupandehi (10) districts have higher numbers of cultural heritage sites (Figure 24), making them highly exposed to climate-induced disasters. Some of the key cultural heritage sites in Mustang are Lomanthang palace, Damodar Kunda, Kagbein Castle, Muktikshetra, and Tsarang Durbar. These sites are the key attraction for domestic and international pilgrimage, particularly Indians, and are of historical importance as well. Likewise, a few such sites in Kathmandu Valley are Pashupatinath, Swayambhunath Stupa, Bouddhanath Stupa, Hanumandhoka Durbar Complex, Patan Durbar Complex, Bhaktapur Durbar Complex, and Changunarayan. All these sites are included in the UNESCO world heritage sites list and are highly attractive to both domestic and international tourists. For instance, Pashupatinath was visited by 171,937 international tourists, excluding Indians, in 2019 (MoCTCA, 2020a).

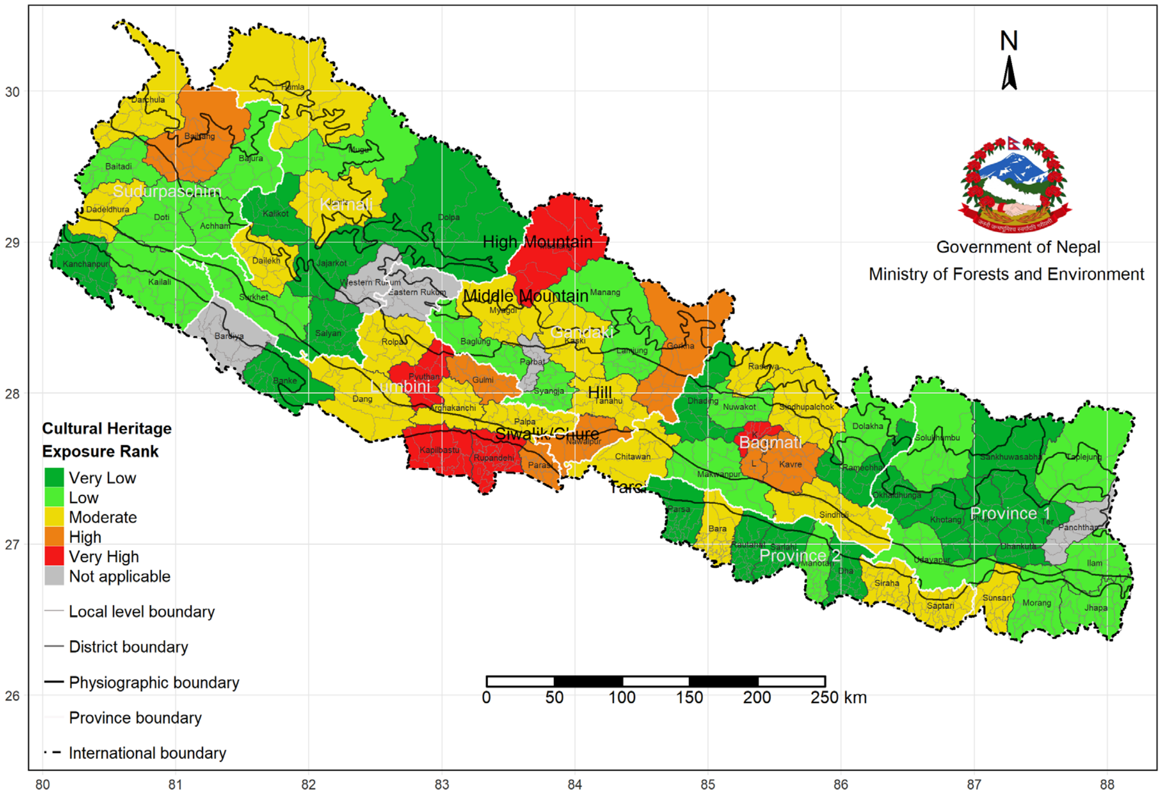


Figure 24: Exposure ranking of districts with cultural heritage sites

Table 11: Exposure rank of the districts with cultural heritage sites

Exposure Rank	District
Very High (0.632 - 1)	Kapilbastu, Pyuthan, Rupandehi, Mustang, Kathmandu
High (0.361 - 0.631)	Gorkha, Lalitpur, Kavrepalanchok, Bhaktapur, Nawalpur, Parasi, Bajhang, Gulmi
Moderate (0.181 - 0.360)	Rolpa, Humla, Rasuwa, Myagdi, Sunsari, Sindhupalchok, Tanahu, Dailekh, Darchula, Siraha, Arghakhanchi, Palpa, Sindhuli, Bara, Chitawan, Dang, Kaski, Jumla, Saptari, Dadeldhura
Low (0.001 - 0.180)	Makawanpur, Mugu, Lamjung, Dolakha, Nuwakot, Baglung, Solukhumbu, Udayapur, Syangja, Kailali, Surkhet, Achham, Baitadi, Morang, Doti, Manang, Bajura, Taplejung, Jhapa, Mahottari, Ilam
Very Low (0)	Dhading, Dhankuta, Terhathum, Sankhuwasabha, Rautahat, Banke, Dolpa, Bhojpur, Salyan, Khotang, Okhaldhunga, Dhanusha, Kalikot, Kanchanpur, Jajarkot, Sarlahi, Parsa, Ramechhap

The Rupandehi and Kapilbastu districts consist of several cultural heritage sites related to the Lord Buddha. Some of the key sites are Tilaurakot, Gotihawa, Nigalihawa, and Lumbini. Lumbini, considered the birthplace of the Lord Buddha, is listed in the UNESCO world heritage sites list and is a key attraction for Buddhists from all over the world. It was visited by 377,908 international tourists in 2019 (LDT, 2020). The districts also have several places that have historical importance, such as Jitgadhi, Phulbari, and Nuwakot Gadhi. Another district with a high number of cultural heritage sites is Pyuthan, which has Sworgadwari Ashram and many forts. The Sworgadwari Ashram is a holy place for both Nepali and Indian pilgrimage. The province-wise exposure maps are presented in Annex 1.

Chapter 6

Observed Climate Change Vulnerability in the TNCH Sector

6.1 Sensitivity in the TNCH sector

Sensitivity in this study is assessed based on the predisposition of the TNCH sector to suffer harm as a consequence of intrinsic and contextual conditions, making it plausible that once impacted by a hazard event, the sector will collapse or experience major harm and damage. This study analysed the sensitivity of PAs and cultural heritage sites separately.
Protected Areas

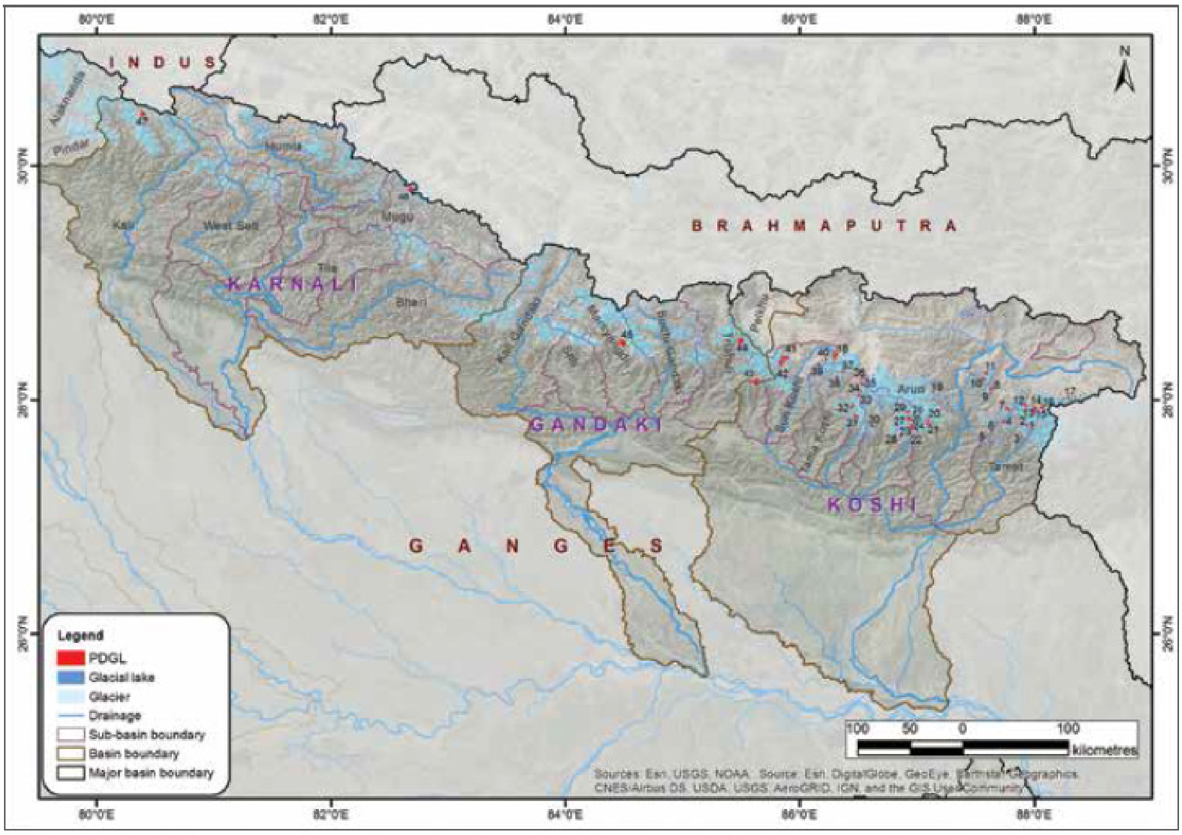
The slopes of the PAs, hazard severity, fragile soil, lengths of the non-paved road, changes in snow cover area, lengths of river potentially impacted by GLOFs, female-headed households, and economically active females in agriculture were used as indicators to assess the sensitivity of the PAs. The last two variables are regarded as proxy indicators for gauging the sensitivity of tourism-dependent people, as research indicates that workload for women increases when the agricultural calendar overlaps with the tourism season (Rayamajhi, 2012).

Table 12 shows that the sensitivity index of Kanchenjunga CA is the highest, followed by Makalu Barun NP, Gaurishankar CA, Sagarmatha NP, Annapurna CA, and Manaslu CA. The high sensitivity indexes of the PAs are mostly due to sloppy terrains, fragile soil, occurrences of hazards in the past, lengths of river potentially impacted by GLOF, and percentage of women involved in agriculture activities. Most of these PAs have an average slope of more than 25 degrees. The higher the slope, the higher the likelihood of landslides and avalanches that ultimately block trekking routes or pose a high risk to mountaineers.

Table 12: Sensitivity Indexes of protected areas

SN	Name of PA	Sensitivity Index	Rank	SN	Name of PA	Sensitivity Index	Rank
1	Annapurna CA	0.817	High	11	Koshi Tappu WR	0.407	Very low
2	Api Nampa CA	0.601	Moderate	12	Langtang NP	0.718	High
3	Banke NP	0.53	Low	13	Makalu Barun NP	0.927	Very high
4	Bardiya NP	0.509	Low	14	Manaslu CA	0.793	High
5	Blacbuck CA	0.436	Very low	15	Parsa NP	0.396	Very low
6	Chitwan NP	0.488	Low	16	Rara NP	0.453	Low
7	Dhorpatan HR	0.667	Moderate	17	Sagarmatha NP	0.83	High
8	Gaurishankar CA	0.843	Very high	18	Shey Phoksundo NP	0.535	Moderate
9	Kanchenjunga CA	1.000	Very high	19	Shivapuri Nagarjun NP	0.527	Low
10	Khaptad NP	0.609	High	20	Shuklaphanta NP	0.378	Very low

Furthermore, these PAs have rivers that can be potentially impacted by GLOFs. Kanchenjunga CA has the longest stretch of such rivers (84.55 km), followed by Makalu Barun NP (73.01 km) and Annapurna CA (24.34).



Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 25: Location of potentially dangerous glacier lakes for GLOF in the Koshi, Gandaki and Karnali basins in Nepal, Tibet, and India

Figure 25 shows the location of potentially dangerous glacier lakes in the Koshi, Gandaki, and Karnali basins. Among the three river basins, the Koshi basin contains the highest number of potentially dangerous glaciers lakes (42), followed by the Gandaki basin (3) and Karnali basin (2) (Bajracharya et al., 2020). Out of the 47 potentially dangerous glacier lakes that discharge to the above-mentioned river basins, 21 are located in Nepal (Table 12). All the PAs with high sensitivity indexes fall under two river basins – Koshi and Gandaki.

Table 13: Potentially Dangerous Glacial Lakes in Nepal

River Basin	Sub-basin	Potentially Dangerous Glacial Lakes
Koshi	Tamor	4
	Arun	4
	Dudh Koshi	9
	Tama Koshi	1
Gandaki/Narayani	Trishuli	1
	Marsyangdi	1
Karnali	Humla	1

Figure 26 further shows that most of the PAs situated in the mountainous area are either very highly, highly or moderately sensitive. As explained earlier, topography and unpredictable climatic conditions could be the key reasons behind the varying degrees of sensitivity. Although Rara NP is located in a mountainous area, its sensitivity is low compared to its neighboring PAs. This is because the terrain of Rara NP is less sloped compared to the other PAs. In line with this, the MoHA data shows that the Rara NP experienced few climate-induced hazards in the past compared to the other PAs (MoHA, 2015).

The sensitivity of PAs is also influenced by changes in glacier and snow cover areas. Analysis of data from 2001 to 2019 shows that Api Nampa CA, Gaurishankar CA, Kanchenjunga CA, Makalu Barun NP, and Sagarmatha NP experienced the highest decrease in snow cover area (slope ranges from -3 to -16). It also shows that snow and glacier melting in the PAs in the mid and eastern parts of Nepal is in an increasing trend.

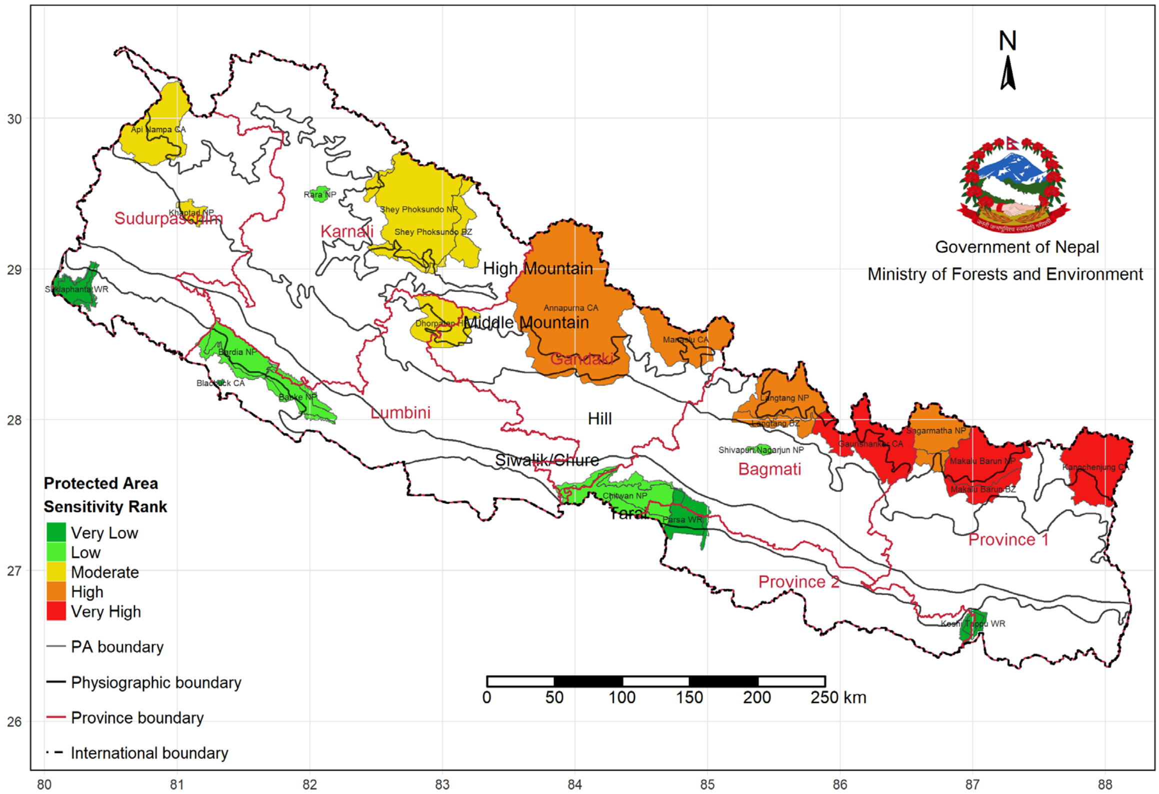


Figure 26: Sensitivity ranking of protected areas

Cultural Heritage

The sensitivity of the cultural heritage sites is measured by assessing indicators such as fragile soil, the slope of the area, and hazard severity. Figure 27 shows that cultural and heritage sites in the hilly and high mountain districts are generally sensitive to climate change. This is because these sites are situated mostly on hills or along riverbanks, which are prone to landslides and soil erosion. On the other hand, most of the sites in the Terai region are relatively less sensitive to climate change, except those in Jhapa, Sunsari, Chitwan, Rupandehi, and Dang as the cultural and heritage sites in these districts are prone to floods.

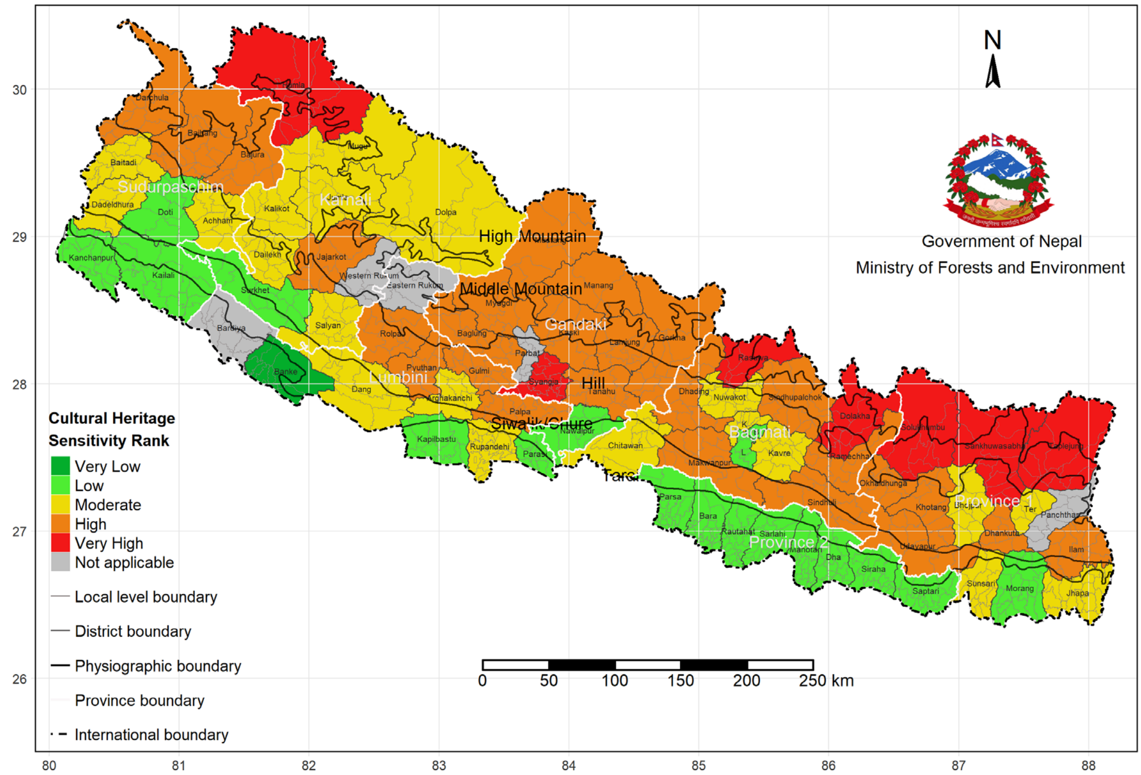


Figure 27: Sensitivity ranking of districts with cultural heritage sites

The sensitivity of many of the Terai districts in terms of cultural sites is either low or very low. This is mainly because of the low risk of soil erosion and landslides in those districts. The most prominent hazard in these districts is flood-related inundation (Table 14).

Table 14: Sensitivity rank of the districts with cultural heritage sites

Sensitivity Rank	District
Very High (0.774 - 1)	Humla, Rasuwa, Dolakha, Sankhuwasabha, Solukhumbu, Syangja, Taplejung, Ilam
High (0.631 - 0.773)	Dhading, Rolpa, Makawanpur, Mugu, Myagdi, Lamjung, Dhankuta, Baglung, Sindhupalchok, Gorkha, Tanahu, Udayapur, Pyuthan, Darchula, Palpa, Sindhuli, Mustang, Manang, Khotang, Okhaldhunga, Bajura, Kaski, Jajarkot, Bajhang, Gulmi, Ramechhap
Moderate (0.441 - 0.630)	Sunsari, Terhathum, Nuwakot, Kavrepalanchok, Dailekh, Dolpa, Achham, Arghakhanchi, Baitadi, Rupandehi, Bhojpur, Salyan, Chitawan, Dang, Kalikot, Jhapa, Jumla, Kathmandu, Dadeldhura
Low (0.082 - 0.440)	Kapilbastu, Rautahat, Lalitpur, Bhaktapur, Kailali, Surkhet, Siraha, Morang, Bara, Doti, Dhanusha, Nawalpur, Kanchanpur, Sarlahi, Mahottari, Parasi, Parsa, Saptari
Very Low (0.079 - 0.081)	Banke

6.2 Adaptive capacity

Adaptive capacity in this study is assessed based on the ability of the TNCH sector to adjust to current or expected climate change and its effects. The indicators of the adaptive capacity of the TNCH sector are related to access to tourist destinations, access to quality services, and adoption of precautionary measures.

Protected Areas

The adaptive capacity of the PAs was assessed using indicators such as length of blacktop strategic road, density of trekking trails, access to airports, number of airlines operating in the airports, GLOF prevention activities in place, revenue collected by the PAs, diversity of key fauna, early warning coverage, availability of district-level disaster preparedness plans, availability of places for food and accommodation, availability of financial institutions in the districts, sanitation coverage, and availability of health facility the district.

Table 15 shows that the adaptive capacity index of Bardiya NP is the highest, followed by Chitwan NP, Shivapuri Nagarjun NP, Banke NP, and Annapurna CA. The high adaptive capacity of these PAs is due to their revenue regeneration capacity, access to airports, number of airlines operating in the airports, availability of places for food and accommodation, availability of financial institutions, and availability of health facilities.

Table 15: Adaptive Capacity Index of protected areas

	Name of PA	Adaptive Capacity Index	Rank		Name of PA	Adaptive Capacity Index	Rank
1	Annapurna CA	0.730	High	11	Koshi Tappu WR	0.701	Moderate
2	Api Nampa CA	0.332	Very low	12	Langtang NP	0.470	Low
3	Banke NP	0.786	High	13	Makalu Barun NP	0.476	Low
4	Bardiya NP	1.000	Very high	14	Manaslu CA	0.447	Low
5	Blackbuck CA	0.649	High	15	Parsa NP	0.757	High
6	Chitwan NP	0.946	Very high	16	Rara NP	0.530	Low
7	Dhorpatan HR	0.407	Very Low	17	Sagarmatha NP	0.694	Moderate
8	Gaurishankar CA	0.539	Moderate	18	Shey Phoksundo NP	0.418	Very Low
9	Kangchenjunga CA	0.410	Very Low	19	Shivapuri Nagarjun NP	0.816	Very High
10	Khaptad NP	0.432	Very Low	20	Shuklaphanta NP	0.698	Moderate

For instance, Banke and Chitwan NPs are situated in plain areas of Nepal. They both have good access to strategic roads and have a good number of hotels and restaurants, financial institutions, and health service facilities in the districts. Additionally, Chitwan NP collected revenue of NPR 296 million in 2018 (DNPWC, 2019). Although revenue collection of Shivapuri Nagarjun NP is low (NPR 3.3 million), its adaptive capacity index is very high because of its access to an international airport where 41 different airlines provide services (CAAN, 2020). Further, the number of places for accommodation, financial institutions, and health service facilities are in greater number near the Shivapur NP.

Although Sagarmatha NP and Annapurna CA do have good revenue collection-- NPR 161 million and 140 million respectively in 2018 (DNPWC, 2019)—their adaptive capacity is relatively low compared to Chitwan NP because both of them are located remotely and have limited access to strategic roads, a smaller number of places for food and accommodation and limited health facilities and services.

Figure 28 shows that most of the PAs in the mountain have a low adaptive capacity. This is mainly because of poor accessibility, fewer basic services such as hotels and restaurants, financial institutions and health services, and low revenue.

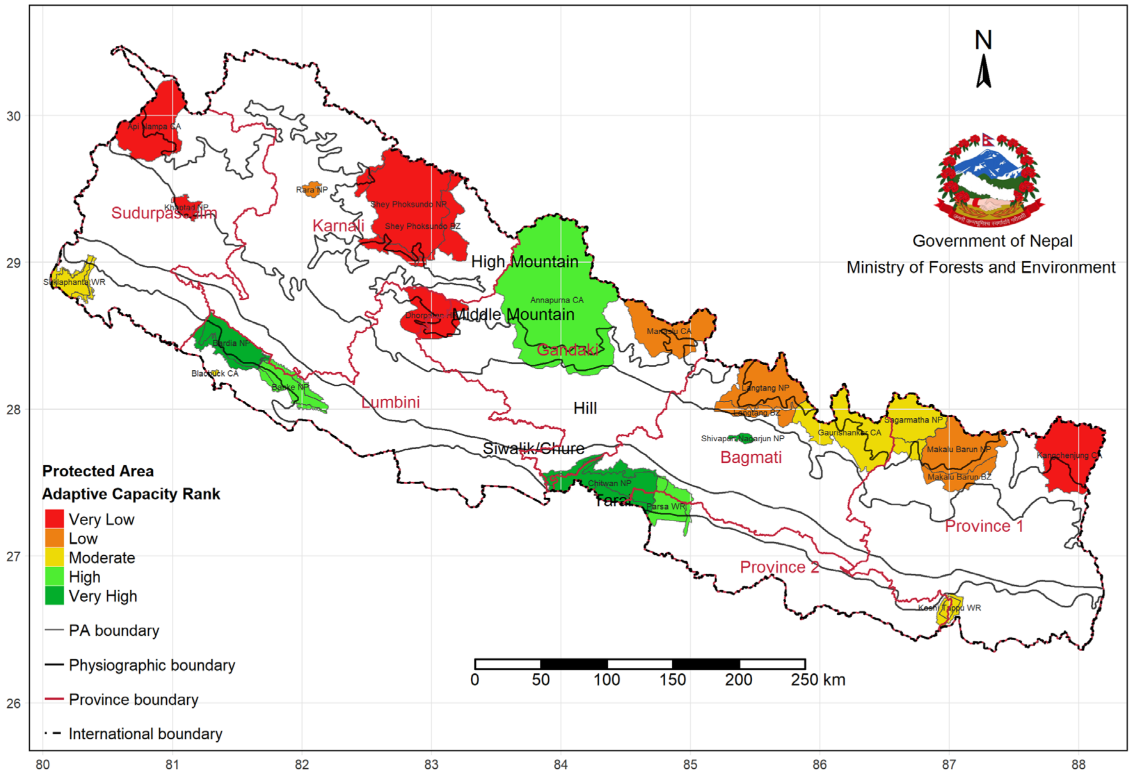


Figure 28: Adaptive capacity ranking of protected areas

Cultural Heritage

The adaptive capacity of cultural heritage sites was assessed by using indicators such as early warning coverage of the sites, and health service facilities in the districts. Figure 29 and Table 16 show that most of the mountainous districts of western regions have comparatively less adaptive capacity. This is mainly because of less early warning coverage and a smaller number of health service facilities available in those districts. Few of the Terai districts, such as Morang, Sarlahi, Parsa, and Banke, also have low adaptive capacity despite the good number of health facilities there. This is because the early warning system does not cover the cultural and heritage sites in those districts.

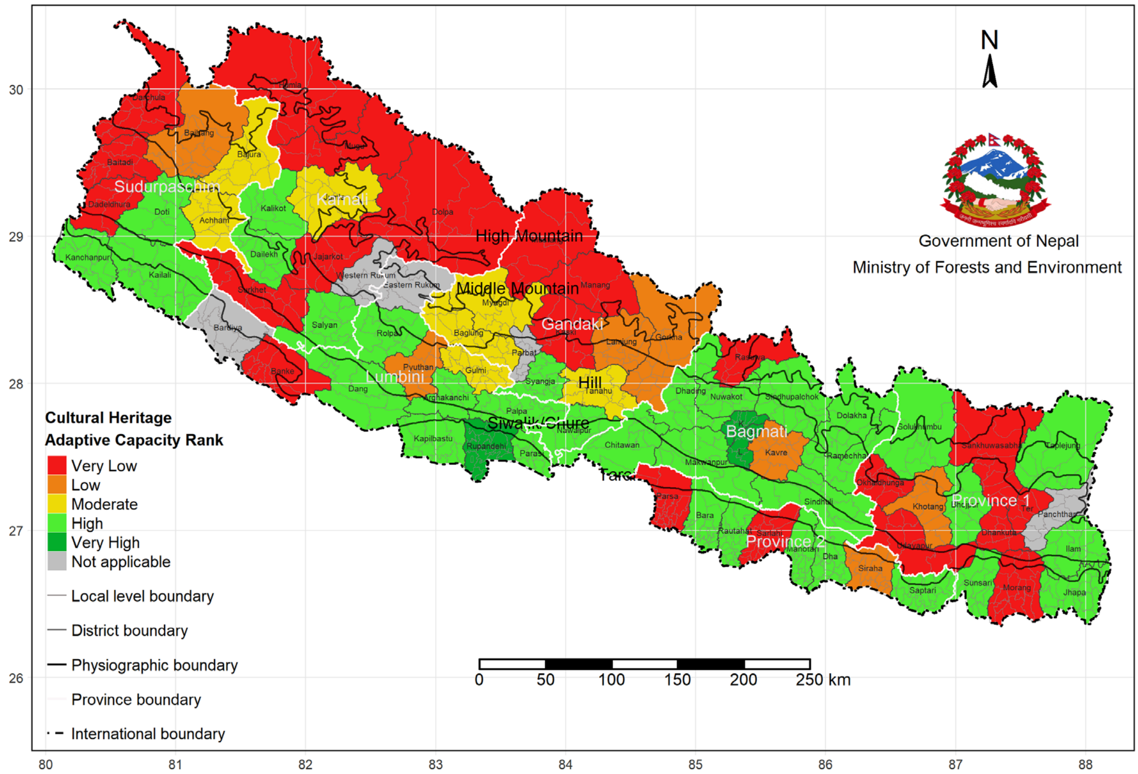


Figure 29: Adaptive capacity ranking of districts cultural heritage sites

Table 16: Adaptive capacity ranking of the districts with cultural heritage sites

Adaptive capacity rank	District
Very High (0.603 - 1)	Lalitpur, Bhaktapur, Kathmandu, Rupandehi
High (0.462 - 0.602)	Dhading, Rolpa, Makawanpur, Kapilbastu, Sunsari, Dolakha, Nuwakot, Rautahat, Sindhupalchok, Solukhumbu, Dailekh, Syangja, Kailali, Arghakhanchi, Palpa, Bhojpur, Sindhuli, Salyan, Bara, Doti, Chitawan, Dhanusha, Dang, Nawalpur, Kalikot, Kanchanpur, Taplejung, Jhapa, Mahottari, Parasi, Ramechhap, Saptari, Ilam
Moderate (0.289 - 0.461)	Myagdi, Baglung, Tanahu, Achham, Bajura, Jumla, Gulmi
Low (0.107 - 0.288)	Lamjung, Gorkha, Kavrepalanchok, Pyuthan, Siraha, Khotang, Bajhang
Very Low (0 - 0.106)	Humla, Mugu, Rasuwa, Dhankuta, Terhathum, Sankhuwasabha, Udayapur, Darchula, Banke, Dolpa, Surkhet, Baitadi, Morang, Mustang, Manang, Okhaldhunga, Kaski, Jajarkot, Sarlahi, Parsa, Dadeldhura

6.3 Vulnerability in the TNCH sector

Vulnerability in the TNCH sector looks at the sensitivity of the exposed population, their access to resources, and services, and their capacity to respond to climate change impact. It is determined by the characteristics and features of PAs and cultural heritage, characteristics of the population dependent on the tourism sector, locations and conditions of the tourism infrastructure including cultural heritage sites, and access to and quality of services.

Protected Areas

An increase in sensitivity of any exposed element increases vulnerability whereas the relationship between adaptive capacity and vulnerability is vice versa. Table 17 shows that Kanchenjunga CA is the most vulnerable, followed by Makalu Barun NP, Manaslu CA, and Gaurishankar CA. The sensitivity of all these PAs is either very high or high whereas their adaptive capacity is very low or low. These PAs are characterized by remoteness with limited basic services and low revenue collection as well. Connectivity to these PAs is poor, with no good roads and airports, and they lack a sufficient number of facilities for food, accommodation, and health services. Further, poor tourism infrastructure is responsible for the fewer numbers of tourists visiting the areas.

Table 17: Vulnerability of protected areas

SN	Name of PA	Vulnerability Index	Vulnerability Rank	SN	Name of PA	Vulnerability Index	Vulnerability Rank
1	Annapurna CA	0.548	Moderate	11	Koshi Tappu WR	0.161	Low
2	Api Nampa CA	0.665	High	12	Langtang NP	0.667	High
3	Banke NP	0.213	Low	13	Makalu Barun NP	0.873	Very High
4	Bardia NP	0.013	Very low	14	Manaslu CA	0.762	Very High
5	Blackbuck CA	0.234	Low	15	Parsa NP	0.103	Very low
6	Chitwan NP	0.037	Very low	16	Rara NP	0.351	Moderate
7	Dhorpatan HR	0.668	High	17	Sagarmatha NP	0.593	High
8	Gaurishankar CA	0.735	High	18	Shey Phoksundo NP	0.527	Moderate
9	Kangchenjunga CA	1.000	Very high	19	Shivapuri Nagarjun NP	0.185	Low
10	Khaptad NP	0.590	Moderate	20	Shuklaphanta NP	0.134	Low

Figure 30 further shows that all the PAs in the southern plain area and close to Kathmandu have very low vulnerability, mostly because of their accessibility, and availability of basic tourism services in and around the PAs. These PAs also have good road and air connectivity. Furthermore, the existence of a good number of hotels and restaurants, and medical facilities make them less vulnerable. In contrast, most of the PAs in the high mountain area are vulnerable to climate change mainly because of their remoteness and difficulty for the tourists and tourism-dependent people in accessing basic services in case of emergency.

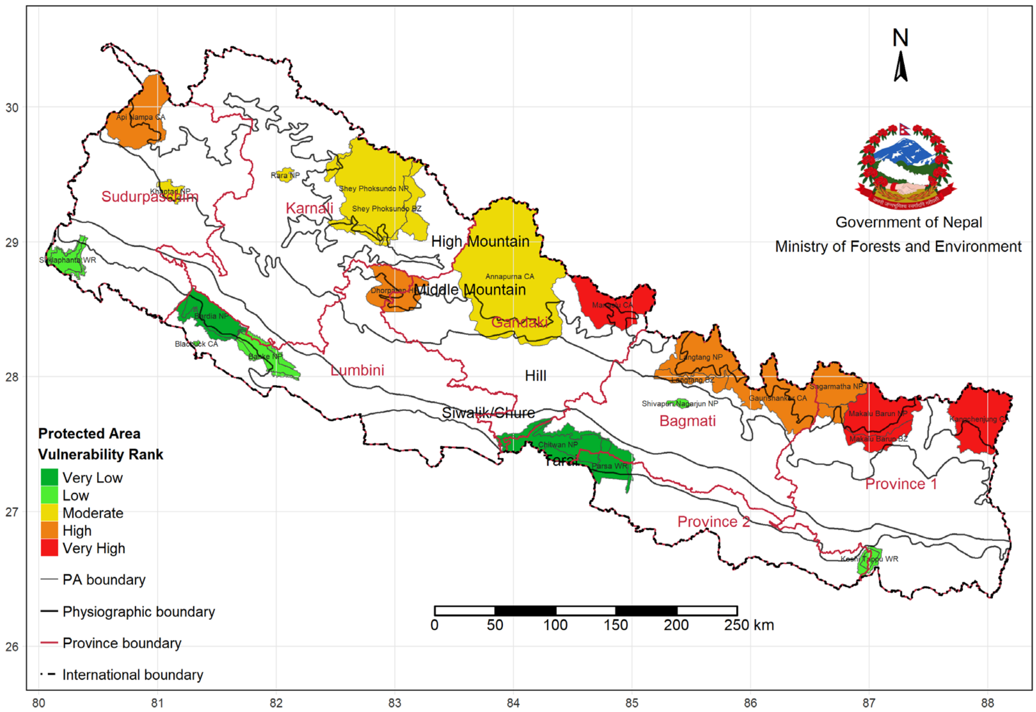


Figure 30: Vulnerability ranking of projected areas

Although Annapurna CA is a mountainous PA, its vulnerability is relatively low compared to the other mountainous PAs. This is mainly because of their high adaptive capacity. Annapurna CA is among the most revenue-generating PAs in the country. The revenue generation is directly related to the number of tourists visiting there, which has a direct impact on the livelihoods of tourism-dependent people, as business flourishes and local people get a market for selling local products. Furthermore, this PA has good air and road connectivity. The good trekking route networks also make them comparatively less vulnerable as the tourists can follow alternative trekking routes in case of disaster or emergency. Similarly, Shey Phoksundo NP, being a mountainous PA, has relatively low vulnerability as that of Annapurna CA. This is due to its low sensitivity.

Cultural Heritage

Figure 31 shows that cultural heritage sites in most of the mountainous districts, with few exceptions in Province 1 and Bagmati Province, are either very highly or highly vulnerable. This is mainly because these sites are situated on steep terrain with a high likelihood of and impact from soil erosion, including landslides. Besides, these districts generally do not have good medical facilities and services for the pilgrims visiting the sites.

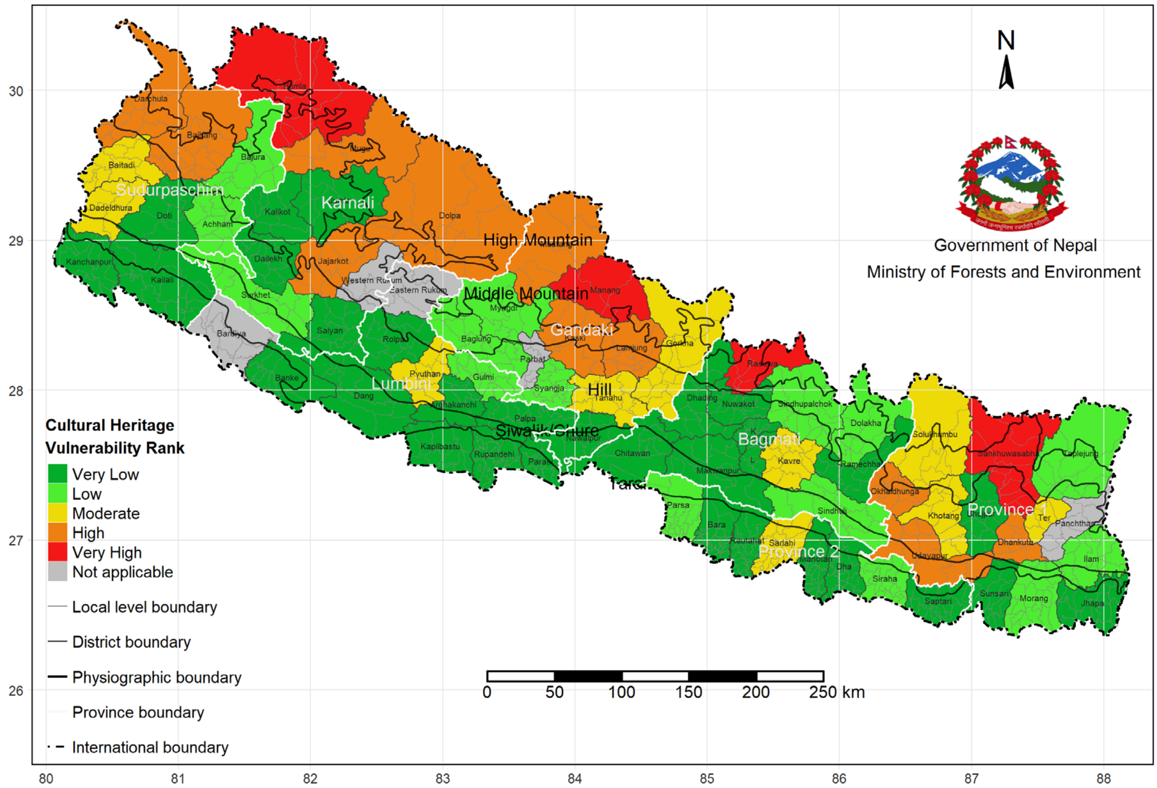


Figure 31: Vulnerability ranking of districts with cultural heritage sites

Table 18: Vulnerability ranking of districts with cultural heritage sites

Vulnerability Rank	District
Very High (0.784 - 1)	Humla, Rasuwa, Sankhuwasabha, Manang
High (0.565 - 0.783)	Mugu, Lamjung, Dhankuta, Udayapur, Darchula, Dolpa, Mustang, Okhaldhunga, Kaski, Jajarkot, Bajhang
Moderate (0.340 - 0.564)	Terhathum, Gorkha, Solukhumbu, Tanahu, Kavrepalanchok, Pyuthan, Baitadi, Khotang, Sarlahi, Dadeldhura
Low (0.131 - 0.339)	Myagdi, Dolakha, Baglung, Sindhupalchok, Syangja, Surkhet, Achham, Siraha, Sindhuli, Morang, Bajura, Taplejung, Parsa, Gulmi, Ilam
Very Low (0 - 0.130)	Dhading, Rolpa, Makawanpur, Kapilbastu, Sunsari, Nuwakot, Rautahat, Lalitpur, Dailekh, Bhaktapur, Banke, Kailali, Arghakhanchi, Rupandehi, Palpa, Bhojpur, Salyan, Bara, Doti, Chitawan, Dhanusha, Dang, Nawalpur, Kalikot, Kanchanpur, Jhapa, Jumla, Mahottari, Parasi, Ramechhap, Kathmandu, Saptari

Despite being mountainous districts, the cultural heritage sites in Taplejung, Dolakha, and Sindhupalchok districts have low vulnerability because they have good coverage of early warning systems.

Chapter 7

Projected Climate Change Risks and Adaptation Options in the TNCH sector

7.1 Future climate change risks in the TNCH sector

This section describes the climate change risks in the TNCH sector, where risk is considered a combined effect of hazard, exposure, and vulnerability of the sector. The numbers of exposure elements, hazard events, and vulnerability of the elements determine the risk of the tourism areas, i.e., protected areas and districts with cultural heritage sites.

This assessment presents the current (baseline) and future scenarios of climate risks of the TNCH sector. The current risk level was assessed in five levels: very low (0.006-0.129), low (0.130-0.253), moderate (0.254-0.382), high (0.383-0.583), and very high (0.584-0.844). The future scenarios of climate risks were assessed under RCP 4.5 (intermediate scenario) and RCP 8.5 (worst-case scenario) for two time periods i.e., 2030 and 2050, in comparison with the baseline

Protected Area

The baseline climate risk rank of PAs shows that Sagarmatha NP and Makalu Barun NP are ranked with the highest risk as they are characterized by very high to high vulnerability levels and very low to low adaptive capacity levels, and high exposure levels (Figure 32). Additionally, all the other PAs in the high mountainous regions of Province 1 and Bagmati Province are ranked as having high risk. This is because of their very high to high exposure levels, very high to high vulnerability levels, and high extreme climate index. The temperature increase, glacier melting, and the formation of glacier lakes in Province 1 and Bagmati Province made the PAs in these provinces at high risk. The PAs of Terai regions are ranked with low to very low risk at baseline, mainly because of their better adaptive capacity.

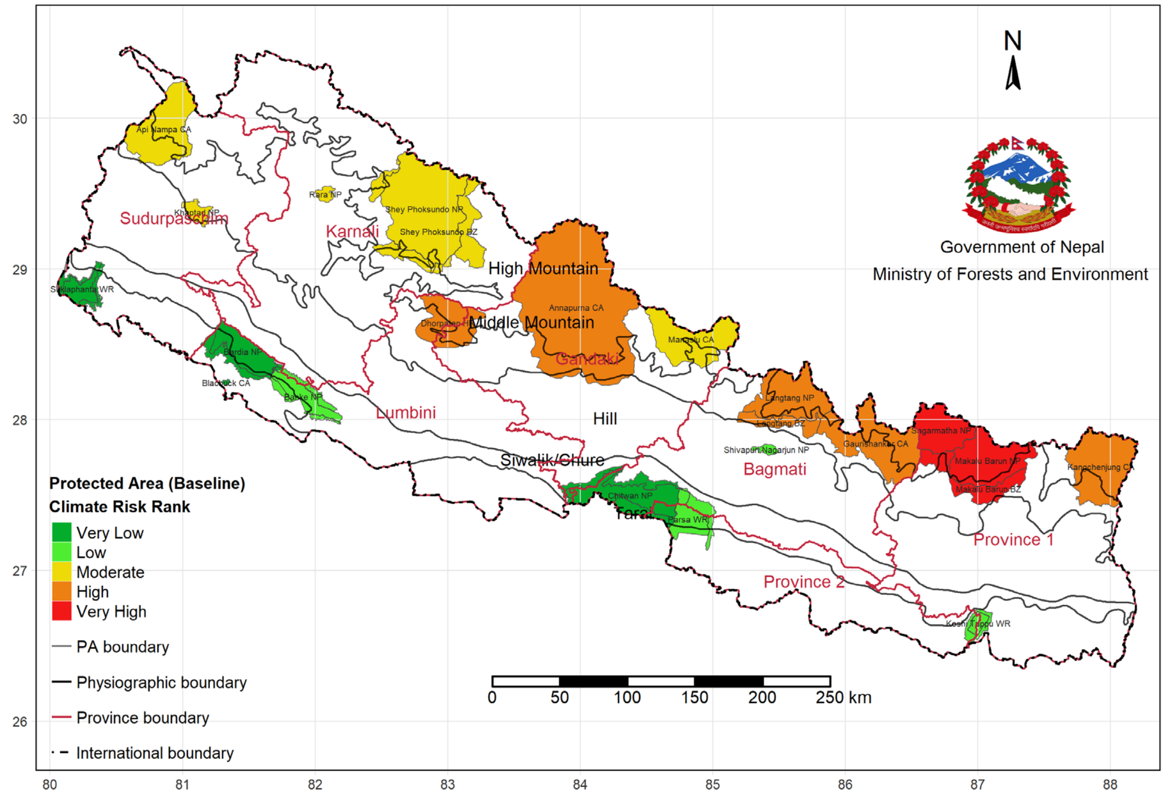
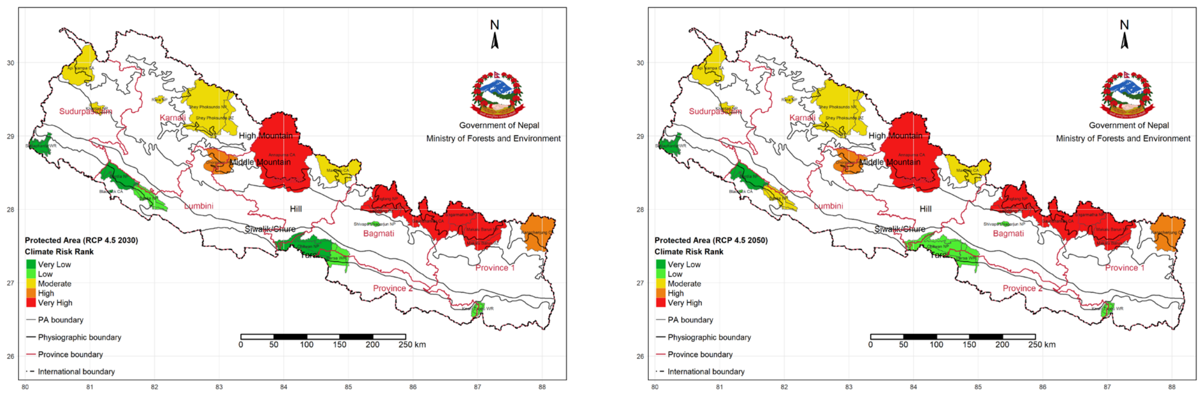


Figure 32: Climate change risk of protected areas (baseline)

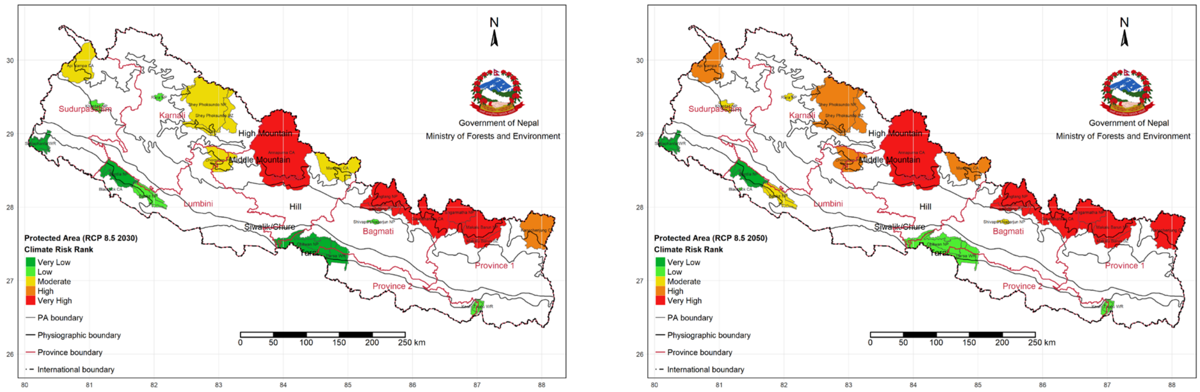
Despite the very high element of exposure and moderate level vulnerability, Annapurna CA ranked as moderately at risk because of its very high adaptive capacity and moderate extreme events index. The PAs in the remaining provinces are at either very low, low or moderate risk either due to their high adaptive capacity (e.g., Banke NP, and Bardiya NP) or low exposure level with relatively low extreme climate event index.



(a) (b)

Figure 33: Climate risk on protected areas in RCP 4.5 (2030) (a) and RCP 4.5 (2050) (b) scenario

Regarding future risk scenarios, the findings reveal that risk scenarios will increase under both RCPs 4.5 and 8.5 in the future (Figures 33 and 34). The PAs at moderate risk at baselines—such as Annapurna CA, Sagarmatha NP, and Gaurishankar CA—are likely to be at very high risk under both RCP 4.5 (2030) and RCP 4.5 (2050), meaning that risk from climate change in these areas is expected to increase in the future. However, there is no substantial change in the risk ranks of PAs like Shey Phoksundo NP, Rara NP, and Kanchenjunga CA under RCP 4.5 (2030) and RCP 4.5 (2050) scenarios compared to the baseline. The climate risk ranks for the rest of the PAs such as Api Nampa NP, Khaptad NP, Shuklaphanta NP, Bardiya NP, and Dhorpatan HR, are likely to be the same in the future as they are at baseline.



(a) (b)

Figure 34: Climate risk of protected areas in RCP 8.5 (2030) (a) and RCP 8.5 (2050) (b) scenarios

The findings further reveal that the future scenarios under RCP 8.5 (2030) are almost similar to RCP 4.5 (2030), except in Kanchenjunga CA, Chitwan NP, and Parsha NP, which are likely to be at high risk under RCP 8.5 (2030), compared to RCP 4.5 (2030). However, the future scenario under RCP 8.5 (2050) is alarming. Almost all PAs in mountain areas are likely to be at a very high to high risk from climate change impacts. In contrast, the Rara NP, Khaptad NP, and Shivapuri Nagarjun NP are likely to be at moderate risk.

Cultural Heritage

The analysis of baseline risk of cultural heritage sites shows that mainly Pyuthan, Gorkha, and Mustang are in the highest risk rank (Figure 35). The sites in these districts are characterized by moderate to very high vulnerability and exposure levels and moderate to very low adaptive capacity levels. For instance, the sites in Mustang districts have very high exposure and high vulnerability, which makes the sites in the district at very high risk. Despite the very low vulnerability of the cultural heritage sites in the Kapilbastu and Rupandehi districts, they are in high and moderate risk ranks respectively because of the very high level of exposure of such sites. In the case of the Gulmi and Myagdi districts, moderate to high levels of exposure and relatively high levels of climate extreme events put them at high risk despite their low levels of vulnerability. The cultural heritage sites in Sankhuwasabha and Humla districts, which are highly vulnerable, are in very low and low-risk ranks. The underlining reason for this could be the very low exposure level in Sankhuwasabha and the very low level of climate extreme events in Humla.

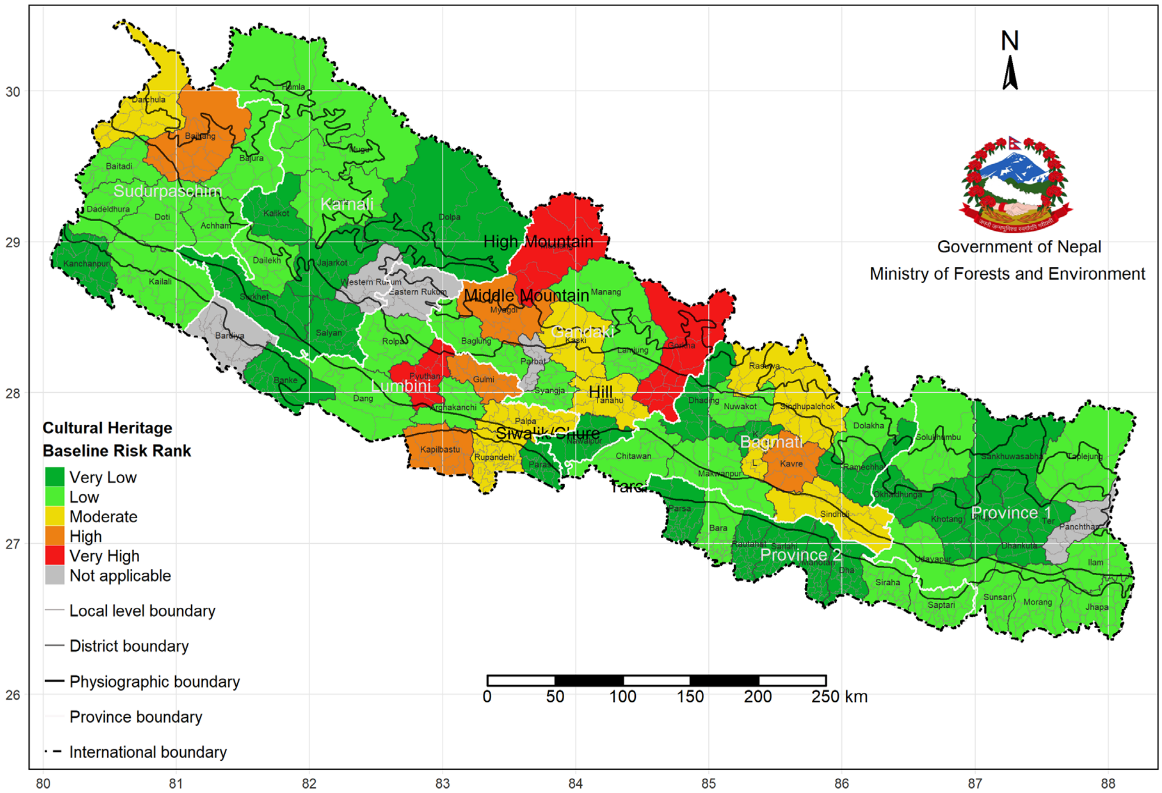


Figure 35: Climate change risk of cultural heritage sites (baseline)

Regarding the future scenario, there is a mixed result under RCP 4.5 (2030 and 2050), compared to the baseline. The cultural heritage sites in the Bajura, which are at high risk in the baseline are likely to be at very high risk under RCP 4.5 (2030) and RCP 4.5 (2050) (Figure 36). Likewise, the sites in Kavrepalanchok, Kapilbastu, and Gulmi districts that are at high risk in the baseline and under RCP 4.5 (2030) are likely to be in the very high risk rank under RCP 4.5 (2050). Additionally, the sites in the Rasuwa district that are at moderate risk in the baseline are likely to be at high risk under both RCP 4.5 (2030) and RCP (2050) scenarios. The sites in Bhaktapur districts that are at moderate risk in the baseline are likely to be at high risk under RCP 4.5 (2030) and RCP 4.5 (2050).

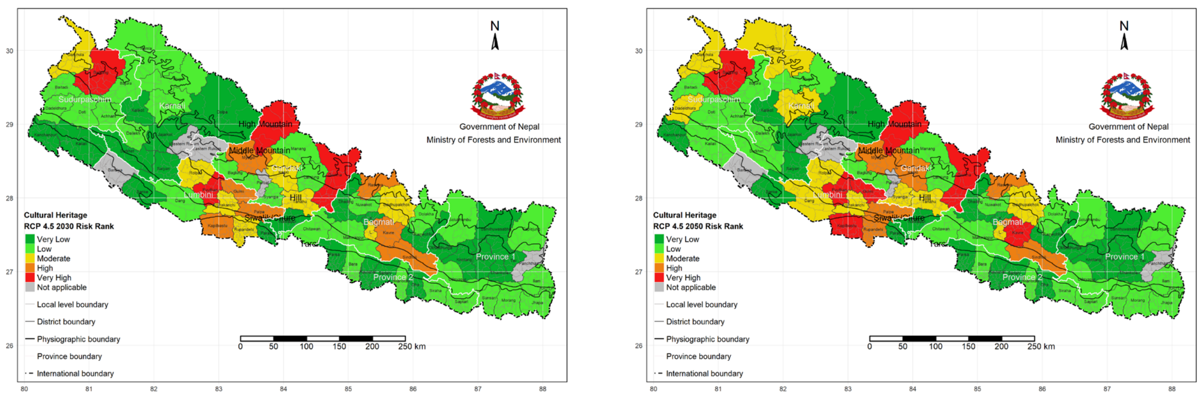


Figure 36: Climate risk of cultural heritage sites in RCP 4.5 (2030 and 2050) scenarios

The findings further reveal that the RCP 8.5 (2030) scenario is quite similar to the RCP 4.5 (2030) scenario, with very slight changes in the risk categories of districts. However, Gulmi and Kapilbastu districts, which are at high risk at both baseline and under RCP 4.5 (2030), are likely to be at very high risk under RCP 8.5 (2050) (Figure 37). Similarly, Dadeldhura, Jumla, and Dailekh, which are at low risk in the baseline and under RCP 4.5 (2030) and RCP 8.5 (2030), are likely to be at moderate risk under RCP 4.5 (2050) and RCP 8.5 (2050). Table 19 further shows that there is a likelihood of the number of districts in very high risk rank increasing under different RCP scenarios, compared to the baseline.

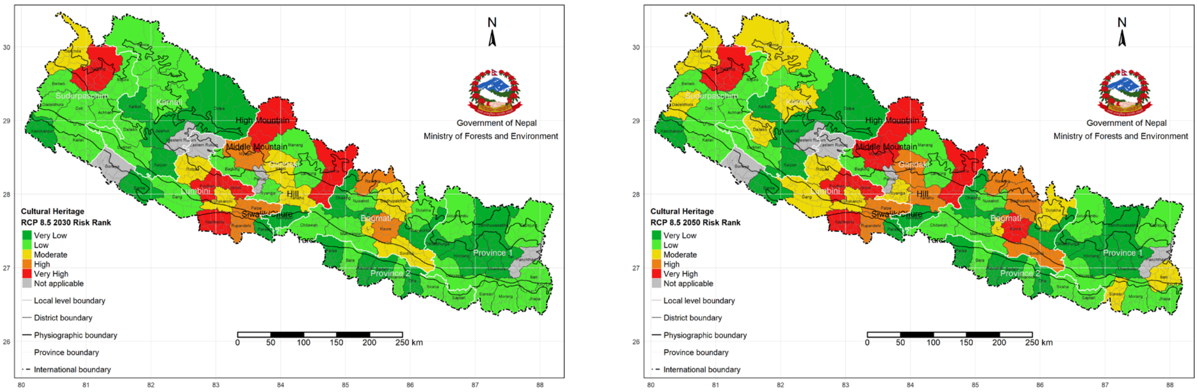


Figure 37: Climate change risk of cultural heritage sites in RCP 8.5 (2030 and 2050) Scenarios

Table 19: Number of districts in different risk ranks in different climate change scenarios

Risk Rank	Baseline	RCP 4.5 (2030)	RCP 4.5 (2050)	RCP 8.5 (2030)	RCP 8.5 (2050)
Very High (More than 0.358)	3	4	7	6	8
High (0.241 – 0.358)	5	8	7	6	8
Moderate (0.136 – 0.240)	10	8	11	8	13
Low (0.040 – 0.135)	31	29	26	31	22
Very Low (Less than 0.040)	23	23	21	21	21
Total	72	72	72	72	72

Physiography-wise climate risk of cultural heritage sites

Figure 38 shows that the cultural heritage sites in the high mountain region are in the very high risk rank, followed by the hills, middle mountain, Siwalik, and Terai regions. The very high risk in the high mountain region is because of its sloppy terrain combined with highly fragile soil.

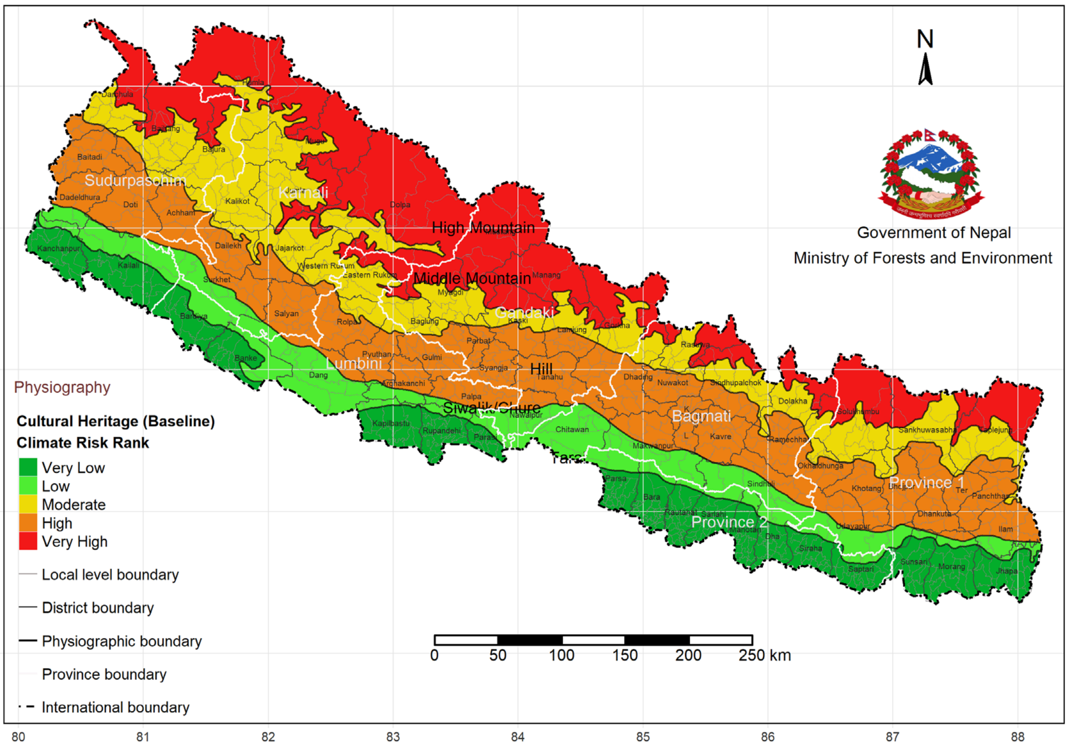
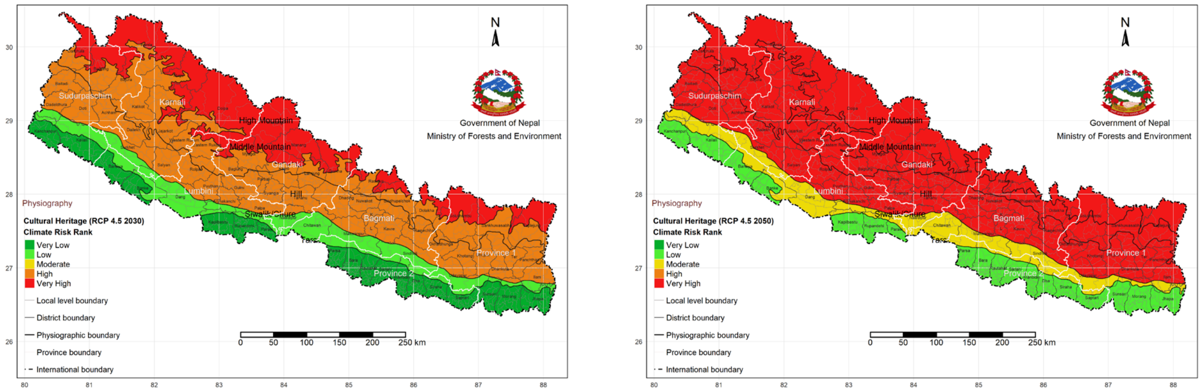


Figure 38: Physiography wise cultural heritage climate risk rank (baseline)

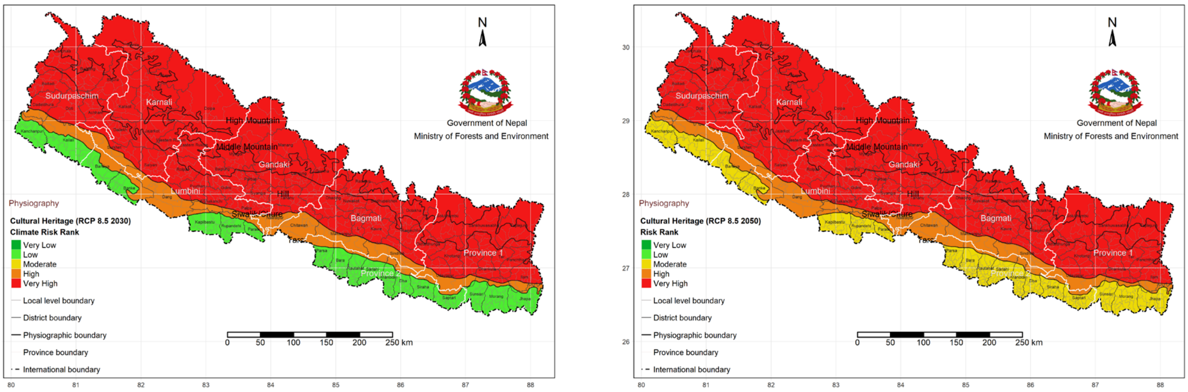
The risk in the hills region is higher than in the middle mountain region mainly because of the higher number of such sites in the mid-hills region.



(a) (b)

Figure 39: Physiography wise climate risk scenario of cultural heritage sites in RCP 4.5 (2030 and 2050)

The future scenario analysis shows that the sites in the middle mountain regions that are at moderate risk in the baseline are likely to be at high risk under RCP 4.5 (2030) (Figure 39a). Furthermore, all the sites in the hills, middle mountain, and high mountain regions are likely to be at very high risk under the RCP 4.5 (2050) scenario. The cultural sites in the Siwalik and Terai regions that are at low and very low-risk ranks respectively in the baseline and under RCP 4.5 (2030) are likely to be in moderate and low risk ranks respectively under RCP 4.5 (2050) (Figure 39b).



(a) (b)

Figure 40: Physiography wise climate risk scenario of cultural heritage sites in RCP 8.5 (2030) (a) and RCP 8.5 (2050) (b)

Furthermore, the cultural heritage sites in the middle mountain and hill regions that are in moderate and high risk ranks in the baseline are likely to be in very high risk rank under the RCP 8.5 (2030) scenario (Figure 40a). Similarly, the sites in Siwalik and Terai which are in low and very low risk ranks in the baseline are likely to be in high and low risk ranks respectively under the RCP 8.5 (2030) scenario. The likely scenario of RCP 8.5 (2050) looks to be the worst for the cultural heritage sites in all physiological regions (Figure 40b). Only the sites in the Terai and Siwalik regions are likely to be in moderate and high risk ranks, while the sites in all the other regions are likely to be in the very high risk category.

7.2 Opportunities of adaptation in the sector

Adaptation is the process of adjustment to actual or expected climate and its effects. Adaptation involves reducing risk and vulnerability; seeking opportunities; and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions. Adaptation encompasses adjustments in ecological, social, or economic systems in response to actual or expected climate stimuli and their effects or impacts (Smith & Pilifosova, 2002). Likewise, the IPCC has defined adaptive capacity as the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to the consequences of climate change (IPCC, 2014a).

As the TNCH sector is climate-sensitive, necessary arrangements should be planned and delivered to protect and recover from hazards. Tourism entrepreneurs should be alerted to the climate change situation so that that they can provide alternative options for destinations and activities to tourists who have already prepared to travel. As climate change is unavoidable and striking everywhere regardless of the political and ecological boundaries, anticipatory and precautionary adaptation is more effective and less costly than its alternative (Burton, 1996). Furthermore, immediate benefits may be gained from the better adaptation: for example, increased investments in climate-neutral technologies can boost local economies. Additionally, immediate benefits can also be gained by overcoming maladaptive policies and practices.
Adaptation options need to be sector-, locality- and hazard-specific. For example, an adaptation

option is needed to address issues such as glacier melting and GLOFs which are a major threat to the mountain region of Province 1 in particular. Similarly, there should be measures to address the landslide and flood issues that impact tourist mobility. Another important aspect is to have adaptation measures that will address issues of extreme weather events that disrupt transportation and aviation.

Concrete examples of adaptation strategies in the TNCH sector in Nepal and Asia are hard to find since research in this area has been done at the minimum level (Bhandari, 2014). To overcome this knowledge gap, this study identified adaptation options by reviewing national and international policies, strategies, and action plans related to climate change and the TNCH sector. In addition, the identified adaptation options were further explored and validated during provincial and local level consultations. These adaptation options are presented in Table 20 below.

Table 20: Adaptation options for the TNCH sector

Key Risks and Vulnerabilities in the Sector	Adaptation Options	Short term (5 years)	Medium-term (10 years)	Long term (30 years)
Increased risk of climate extreme events and climate-induced disasters impacting the PAs, people, entrepreneurs, and tourists involved in the nature-based tourism sector Increased risk of extreme climate and weather conditions disrupting the transportation and communication systems, decreasing tourism flow and business Increased risk and threat due to increased temperature, leading to the destruction of natural habitats of key faunal and floral species, which are part of tourist attraction.	Natural Heritage			
	Conduct periodic inventory of flagship species, assess their vulnerability and assess threats including those to tourist attractions in all PAs			
	Manage wildlife habitat; control invasive species with the participation of local communities (promote economic use of invasive species as bioenergy or compost)			
	Develop and implement a system for solid waste management in a public-private partnership model targeting the tourism destinations			
	Promote green trails and nature-based tourism mostly focused on local resources, local products, and a more sustainable way of hospitality management			
	Translocate flagship wild species to minimize the risk of disaster; manage habitats at a translocated place			
	Certify ecosystem services, including tourism, through internationally recognized standards (e.g., FSC standards)			
	Develop carbon-neutral destinations, including alternative tourist destinations, to attract tourists and contribute to climate mitigation			
	Restrict direct sewage disposal in rivers and lakes, and arrange alternative disposal areas while considering options for waste recycling			
	Implement conservation financing in key tourism destinations to protect natural and cultural heritage from climate change impacts in coordination with the private sector			
	Construct fire lines in forest areas for reducing forest fires, which will ultimately preserve the aesthetic value of nature and save the flora and fauna that attract tourists			
Increased risk of temperature increase and precipitation variability, leading to more climate extreme events and climate-induced disasters impacting the cultural heritage sites	Cultural Heritage			
	Maintain a database of all cultural heritage sites in Nepal and their renovation status			
	Promote local and indigenous culture, food, and products (e.g., handicrafts) to directly benefit local communities			
	Conserve the most vulnerable and at-risk cultural heritage sites through community/indigenous people participation			
	Reinforce/retrofit physical structures in the cultural heritage sites			
	Conduct regular maintenance of cultural heritage sites, and develop mechanisms to allocate resources for repair and maintenance			
	Develop climate and environment-friendly guidelines and standards for the protection of cultural heritage sites.			
	Implement disaster risk reduction measures to protect cultural heritage sites from hazards			

Table 21: Cross-cutting adaptation options for the sector

Adaptation Options	Short term (5 years)	Medium-term (10 years)	Long term (30 years)
Policy and program			
Integrate climate change issues/adaptation options into policies, acts, regulations, and plans of the TNCH sector			
Incentivize green tourism investments for the private sector			
Promote domestic tourism, particularly during the lean period (when there are fewer international tourists) through special recreation incentives for government and corporate employees			
Encourage, through policy enforcement, the tourism sector actors to insure the infrastructure			
Review rescue mechanisms, particularly in mountainous regions, and develop context-specific rescue measures/mechanisms			
Identify, design, and implement flood, landslide, and other hazard management schemes for tourist destinations, where appropriate			
Assess the current promotional strategies, considering the emerging scenarios of climate change, and adjust them accordingly			
Develop a strategy to engage the private sector with climate change adaptation and building community resilience through corporate social responsibility investments			
Review existing insurance mechanisms to cover all the actors involved in the tourism value chain			
Promote gender responsiveness in the tourism industry (e.g., through addressing sexual objectification/harassment, bringing more women into formal employment/skilled labour, equal pay)			
Encourage and/or develop incentive mechanisms for community-based, climate-friendly, and nature-based tourism, e.g., by providing soft loans for alternative energy technologies			
Increase access to financial services/cooperatives, credit facilities, insurance, and loans for women and marginalized groups in the tourism sector, and increase access to employment and market opportunities created from green economy/eco-culture			
Develop and implement rescue protocols of international standards that support establishing and operating rescue mechanisms efficiently and effectively			
Develop integrated tourism activities and products for generating employment in the rural areas			
Enhance inclusiveness of women and other deprived communities for trickling down of the benefits from the tourism industry			
Promote climate insurance schemes to buffer against impacts and secure private sector investment, including homestay operators, to protect against agriculture losses during extreme events (insurance premium can be surcharged by dividing to all tourists visiting in a year)			
Identify and improve alternative trekking trails so that tourists can use them in case of emergency			
Demarcate buffer zone areas for potential damage by GLOFs/floods/landslides and put a restriction on the construction of infrastructure			
Infrastructure and Technology			
Enforce mandatory provision for the construction of climate-resilient roads, e.g., engineer-designed roads			
Enforce implementation of building codes while constructing tourism infrastructures, such as hotels, homestays, basecamps, and campsites			

Adaptation Options	Short term (5 years)	Medium-term (10 years)	Long term (30 years)
Build accommodation facilities with insulation to avoid the detrimental effects of temperature extremes			
Promote the use of renewable energy and energy-efficient technologies in tourism destinations			
Enforce GPS tracking system, particularly on mountaineers and trekkers so that they can be tracked in case of emergency			
Establish real-time early warning information dissemination mechanism through a smartphone for tourists, in coordination with DHM, MoCTCA, TAAN, NMA, etc.			
Promote water-saving measures in hotels, restaurants, camping sites			
Promote climate-smart technologies, such as solar water lifting pumps, that decrease drudgery for women			
Establish a reliable weather information system targeting major tourism destinations, particularly for mountaineering and trekking			
Increase private sector's investment in the development of climate-resilient tourism infrastructures in public (the private partnership model)			
Establish research stations in all the major tourist destinations to understand how climate change is happening and impacting the sector			
Increase hydrological and metrological stations, particularly in the mountainous region, to monitor changes in glaciers and patterns of a snowstorm, for example			
Relocate existing tourism facilities to low-risk areas; e.g., relocation of hotels and homestays from landslide-prone areas to safer areas			
Implement measures (e.g., water draining) to reduce the risk of GLOF in the potentially dangerous glacier lakes			
Capacity Development			
Conduct education and awareness programs on the impact of climate change and possible adaptation options, targeting tourism value chain actors			
Allocate adequate, dedicated, trained, and equipped human resources for rescue at strategic points of the tourism destinations			
Establish a cross-border information-sharing mechanism between Nepal and China for monitoring of the glacier lakes			
Establish emergency communication channels (hotlines) for tourists and operators to deal with emergencies during major disasters			
Identify and diversify complementary/alternative employment and income sources for marginalized groups, youth (both male and female), and women through skill development training (bakery, local cuisine, homestay, nature guide, handicrafts, and cooking)			
Provide training to the frontline human resources on extreme crisis management			
Research and Data management			
Carry out research for controlling or managing invasive plant species that threaten the habitat of the wildlife that tourists find attractive			
Maintain a database of tourism-dependent populations in key destinations and implement actions that build their adaptive capacity			
Encourage research and knowledge curation on climate change impacts on tourism, and natural and cultural heritages			
Carry out a detailed assessment of the impact of climate change on archaeological sites, monuments, and cultures and practices			
Develop adjustable tour/trekking packages according to weather condition or forecast			
Maintain destination wise disaggregated data of tourists to understand the impact of climate change on tourists' arrival; in the long run, develop climate-smart tourism plans at the destinations			

Chapter 8

Conclusion and Recommendations

8.1 Conclusion

The TNCH sector is one of Nepal's most important economic sectors, accounting for 2.2 percent of the country's overall GDP. More than a million individuals are employed in this industry. Nepal's tourism sector, which began with mountaineering, has now extended to include trekking, rafting, paragliding, mountain flights, and other activities. However, insufficient infrastructure, the problem of solid waste management at tourist destinations, poor basic services, and a lack of competent human resources are a few of the sector's major challenges, which have been further exacerbated by climate change in recent decades.

Floods, landslides, GLOFs, avalanches, forest fires, and water-borne diseases are only a few of the significant climate change-related hazards that have an impact on the TNCH sector, either directly or indirectly. Furthermore, high mountains are expected to be more vulnerable to avalanches and GLOFs; hills to landslides, flash floods, and debris flows; and Terai lowlands to floods; all of which will have an impact on the TNCH sector as a whole.

Climate change is already having an impact on the TNCH sector. A decrease in minimum temperature has a detrimental impact on the tourism business, and a temperature rise has the opposite effect. With the rise in the country's maximum temperature, there is an increase in tourist arrivals. However, the negative effects of rising temperatures, such as water scarcity and decreased aesthetic value of tourist attractions due to forest fires and glacier melting, cannot be ignored. This is particularly a concern because Nepal's tourism destinations are largely nature-based and are concentrated in PAs.

Landslides, avalanches, snowstorms, and GLOFs are common in mountainous PAs. They cause havoc on tourism infrastructures such as walking trails, roads, and campsites. Additionally, glacier melting has a significant impact on mountaineering and river-based tourism. Furthermore, floods and invasive plant species are causing chaos in the PAs of the Terai region. Wild animals, who are also an attraction for tourists, are dying as a result of an increase in floods, forest fires, and habitat destruction caused by invasive plant species.

The increasing occurrences of hazards put the life of tourists and tourism-dependent people at risk. The increased incidences of avalanches and snowstorms result in the deaths of tourists and tourist guides. Furthermore, long droughts lead to scarcity of water at tourism destinations, resulting in poor service delivery and poor hygienic conditions. Water scarcity has also increased the workload of women, as they are the de facto managers of the hospitality business, particularly in rural areas. Moreover, the workload of women further increases when the tourism season overlaps with the cropping calendar.

This study assessed the vulnerability and risk of the TNCH sector following the VRA framework developed by the government of Nepal. For this study, the sector was divided into two subsectors: i) natural heritage, represented by PAs; and ii) cultural heritage, represented by temples, monuments and monasteries, and cultures and practices that people follow. Tourism is naturally included in both these subsectors and is therefore considered a cross-cutting theme. A list of the indicators was developed based on the aforementioned VRA framework, a literature review, and expert consultation. Secondary data at the national level was collected from the different governmental organizations, such as MoCTCA, DoT, DNPWC, DoS, DoA, and DHM; development organizations, such as ICIMOD, WWF, and NTNC; and private sector associations, such as HAN, TAAN, NMA, NATTA, and RNRA. Due to the fact that this kind of work has not been done before, there were a lot of data gaps for the TNCH sector.

Based on the availability of data at the national level, indicator lists were finalized. The indicators were then given weight with the help of experts in the sector, including TWG members. The data were then tabulated, filtered, and normalized. Analysis was done to calculate exposure, sensitivity, adaptive capacity and hazard intensity indexes. The vulnerability index of each PA and cultural heritage site in the district was calculated by subtracting the sensitivity index from the adaptive capacity index. Finally, the climate risk of each PA and cultural site in the district was calculated as a product of hazard intensity index, vulnerability index, and adaptive capacity index. In the end, the adaptation options for the sector were developed through a literature review, expert consultation, and provincial and local level consultations.

The analysis showed that the PAs that are the most popular destinations for tourists are highly exposed to climate change. These destinations are visited by a large number of tourists and have a larger number of infrastructures, such as hotels, roads, trekking routes, airports, and campsites. Regarding the sensitivity component of vulnerability, the PAs located in mountainous regions are more sensitive compared to those located in hilly and plain areas. Sloppy terrain, fragile soil, hazard severity of the location, and unpredictable weather conditions made the PAs in the mountain region more sensitive. Regarding adaptive capacity, the PAs in mountainous regions have a low adaptive capacity due to poor accessibility, poor availability of basic services such as hotels and restaurants, financial institutions, and health services, and low levels of revenue collection.

The PAs located in the mountainous regions are highly vulnerable because of their high sensitivity and low adaptive capacity. In addition, the analysis showed that almost all PAs in

Bagmati Province, Province 1, and Province 2 are at very high or high risk because of high exposure elements and high levels of extreme events in the past. The future scenario analysis using RCP 4.5 (2030 and 2050) and RCP 8.5 (2030 and 2050), showed that it is very likely that even the PAs that were at low or very low risk in the baseline will shift to high or very high risk in future.

In terms of Cultural heritage sites are scattered all over the country. A large number of Nepal's cultural heritage sites are located in Kathmandu Valley, Mustang, Pyuthan, Rupandehi, and Kapilbastu, making them highly exposed to climate change. The sites that are located in hilly and mountainous districts are more sensitive to climate change due to the sloppy terrain of the districts and fragile soil for landslides. Regarding the adaptive capacity, the sites in most of the mountainous districts of western regions have less adaptive capacity because these districts have low early warning coverage, and a few health service facilities available. As the cultural and heritage sites in hills and mountains are more sensitive and do have a low adaptive capacity, they are more vulnerable as well. The analysis showed that the districts with a large number of cultural heritage sites—such as Mustang, Gorkha, Pyuthan, Gulmi, and Kapilbastu—have a high level of vulnerability and risk at baseline. Most of the sites in the districts of Gandaki and Lumbini Provinces have a higher risk compared to the other provinces. The analysis of the future scenario under RCP 4.5 (2030 and 2050) and RCP 8.5 (2030 and 2050) showed that there is a high likelihood that even the PAs that were at low or very low risk in the baseline will shift to high or very high risk in future.

As climate change is unavoidable, adapting to it is a necessity. The adaptation options in the TNCH sector are related to policy and program reform, innovative infrastructure and technology, improving capacity development, and innovative research and data management. These options aim to reduce the risks and vulnerability in the sector by enhancing adaptive capacity and resilience of resources and stakeholders engaged in the sector in the short, medium, and long terms.

8.2 Recommendations

This study is the first of its kind in the TNCH sector and can therefore be treated as a baseline and key document for carrying out similar assessments in the future at the national, provincial, and local levels. A serious constraint faced during the assessment was the unavailability or inaccessibility of the required data. The necessity of developing a strong database related to climate change was felt by the actors and the stakeholders in the sector. Based on the learnings gathered during the study, the following recommendations are made:

- Key tourism destinations should maintain season-wise disaggregated data of tourists visiting and this should be consolidated at the national level.
- A system of data generation, collection, analysis, and storage should be established at the destination, provincial and national levels.
- Concerned authorities should have a digital database of trekking routers and spatial distribution of the tourism-related services, including rescue services at the destinations.
- The DoA should have a detailed database, including spatial distributions of cultural heritage sites, their physical condition, repair and maintenance status, and annual budget expenditure.
- The DoT and HAN should have detailed data on the number of hotels and their conditions in each district.
- The DoT should have spatial data related to campsites and available services.

References

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature climate change*, *3*(2), 112-117.

Adhikari, A., & Shah, D. N. N. (2020). Potential Impact of Climate Change on One-Horned Rhinoceros (Rhinoceros unicornis) in Nepal. *bioRxiv*.

Amelung, B., & Nicholls, S. (2014). Implications of climate change for tourism in Australia. *Tourism Management*, *41*, 228-244.

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

Aryal, A., Brunton, D., Ji, W., Barraclough, R. K., & Raubenheimer, D. (2014). Human–carnivore conflict: ecological and economical sustainability of predation on livestock by snow leopard and other carnivores in the Himalaya. *Sustainability Science*, *9*(3), 321-329.

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

Badal, B. P., & Kharel, S. (2019). *Opportunities and Challenges of Tourism Industry in the Context of Visit Nepal 2020.* Tribhuvan University Journal, 33(1), 67-80.

Bajracharya, S. R., Maharjan, S. B., Shrestha, F., Sherpa, T. C., Wagle, N., & Shrestha, A. B. (2020). *Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali River Basins of Nepal, the Tibet Autonomous Region of China*. by International Centre for Integrated Mountain Development GPO Box 3226, Kathmandu, Nepal and United Nations Development Programme (UNDP) GPO Box 107, Kathmandu, Nepal.

Bajracharya, S.R., Maharjan, S.B., Shrestha, F., Bajracharya, O.R., & Baidya, S. (2014). *Glacier status in Nepal and decadal change from 1980 to 2010 based on Landsat data.* Kathmandu: ICIMOD

Baral, S., Dhakal, M., & Khanal, R. (2016). *Lake cluster of Pokhara valley.* Department of National Parks and Wildlife Conservation and International Union for Conservation of Nature and Natural Resources, Kathmandu Nepal.

Bhandari, L.N. (2014). Climate change impacts and adaptation strategies on tourism in Nepal. Crossing the Border: International *Journal of Interdisciplinary Studies. 2* (1)

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

Burton, I. (1996). The growth of adaptation capacity: practice and policy. In *Adapting to climate change* (pp. 55-67). Springer, New York, NY. CAAN. (2020). *Civil Aviation Authority Nepal.* Kathandu, Nepal. www.caanepal.gov.np

Callaghan, A., & Thapa, R. (2015). *An Oral History of Langtang, The Valley Destroyed by Nepal Earthquake*. Retrieved February 10, 2017, from https://www.outsideonline.com/2016856/oral-history-langtang-valleydestroyed-nepal-earthquake.

CBS. (2011). *National Population and Housing Census, 2011. (National Report).* Central Bureau of Statistics, Kathmandu, Nepal.

CBS. (2014). *Population Monograph of Nepal. Volume II (Social Demography).* Central Bureau of Statistics, Kathmandu, Nepal.

Dahal, N. (2020). Perceptions of Climate Change in the Himalaya. Himalayan *Journal of Sociology & Anthropology, 5*, 55–75. Retrieved from http://tiempo.sei-international.org/newswatch/feature050910.htm on 16 November 2020.

Dawson, J., & Scott, D. (2013). Managing for Climate Change in the Alpine Ski Sector. *Tourism Management, 35*, 244-254. doi: 10.1016/j.tourman.2012.07.009

Devkota, F. (2013). Climate Change and its socio-cultural impact in the Himalayan region of Nepal – A Visual Documentation. *Anthrovision. 1*.2. DOI: 10.4000/anthrovision.589

Dhakal, R. (2015). *Overview of Tourism Development prospects in Nepal.* Laurea University of Applied Sciences. Kerava, Finland

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

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

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

DNPWC. (2019). *Annual Report, Chitwan National Parks*. Department of National Park and Wildlife Conservation, Nepal.

DoA. (2007). *Archaeological sites and Monuments in Nepal.* Department of Archaeology, Ministry of Culture, Tourism and Civil Aviation, Kathmandu, Nepal.

Dogura, T., Marchiob, E.A., Bulutc, U., & Suess, C. (2018). Climate change: Vulnerability and resilience of tourism and the entire economy. *Journal of Tourism Management, Vol 72*: 292-305.

Dogru, T., Marchio, E. A., Bulut, U., & Suess, C. (2019). Climate change: Vulnerability and resilience of tourism and the entire economy. *Tourism Management*, 72, 292-305.

DoR. (2018). *Strategic Road Network of Nepal.* HMIS-ICT Unit, Department of Roads. Nepal

Ehmer, P., & Heymann, E. (2008). *Climate Change and Tourism, Where Will the Journey Lead?* In T. Just (Ed.). Frankfurt, Germany: Deutsche Bank AG, DB Research.

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

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

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

Hamilton, J. M., & Tol, R. S. (2004). *The impact of climate change on tourism and recreation.* Centre for Marine and Climate Research University of Hamburg Bundesstr. 55 20146 Hamburg Germany.

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

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

ICIMOD. (2019). *Air pollution in the Hindu Kush Himalaya.* ICIMOD. Retrieved from https://doi.org/10.1007/978-3-319-92288-1_10

IPCC. (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

IPCC. (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 1132 pp.

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

Jacqueline, M., Hamilton, J.M., & Tol, R.S.J. (2004). *The Impact of Climate Change on Tourism and Recreation*. Working Paper. The University of Hamburg. DOI: 10.1017/CBO9780511619472.015

Jones, H. (2013). *Entry Points for Developing Tourism in Nepal: What Can Be Done to Overcome Constraints to Inclusive Growth?* Joint CIG-ODI working paper. Kathmandu.

Kafle, J. (2011). *Poverty Alleviation through Sustainable Tourism Development in Nepal: Marketing Strategy Point of View.* International Business Management. Seinajoki University of Applied Sciences.

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

KC, A. (2017). Climate Change and its Impact on Tourism in Nepal. *Journal of Tourism and Hospitality Vol. 7.*

Kumar, R. A. (2019). The Impact of Inbound Tourism on Economic Growth of Nepal. *International Journal of Academic Research in Business and Social Sciences, 9*(3), 183–195.

Kurk, E. (2009). *Tourism in Himalayan Mountains of Opportunities in a Changing Climate, A Position Paper.* Kathmandu: ICIMOD.

Kurniawan, F., Adrianto, L., Bengen, D.G., and Prasetyo, L. (2016). Vulnerability assessment of small islands to tourism: The case of the Marine Tourism Park of the Gili Matra Islands, Indonesia. *Global Ecology and Conservation, 6* (2016) 308–326.

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

Lamichhane, B.R., Subedi, N., Chapagain, N.R., Dhakal, M., Pokheral, C.P., Murphy, S.T., & Amin, R. (2014). Status of *Mikenia micrantha* Invasion in the Rhino Habitat of Chitwan National Park, Nepal. In. Thapa, G.J., Subedi, N., Pandey, M.R., Thapa, S.K., Chapagain, N.R., and Rana, A. (eds), *Proceeding of the International Conference on Invasive Alien Species.* Sauraha Nepal, 25-27 March 2014. pp. 52-60.

Lamsal, P., Kumar, L., Atreya, K., and Pant, K.P. (2017). Vulnerability and impacts of climate change on forests and freshwater wetland ecosystems in Nepal. A review. *Ambio 2017, 46*:915-930. DOI 10.1007/s13280-017-0923-9

LDT. (2020). *Lumbini Development Trust.* Rupendeshi. Nepal

MoCTCA. (2014). *Tourism Employment Survey 2014.* Ministry of Culture, Tourism and Civil Aviation, Singhadurbar, Nepal

MoCTCA. (2018). *Economic Impact Assessment of Climate Change on Tourism in Nepal*. Ministry of Culture, Tourism and Civil Aviation, Kathmandu, Nepal.

MoCTCA. (2020a). *Mountaineering in Nepal: Facts and Figures.* Tourism Industry Division. Ministry of Culture, Tourism and Civil Aviation, Nepal.

MoCTCA. (2020b). *Tourism Statistics 2019.* Ministry of Culture, Tourism and Civil Aviation, Singhadurbar Nepal

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

MoF. (2019). *Economic Survey 2019.* Ministry of Finance, Singhadurbar, Nepal

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

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

MoHA. (2015*). Nepal Disaster Report.* Kathmandu: Ministry of Home Affairs. Kathmandu, Nepal.

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

MoHA. (2020). *Nepal Disaster Risk Reuction Portal.* Ministry of Home Affairs. Kathmandu Nepal. http://www.drrportal.gov.np (accessed on 8 Oct 2020).

MoITFE. (2019). *Annual Progress Report.* Ministry of Industry, Tourism, Forest and Environment. Gandaki Province. Pokhara. Nepal.

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

Murphy, S.T., Subedi, N., Jnawali, S.R., Lamichhane, B.R., Upadhaya, G.P., Kock, R., & Amin, R. (2013). Invasive mikania in Chitwan National Park, Nepal: the threat to the greater one-horned rhinoceros Rhinoceros unicornis and the factor driving the invasion. Fauna and Flora International, Oryx, *47*(3), 361-368.

Navarro-Drazich, D. (2020). *Climate Change and Tourism in Latin America.* In Latin America in Times of Global Environmental Change. Ed. Lorenzo, C. Springer Nature Switzerland AG 2020.

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

NPC. (2017). *Nepal Flood 2017: Post Flood Recovery Needs Assessment*. Government of Nepal, National Planning Commission, Singha Durbar, Kathmandu.

NTNC. (2020). *Nature for Prosperity – Strategic Plan (2020-2025).* National Trust for Nature Conservation. Khumaltar, Lalitpur, Nepal.

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

Odimegwu, F. and Francis, O.C. (2018). The Interconnectedness between Climate change and Tourism. Sociology Today: a Journal of Contemporary Sociological Research. 1 (1)

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

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

Rayamajhi, S. (2012). The linkage between Tourism and Climate Change: A Study of the Perceptions of Stakeholders along the Annapurna Trekking Trail. *Nepal Tourism and Development Review 2* (1).

Reddy, M.V. and Wilkes, K. (2015). *Tourism in the Green Economy.* Routledge. ISBN 9780415709217.

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

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

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

Sangraula, B. (2010, November 20, 2010). *1,000 Tourists Stranded in Lukla Due to Week-Long Flight Shutdown*. Republica.

Sharma, P. (2012). *Tourism in Nepal 2030.* In R.S. Sagar, *Nepal 2030: A vision for the peaceful and prosperous nation (p. 100).* Kathmandu: South Asia Regional Coordination Office of the Swiss National Center for competence in Research (NCCR North-South).

Sherpa, Y. (2006). *Mountain Tourism: A Boon or a Bane? Impacts of Tourism on Himalayan Women.* Kathmandu, Nepal: Federation of Women Entrepreneurs Association of Nepal

Shrestha, A. B., Wake, C. P., Mayewski, P. A., and 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. Jour. Clim. Res*., v. 12*(9), pp. 2775–2786.

Shrestha, A.B. & Aryal, R. (2011). Climate change in Nepal and its impact on Himalayan glaciers. *Reg Environ Change 11*(1):65–77.

Shrestha, H. P., & Shrestha, P. (2012). Tourism in Nepal: A historical perspective and present trend of development. *Himalayan Journal of Sociology and Anthropology, 5,* 54-75.

Siddiqui, S. & Imran, M. (2019)**.** *Impact of Climate Change on Tourism.* In Environmental Impact of Tourism in Developing Nations. Ed. Sharma, S, and Rao, P. Information Resources Management Association. 701 East Chocolate Avenue, Hershey, PA 17033.

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

Smith, B. & Pilifosova, O. (2002). *Adaptation to climate change in the context of sustainable development and equity. Chapter 18.* IPCC Third Assessment Report on Climate Change 2001.

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

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

THT. (2019). The Himalayan Times. https://thehimalayantimes.com/nepal/avalanche-hit-trekkers-still-missing/.

Tse-ring, K., Sharma, E., Chettri, N., & Shrestha, A. B. (2010). *Climate change vulnerability of mountain ecosystems in the Eastern Himalayas*. International center for integrated mountain Development (ICIMOD).

Udas, G.M. (2013). *Historical review of the natural and cultural heritage of paradise Pokhara*. In, Tourism in Pokhara, issues, trends and future prospect for peace and prosperity (Ed.) Uprety, B.R. Upadhayaya, P.K. and Sapkota T., Pokhara Tourism Council and Nepal Center for Contemporary Research, Katmandu.

UNFCCC. (2012). *National Adaptation Plans: Technical Guidelines for the National Adaptation Plan Process.* In United Nations Framework Convention on Climate Change: Bonn, Germany (pp. 1-152).

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

Wall, G. (2011). *The Tourism Industry: Its Vulnerability and Adaptability to Climate Change.* Tourism and Climate Change. University of Waterloo, Waterloo, Ontario, Canada

Wang, S.-Y., Fosu, B., Gillies, R. R., Singh, P. M. (2015). The Deadly Himalayan Snowstorm of October 2014: Synoptic Conditions and Associated Trends. *Bulletin of the American Meteorological Society, 96*, S89-94.

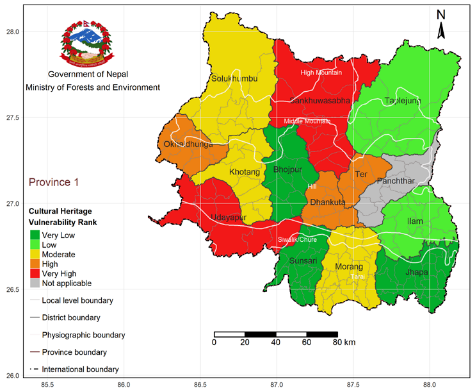
Watson, C.S., Kargel, J.S., Regmi, D., Rupper, S., Maurer J.M., & Karki, A. (2019). Shrinkage of Nepal's Second Largest Lake (Phewa Tal) Due to Watershed Degradation and Increased Sediment Influx. *Remote Sens. 2019, 11*(4), 444; https://doi.org/10.3390/rs11040444.

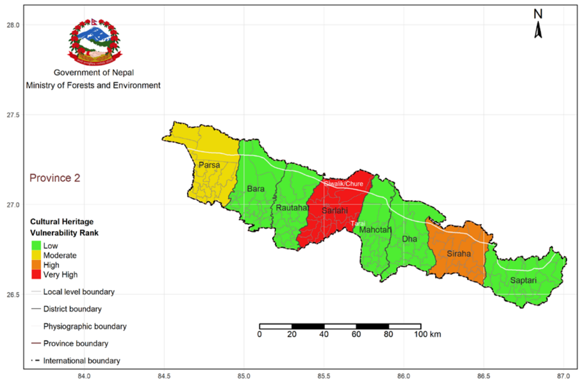
WHO. (2003). *Climate change and human health: risks and responses, Summary.* World Health Organization, Geneva, 2003.

WTTC. (2020). *Travel & Tourism: Economic impact 2020 Nepal.* World Travel and Tourism Council. www.wttc.org

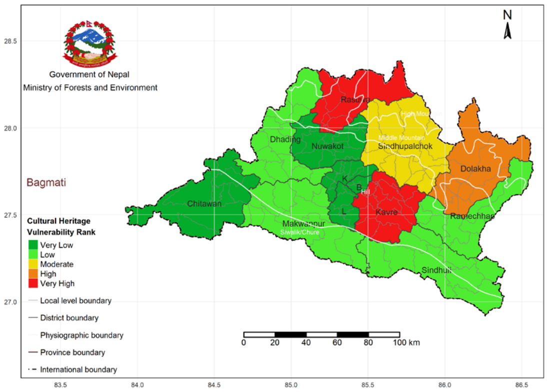
Annexes

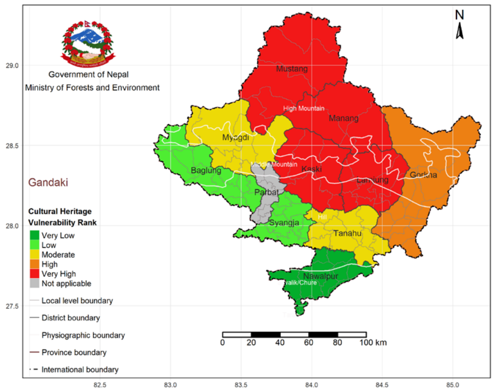
Annex 1: Province wise vulnerability maps of cultural heritage sites



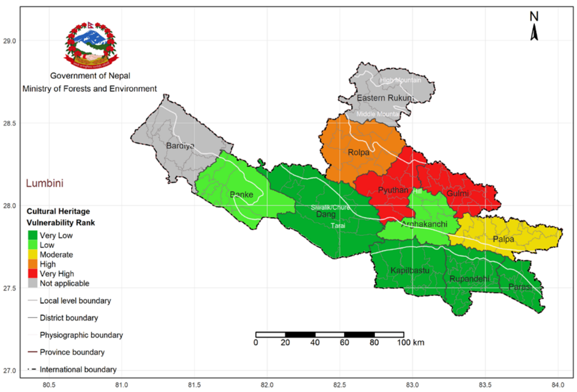


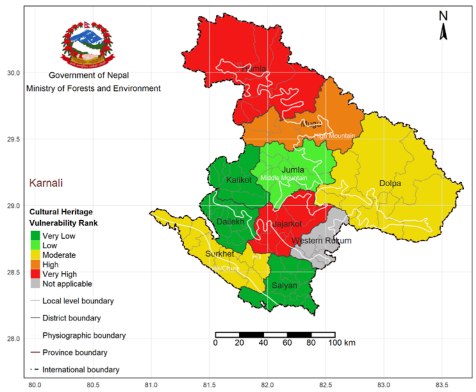
Province 1 **Province 2**



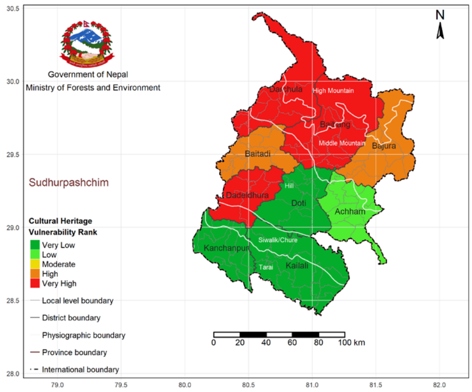


Bagmati Province **Gandaki Province**





Lumbini Province **Karnali Province**



Sudurpaschhim Province

Annex 2: Summary Findings of Provincial Consultation

1. Province 1

During consultations and field visits, participants reported that extreme cold, GLOF potential, LDOF potential, intense rainfall (more rain in a short duration) droughts, fires, landslides, and flash floods are the most common climatic stressors in this province. Less tourist flow; less income and employment; GLOFs damaging infrastructure such as trails, bridges, and connectivity to a touristic destination; loss and damage to infrastructure related to health and services; damage to cultural heritage sites; and damage to the natural touristic stations were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years. are impacts within the sector that have been observed in recent years.

Suggested Adaptation Options:

- Promote early warning systems
- Reinforce building and infrastructure development codes
- Undertake capacity building of private sectors and people engaged in the TNCH sector related to the impact of climate change
- Research how climate change impacts the sector in the mountainous regions
- Develop standards and guidelines for climate-resilient physical infrastructure development
- Promote riverbank protection and bioengineering to reduce the impact of flooding

2. Province 2

During consultations and field visits, participants reported that heavy rainfall in short duration, increasing flood incidences, increasing temperature and massive loss of life and property are the most common climatic stressors in this province. Less tourist flow; disruption of road and transport services due to floods, fogs, and cold waves; floods and landslides damaging infrastructures such as trails, bridges, and connectivity to touristic destinations; loss and damage to infrastructure related to health and services; damage to cultural heritage sites; disruption of transport and communication; fragmentation and habitat degradation; and loss of diversity of endemic plants and wildlife were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years. are impacts within the sector that have been observed in recent years.
Suggested Adaptation Options:

Promote early warning systems

- Develop and implement climate-resilient standards and protocols for transport and communication infrastructures
- Develop policy and regulations for the management of churiya and ensuring its environmental and ecological stability
- Develop and implement land-use management policy targeting the climate-vulnerable forest and land areas
- Riverbank protection works
- Enforce code compliance and retrofitting mechanism for cultural sites

3. Bagmati Province

During consultations and field visits, participants reported that temperature increase leading to avalanches and GLOFs; changes in the growth cycle of crop and plant species; flooding and inundation; landslide and soil erosion; droughts; emergence of new diseases; and increasing incidences of extreme events are the most common climatic stressors experienced in this province. Less tourist flow, damage to infrastructures such as road, bridges, culverts, buildings, transmission lines, water pipes, and hydropower stations; impact on air and road travel due to weather events and related impacts; decreasing numbers of migratory birds; destruction and damage to cultural heritage sites and infrastructure; and impact on tourism business due to weather extremes were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years. are impacts within the sector that have been observed in recent years.

Suggested Adaptation Options:

- Promote early warning systems
- Carry out emergency rescue and response
- Drain dangerous glacial lakes
- Establish metrological stations countrywide
- Conserve rare and threatened species
- Ensure infrastructure development follows climate resilience standards and codes
- Develop alternative routes and safe passage for stranded passengers and commuters
- Enforce code compliance and retrofitting mechanisms for cultural sites

4. Gandaki Province

During consultations and field visits, participants reported identified that temperature rise, floods, landslides, avalanches, and air pollution are the most common climatic stressors in this province for TNCH sector. Also experienced are: drying of water sources; impacts on wildlife, wetlands, waterfalls and related decline in tourist inflow; loss of snow in the mountains; loss of water in ponds; GLOFs, loss of agriculture productivity; displaced settlements; physical infrastructure and human casualties; destruction of cultural heritage sites; migration of entire settlements resulting in loss of cultural values and ethics; and adoption of new cultural rituals; loss of natural beauty; damage to a tourist destinations and their 'original' condition'; the overall impacts on the environment, health, air, and water pollution; increase in human diseases; unorganized and rampant industrialization; loss of mud roofed houses; and increase in concrete houses were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years. are impacts within the sector that have been observed in recent years.

Suggested Adaptation Options:

- Promote the use of alternative or clean fuel/energy
- Raise awareness
- Control deforestation
- Promote the use of electric vehicles
- Enact appropriate policy and its implementation
- Establish information centres
- Establish an emergency response team with adequate management of equipment

- Identify risk-prone areas and adopt mitigation measures to control the risk
- Promote plantation
- Establish a disaster management fund with operating guidelines and appropriate resources
- Carry out watershed conservation
- Carry out integrated river basin management and management of riverbank erosion by establishing dikes in risk-prone areas
- Manage the industrialization process
- Increase investment in the tourism business
- Organize functions to attract domestic tourism
- Ensure that cultural heritage originality and its uniqueness are not lost

5. Lumbini Province

During consultations and field visits, participants reported that rapid ice melting, GLOFs, avalanches, extreme temperature increase, extreme variability in rainfall patterns, extreme events, floods, landslides, and increase in the incidence of forest fires are the most common climatic stressors experienced in this province for the sector. Decreasing tourism flow, high risk of GLOFs; impact on transportation due to extreme weather events; increasing frequency of accidents, shifting vegetation and related loss of species; reduced opportunities for people whose livelihoods are dependent on tourism business; damage of roads, infrastructure and industries along with disruption to communication and commuting from flash floods and landslides; damage to buildings, bridges, water services and drainage systems; disruption of services (transport, production, processing, and communication); disruption of air transport; and damage to cultural heritage sites were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years. are impacts within the sector that have been observed in recent years.

Suggested Adaptation Options:

- Make tourist flow more organized
- Establish early warning systems
- Improve communication system for informing the tourist and communities about the risk
- Provide timely information to the tourists and the tourism sector
- Develop alternative tourist routes and destinations
- Declare conservation areas
- Establish risk monitoring systems in the mountains
- Develop physical infrastructure codes and guidelines to increase resilience

6. Karnali Province

During consultations and field visits, participants reported that rapid melting of ice, increase in avalanches, flood-landslides, land degradation, and thunderbolts, and temperature rise are the most common climatic stressors related to the TNCH sector experienced in this province. Decreased tourist flow; decreased attractiveness of the region; increased incidences of flash floods and landslides damaging roads, infrastructures, and industries; increased disruption to communication and transport due to floods/landslides; disruption of air transport; and damage to cultural heritage sites were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years.

Suggested Adaptation Options:

- Develop public awareness program
- Develop own brands and promote them
- Update the policy, laws, and acts to integrate climate change consideration
- Avoid the use of plastics and promote the paper bags
- Establish early warning systems
- Improve communication system for informing the tourists and communities about risks
- Provide timely information to the tourists and the tourism sector
- Develop alternative tourist routes and destinations
- Protect conservation areas

7. Sudurpaschim province

During consultations and field visits, participants reported that snowfalls, avalanches, floods, landslides, soil erosion, fires, floods, inundation, riverbank cutting, windstorms, heavy rains, no rain, and sporadic rain are the most common climatic stressors related to the TNCH sector experienced in this province. Decreased tourism flow; decreased attractiveness of the region; damage to physical and transport infrastructure; obstruction of the tourism access; damage to cultural heritage sites, disruption of livelihoods dependent on the tourism business; damages to tourism infrastructure including natural and cultural heritages and trekking trails were reported to be the most commonly observed climatic impacts related to the TNCH sector in the past recent years.

Suggested Adaptation Options:

- Establish early warning systems
- Improve communication system for informing the tourist and communities about the risk
- Provide timely information to the tourists and the tourism sector
- Develop alternative tourist routes and destinations
- Protect conservation areas
- Promote retaining wall and bioengineering technology
- Carry out reconstruction, renovation, and up-gradation of cultural heritages
- Carry out awareness campaign via local youth clubs, mothers' groups, female groups, etc.
- Carry out compensation and relief program
- Identify upland for construction of physical infrastructures

Annex 3: List of experts consulted for giving weightage to the indicators

S.N	Name	Gender	Organization	Email
1	Tek Bahadur Mahat	M	Hotel Association of Nepal (HAN)	han.tekmahat@gmail.com
2	Ajaya Dhakal	M	Nepal Academy of Tourism and Hotel Management (NATHM)	ajayakumar.dhakal@yahoo.com
3	Uttam Bhattarai	M	Nepal Mountain Academy	uttam@man.gov.np / uttamjee@gmail.com
4	Shishir Khadka	M	Nepal Association of Rafting Agencies (NARA)	nepalnara@gmail.com
5	Bijaya Pradhan	M	Nepal Heritage Society	nheritagesociety@gmail.com
6	Meera Acharya	W	Department of Tourism	meeranpc@gmail.com
7	Bishwa Raj Subedi	M	Hetauda	brsubedi@yahoo.com
8	Surya Ghimire	M	Ex-President -TAAN	suryaghimire1136@gmail.com
9	Shilshila Acharya	W	HCI	shilshila43@gmail.com

Annex 4: Vulnerability and Risk Index of the districts

District	Vulnerability	Exposure	Sensitivity	Adaptive capacity	Baseline context of climate extreme events	Climate extreme events composite (RCP4.5 2030)	Climate extreme events composite (RCP4.5 2050)	Climate extreme events composite (RCP8.5 2030)	Climate extreme events composite (RCP8.5 2050)	Baseline Risk	RCP 4.5 2030 Risk	RCP 4.5 2050 Risk	RCP 8.5 2030 Risk	RCP 8.5 2050 Risk
Achham	0.515	0.09	0.627	0.189	0.384	0.38	0.516	0.418	0.599	0.052	0.051	0.069	0.056	0.081
Arghakhanchi	0.516	0.181	0.601	0.159	0.473	0.536	0.671	0.635	0.791	0.127	0.144	0.181	0.171	0.213
Baglung	0.608	0.09	0.683	0.159	0.542	0.636	0.748	0.664	0.867	0.08	0.094	0.111	0.098	0.128
Baitadi	0.54	0.09	0.6	0.134	0.432	0.442	0.575	0.468	0.669	0.06	0.061	0.079	0.065	0.092
Bajhang	0.681	0.542	0.69	0.094	0.372	0.397	0.513	0.406	0.597	0.354	0.378	0.488	0.386	0.568
Bajura	0.691	0.09	0.696	0.091	0.326	0.332	0.442	0.36	0.543	0.052	0.053	0.071	0.058	0.087
Banke	0	0	0.081	0.131	0.367	0.409	0.575	0.458	0.653	0	0	0	0	0
Bara	0.11	0.181	0.39	0.33	0.443	0.491	0.551	0.505	0.657	0.067	0.074	0.083	0.076	0.099
Bardiya	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bhaktapur	0.3	0.361	0.391	0.14	0.564	0.647	0.698	0.614	0.792	0.232	0.267	0.288	0.253	0.326
Bhojpur	0.484	0	0.598	0.188	0.505	0.59	0.572	0.508	0.713	0	0	0	0	0
Chitawan	0.14	0.181	0.481	0.403	0.489	0.512	0.61	0.568	0.7	0.078	0.082	0.097	0.091	0.112
Dadeldhura	0.555	0.181	0.539	0.05	0.406	0.41	0.545	0.455	0.661	0.114	0.115	0.153	0.128	0.185
Dailekh	0.408	0.181	0.542	0.202	0.375	0.373	0.513	0.408	0.587	0.089	0.089	0.122	0.097	0.139
Dang	0.426	0.181	0.549	0.192	0.411	0.447	0.599	0.52	0.698	0.1	0.109	0.146	0.126	0.17
Darchula	0.696	0.181	0.677	0.064	0.424	0.442	0.57	0.471	0.655	0.136	0.142	0.183	0.152	0.211
Dhading	0.554	0	0.699	0.232	0.513	0.608	0.714	0.623	0.815	0	0	0	0	0
Dhankuta	0.65	0	0.65	0.08	0.513	0.599	0.591	0.531	0.725	0	0	0	0	0
Dhanusha	0.155	0	0.405	0.301	0.397	0.458	0.443	0.455	0.655	0	0	0	0	0
Dolakha	0.716	0.09	0.814	0.198	0.605	0.676	0.717	0.629	0.86	0.099	0.111	0.118	0.103	0.141
Dolpa	0.682	0	0.622	0.016	0.293	0.367	0.487	0.399	0.581	0	0	0	0	0
Doti	0.261	0.09	0.409	0.199	0.414	0.424	0.559	0.446	0.639	0.04	0.041	0.054	0.043	0.062
Eastern Rukum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gorkha	0.59	0.542	0.677	0.171	0.479	0.583	0.703	0.589	0.799	0.418	0.508	0.613	0.514	0.697
Gulmi	0.555	0.361	0.688	0.218	0.525	0.612	0.735	0.67	0.844	0.295	0.344	0.413	0.376	0.474
Humla	0.872	0.181	0.799	0.024	0.291	0.288	0.392	0.322	0.485	0.109	0.107	0.146	0.12	0.181
Ilam	0.715	0.09	0.774	0.155	0.673	0.803	0.78	0.794	0.894	0.11	0.131	0.128	0.13	0.146
Jajarkot	0.762	0	0.714	0.04	0.444	0.459	0.587	0.475	0.657	0	0	0	0	0
Jhapa	0.145	0.09	0.512	0.432	0.691	0.818	0.801	0.844	0.931	0.056	0.066	0.064	0.068	0.075
Jumla	0.547	0.181	0.586	0.111	0.461	0.463	0.572	0.48	0.66	0.128	0.129	0.159	0.134	0.184
Kailali	0.27	0.09	0.397	0.177	0.401	0.397	0.539	0.462	0.643	0.04	0.039	0.053	0.046	0.063
Kalikot	0.61	0	0.628	0.095	0.375	0.365	0.483	0.39	0.562	0	0	0	0	0
Kanchanpur	0	0	0.348	0.561	0.38	0.381	0.504	0.421	0.643	0	0	0	0	0
Kapilbastu	0.104	0.903	0.299	0.234	0.43	0.434	0.565	0.569	0.68	0.32	0.323	0.42	0.423	0.506

District	Vulnerability	Exposure	Sensitivity	Adaptive capacity	Baseline context of climate extreme events	Climate extreme events composite (RCP4.5 2030)	Climate extreme events composite (RCP4.5 2050)	Climate extreme events composite (RCP8.5 2030)	Climate extreme events composite (RCP8.5 2050)	Baseline Risk	RCP 4.5 2030 Risk	RCP 4.5 2050 Risk	RCP 8.5 2030 Risk	RCP 8.5 2050 Risk
Kaski	0.281	0.271	0.771	0.589	0.606	0.71	0.828	0.739	0.955	0.182	0.214	0.249	0.222	0.287
Kathmandu	0	1	0.538	1	0.553	0.65	0.709	0.617	0.795	0.014	0.017	0.018	0.016	0.02
Kavrepalanchok	0.367	0.452	0.573	0.278	0.557	0.619	0.66	0.602	0.797	0.314	0.349	0.372	0.34	0.45
Khotang	0.589	0	0.671	0.164	0.455	0.528	0.509	0.465	0.666	0	0	0	0	0
Lalitpur	0	0.542	0.435	0.556	0.54	0.582	0.635	0.574	0.754	0.162	0.175	0.19	0.172	0.226
Lamjung	0.596	0.09	0.683	0.172	0.549	0.657	0.775	0.679	0.895	0.08	0.096	0.113	0.099	0.131
Mahottari	0.217	0.09	0.411	0.247	0.401	0.456	0.462	0.496	0.675	0.036	0.041	0.042	0.045	0.061
Makawanpur	0.642	0.09	0.728	0.177	0.5	0.533	0.608	0.541	0.704	0.077	0.082	0.093	0.083	0.108
Manang	0.817	0.09	0.73	0.002	0.388	0.499	0.621	0.498	0.716	0.069	0.089	0.111	0.089	0.128
Morang	0.212	0.09	0.364	0.197	0.565	0.655	0.647	0.653	0.777	0.051	0.059	0.058	0.059	0.07
Mugu	0.675	0.09	0.631	0.033	0.303	0.31	0.416	0.326	0.488	0.048	0.049	0.066	0.051	0.077
Mustang	0.746	1	0.665	0	0.193	0.292	0.431	0.337	0.537	0.359	0.544	0.803	0.628	1
Myagdi	0.673	0.271	0.71	0.124	0.51	0.603	0.718	0.632	0.854	0.241	0.285	0.339	0.299	0.404
Nawalpur	0	0.361	0.351	0.724	0.496	0.519	0.617	0.597	0.725	0.023	0.024	0.029	0.028	0.034
Nuwakot	0.483	0.09	0.628	0.223	0.538	0.666	0.766	0.645	0.849	0.07	0.086	0.099	0.084	0.11
Okhaldhunga	0.638	0	0.651	0.093	0.49	0.566	0.549	0.497	0.704	0	0	0	0	0
Palpa	0.549	0.271	0.673	0.207	0.527	0.606	0.716	0.661	0.805	0.221	0.254	0.3	0.277	0.337
Panchthar	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Parasi	0	0.361	0.351	0.724	0.496	0.519	0.617	0.597	0.725	0.023	0.024	0.029	0.028	0.034
Parbat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Parsa	0.095	0	0.283	0.224	0.45	0.469	0.548	0.521	0.65	0	0	0	0	0
Pyuthan	0.656	0.632	0.688	0.117	0.471	0.538	0.661	0.607	0.783	0.511	0.584	0.717	0.659	0.85
Ramechhap	0.557	0	0.681	0.209	0.556	0.629	0.634	0.569	0.786	0	0	0	0	0
Rasuwa	0.944	0.181	0.863	0.024	0.534	0.664	0.788	0.633	0.883	0.211	0.262	0.311	0.25	0.348
Rautahat	0.196	0	0.409	0.265	0.42	0.488	0.541	0.489	0.652	0	0	0	0	0
Rolpa	0.605	0.181	0.691	0.173	0.45	0.498	0.628	0.539	0.73	0.133	0.147	0.185	0.159	0.215
Rupandehi	0	0.813	0.441	0.541	0.455	0.449	0.537	0.547	0.66	0.218	0.215	0.257	0.262	0.316
Salyan	0.539	0	0.6	0.135	0.404	0.436	0.58	0.465	0.654	0	0	0	0	0
Sankhuwasabha	1	0	0.966	0.084	0.755	0.865	0.87	0.776	1	0	0	0	0	0
Saptari	0.069	0.181	0.392	0.373	0.427	0.492	0.474	0.616	0.699	0.059	0.068	0.066	0.085	0.097
Sarlahi	0.251	0	0.404	0.204	0.416	0.476	0.51	0.503	0.683	0	0	0	0	0
Sindhuli	0.618	0.271	0.748	0.223	0.48	0.542	0.545	0.525	0.722	0.215	0.243	0.244	0.235	0.324
Sindhupalchok	0.545	0.181	0.707	0.25	0.613	0.709	0.807	0.691	0.923	0.17	0.197	0.224	0.192	0.256
Siraha	0.121	0.181	0.407	0.338	0.4	0.46	0.437	0.541	0.626	0.062	0.071	0.067	0.083	0.096
Solukhumbu	0.434	0.09	1	0.693	0.594	0.686	0.715	0.618	0.834	0.073	0.084	0.088	0.076	0.102

District	Vulnerability	Exposure	Sensitivity	Adaptive capacity	Baseline context of climate extreme events	Climate extreme events composite (RCP4.5 2030)	Climate extreme events composite (RCP4.5 2050)	Climate extreme events composite (RCP8.5 2030)	Climate extreme events composite (RCP8.5 2050)	Baseline Risk	RCP 4.5 2030 Risk	RCP 4.5 2050 Risk	RCP 8.5 2030 Risk	RCP 8.5 2050 Risk
Sunsari	0.39	0.181	0.522	0.197	0.491	0.567	0.558	0.545	0.7	0.114	0.132	0.13	0.127	0.163
Surkhet	0.232	0.09	0.364	0.177	0.395	0.396	0.537	0.45	0.629	0.037	0.037	0.05	0.042	0.059
Syangja	0.748	0.09	0.847	0.204	0.602	0.703	0.829	0.746	0.911	0.101	0.118	0.14	0.126	0.153
Tanahu	0.589	0.181	0.688	0.185	0.572	0.663	0.791	0.713	0.861	0.166	0.193	0.23	0.207	0.25
Taplejung	0.22	0.09	0.866	0.757	0.736	0.872	0.872	0.809	0.995	0.067	0.08	0.08	0.074	0.091
Terhathum	0.532	0	0.506	0.035	0.562	0.685	0.669	0.607	0.794	0	0	0	0	0
Udayapur	0.733	0.09	0.725	0.081	0.432	0.499	0.479	0.466	0.649	0.072	0.083	0.08	0.078	0.108
Western Rukum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA