



Gandaki Province Government
Gandaki Province Policy and Planning Commission
Pokhara, Nepal

Multi-Hazard Risk Mapping and Identification in Gandaki Province
(Hydrometeorological, Geophysical, Environmental,
Biological - Epidemic and Technological Hazards)

Date: June 2025



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Submitted By:

Sentinel Engineering Consultancy

Kathmandu, Nepal

Date: June 2025

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EXECUTIVE SUMMARY

Gandaki Province, a mid-hill region of Nepal, is characterized by diverse topography, socio-economic conditions, and exposure to multiple natural and technological hazards. This study conducted a comprehensive multi-hazard risk assessment at the municipal level, focusing on hydrometeorological (floods), geophysical (landslides), environmental (forest fires), biological (epidemics), and technological hazards. By integrating spatially explicit data, the assessment identified hazard-prone areas, evaluated exposure levels, and analyzed sensitivity and adaptive capacity to determine vulnerability risk indices. The findings reveal distinct spatial patterns, with southern and central municipalities such as Pokhara, Nawalparasi East, and Syangja facing high flood and landslide risks, while remote districts like Mustang and Manang exhibit heightened sensitivity but lower adaptive capacity due to geographic isolation and limited infrastructure.

The study employed a multi-dimensional vulnerability framework, assessing key indicators such as population density, infrastructure, land use, and socio-economic factors to quantify risk. Flood hazards were most severe in lowland areas, whereas landslides dominated steep terrains in Baglung, Myagdi, and Lamjung. Forest fire risks were prominent in southern and western municipalities, while epidemic hazards were elevated in rural and mountainous regions with poor healthcare access. Technological hazards were concentrated in urban centers like Pokhara, reflecting dense infrastructure and industrial activity. Exposure and sensitivity maps highlighted high-risk zones, while adaptive capacity assessments underscored disparities in resilience, with urban areas benefiting from better infrastructure and emergency preparedness compared to remote regions.

The integrated multi-hazard risk map synthesized these findings, identifying municipalities with overlapping vulnerabilities, such as Pokhara (Kaski), Baglung, and parts of Nawalparasi East, which face compounded risks from multiple hazards. The risk classification ranging from very low to very high that provides actionable insights for policymakers to prioritize disaster risk reduction (DRR) interventions. For instance, high-risk zones require targeted measures like resilient infrastructure, early warning systems, and community-based adaptation programs, while moderate-risk areas may benefit from capacity-building and land-use planning. The study emphasizes the need for localized DRR strategies tailored to the unique hazard profiles and socio-economic conditions of each municipality.

Ultimately, this assessment serves as a critical tool for evidence-based decision-making, supporting the development of Local Disaster and Climate Resilience Plans (LDCRPs) in Gandaki Province. By identifying spatial overlaps of hazards and vulnerabilities, the study enables proactive risk mitigation, enhances climate adaptation efforts, and fosters sustainable development. The findings underscore the importance of multi-sectoral collaboration among government agencies, communities, and stakeholders to build long-term resilience. Future efforts should focus on periodic risk updates, incorporating climate change projections, and strengthening early warning systems to address evolving hazards in this geographically and socio-economically diverse region.

LIST OF ACRONYMS

ADB	Asian Development Bank
CI	Consistency Index
DHM	Department of Hydrology and Meteorology
DEM	Digital Elevation Model
DMG	Department of Mines and Geology
DoS	Department of Survey
DRR	Disaster Risk Reduction
EWS	Early Warning Systems
FRTC	Forest Research and Training Centre
FY	Fiscal Year
GDP	Gross Domestic Product
GLOF	Glacial Lake Outburst Flood
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interviews
MoFE	Ministry of Forest and Environment
MoHA	Ministry of Home Affairs
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NSO	National Statistics Office
NTFPs	Non-Timber Forest Products
OSM	Open Street Map
PTSD	Post-traumatic Stress Disorder
RCP	Representative Concentration Pathway
SPI	Standardized Precipitation Index
SRTM	Shuttle Radar Topography Mission
USGS	United States Geological Survey
VRA	Vulnerability Risk Assessment
WUI	Wildland-urban Interface

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CHAPTER 1: INTRODUCTION

1.1 Background

Vulnerability to climate hazards is regarded as a social construct, encompassing a combination of social, economic, and demographic factors that collectively determine people's and communities' capacity to deal with stressors and shocks. The risk posed by any climatic and non-climatic hazard is determined by both social vulnerability and geophysical conditions, which define the likelihood of hazards occurring and communities' susceptibility to them. Thus, the vulnerability and multi-hazard risk assessment is important to reduce the risk arising from vulnerability and multi-hazard by providing valuable information that can be used to reduce risk and develop adaptation options such as for disaster management, sustainable and resilient development, and climate change adaptation. These evaluations must include socio-economic considerations, which capture community resilience, such as important demographic data, growth patterns, trends, and urbanization. The strategy must be inclusive and consider power relations, gender, caste, and social equity aspects of vulnerability to enhance resilience and minimize disaster risk.

Effectiveness of adaptation and risk reduction measures depends on community-based risk communication, exchange of information, and involvement in planning and implementation. Incorporation of indigenous knowledge into vulnerability assessments is essential for formulating effective adaptation strategies that are tailored to the unique vulnerabilities and needs of the community. Vulnerability and multi-hazard risk assessments also must be carried out through a participatory and transparent process involving all stakeholders, including the local communities, government, and civil society.

The dynamic Himalayan Mountain system, mountain slope, rugged topography, remoteness, and dispersed settlements, along with social factors like low human development index, gender and social disparity, and economic factors including high food insecurity, increased poverty, low economic development, and limited technology adoption, can rapidly escalate hazards. Additionally, susceptibility to climate change, deforestation, and biodiversity loss, along with inadequate health facilities, a high disease burden, malnutrition, sanitation issues, and weak governance, contribute to disaster and vulnerability. Furthermore, Nepal's poor economic condition, inadequately developed infrastructure, and weak technical capacity add to the challenges of building a disaster-resilient community.

Disasters result in loss of people and assets, affect physical and natural processes, and thwart the development of a nation. Their impact varies with the level of exposure and sensitivity towards the disaster. Economic and non-economic loss and damage arising from climate and weather disasters are heightened in the world, with large spatial and inter-annual variability. An analysis carried out to explore the relationships between socio-economic indicators and the economic losses due to climate-induced disasters revealed that economic losses are more associated with exposure than vulnerabilities. Economic loss resulting from such disasters in the long run is largely attributed to growing exposure of economic resources and individuals. The patterns in mortality from climate-related disasters for the period 1971-2019 and economic losses exhibit decreasing trends in mortality due to enhanced early warning and mitigation. In contrast, it shows rising economic losses caused due to growing exposure and vulnerabilities. On average, climate-related disasters in Nepal have been causing 647 deaths annually (Thapa et al., 2021), representing about 65% of all disaster deaths (Dev Bhattarai, 2023) except for road traffic accidents. In terms of economic losses, the average annual loss is about NRS 2.778 billion per year, which is slightly less than 0.08% of the GDP of the country for the FY 2018/19. The most devastating climate-related disasters include floods, landslides, epidemics, and fires. In terms of population mortality and economic losses due to different hazards, epidemics rank first with 52.8%, followed by landslides with 16.7% and floods with 12.7% (MoFE, 2021a). In general, flood disasters make the highest total impact at 71%, followed by landslides at 9.5% and epidemics at 8.2%. Fires cause the highest economic losses, about 56.6%, with floods coming second at 31% and landslides at 3.7%.

The impacts of 'climate extremes' are mainly due to exposure and vulnerability, which are differential with respect to the biophysical and socio-economic factors. The primary sensitive key sectors to climatic extremes are transportation, infrastructure, water, and tourism. Agriculture, where small-scale farming dominates, is particularly vulnerable hence opening up its players to risk. The Climate Risk Profile of Nepal, developed by the World Bank Group and the Asian Development Bank, shows an aggravation in natural hazards such as droughts, heatwaves, river floods, and GLOFs (Climate Risk Country Profile: Nepal (2021), 2021). River flooding might double the population affected and treble its economic loss by 2030, also potentially leading to Nepal losing 2.2% of its GDP by 2050.

The climate record of Nepal from 1971 to 2014 prepared by DHM indicates strong positive trends in maximum and minimum temperatures which have increased by 0.056°C and 0.002°C

per year respectively. Climate extreme indices indicate increasing consecutive wet days and rainy days, but decreasing very wet days, extremely wet days, and consecutive dry days. Warm days, warm nights, and warm spell duration are increasing, while decreasing cold days, cold nights, and cold spell duration are observed in the majority of districts (DHM, 2017). Climate change projections for RCP 4.5 and RCP 8.5 expect increased mean temperature and precipitation, with more frequent intense precipitation events. The future climate will be much warmer and more humid, with more intense events. These events will eventually trigger the nation towards varieties of climate induced disasters.

The study, which analyzed trends in climatic hazards over 49 years based on data from DesInventar (<https://www.desinventar.net/>) and Nepal DRR (<http://drrportal.gov.np/>) revealed a significant increase in climatic hazards, especially after 1990. In view of a significant climate change scenario, this could mean longer fire seasons for the country, with increased intensity and longer fire spread periods. This could, in turn, enhance suppression costs and damage. Additionally, the present risk of fire is also going to be upheld by weather conditions such as temperature, humidity, wind speed, and rainfall. The future could be hotter, windier, and drier. The Standardized Precipitation Index (SPI) data from 1981 to 2019, revealed that Nepal experiences an average drought duration of 3.4 months per year. On average, this affects 56% of the country. Drought events are mostly triggered by low rainfall and high temperature conditions that increase evapotranspiration (MoFE, 2021c).

The trend analysis between Nepal's rain-induced floods and landslides, revealed strong correlations, with flood-prone areas at 8% and landslide prone areas at 59%. Over the past 49 years, Nepal experienced 3443 flood events and 3787 landslide events (MoFE, 2021d). Climate change influences drivers of floods include precipitation, snow cover, soil moisture level, sea level, glacial lake stage, and vegetation which eventually changes the features of flood type. Pluvial floods can be exacerbated by heavy precipitation. The IPCC synthesis report (2014) (IPCC, 2014) estimated an increase in low-frequency flood occurrences across the globe.

Precipitation extremes can be anticipated in the future, which has the potential to cause landslide activity in the China-Nepal border, which could exaggerate landslide captivity by 30-70%. Climatic changes in the form of heatwaves, glacier retreat, and permafrost degradation are anticipated to influence slope instabilities in high mountains and bedrock stability. Changes in total rainfall and rainfall intensity have a direct influence on rockslides, mudflows, and earth

flows. Changes in air temperature also indirectly influence rockfalls and deep-seated landslides. Higher total precipitation can lead to wetter regimes, a rise in the water table, and a decrease in slope stability, which are connected to landslides and soil erosion.

The rising greenhouse gas concentrations and global warming plays a significant role in climatic extremes, higher hotter days, heatwaves, heavy precipitation, windstorms, hailstorms, fewer cold days, and cold waves (IPCC 2001). Thunderbolts, which are a result of charge separation in clouds, are likely to increase by 50% globally by the turn of the century (David et al, 2014). The increased temperatures and humidity have been attributed to increased lightning instances and widespread expansion of future hailstorm damage too. The IPCC's special report (2012) suggests that the frequency and size of ice avalanches may increase due to higher ice melts triggered by higher temperatures. Climatic variations result in the glaciers expanding and contracting in size, which may result in disasters in glacial lake outbursts flooding and really causing a huge human and economic loss in the downstream valleys.

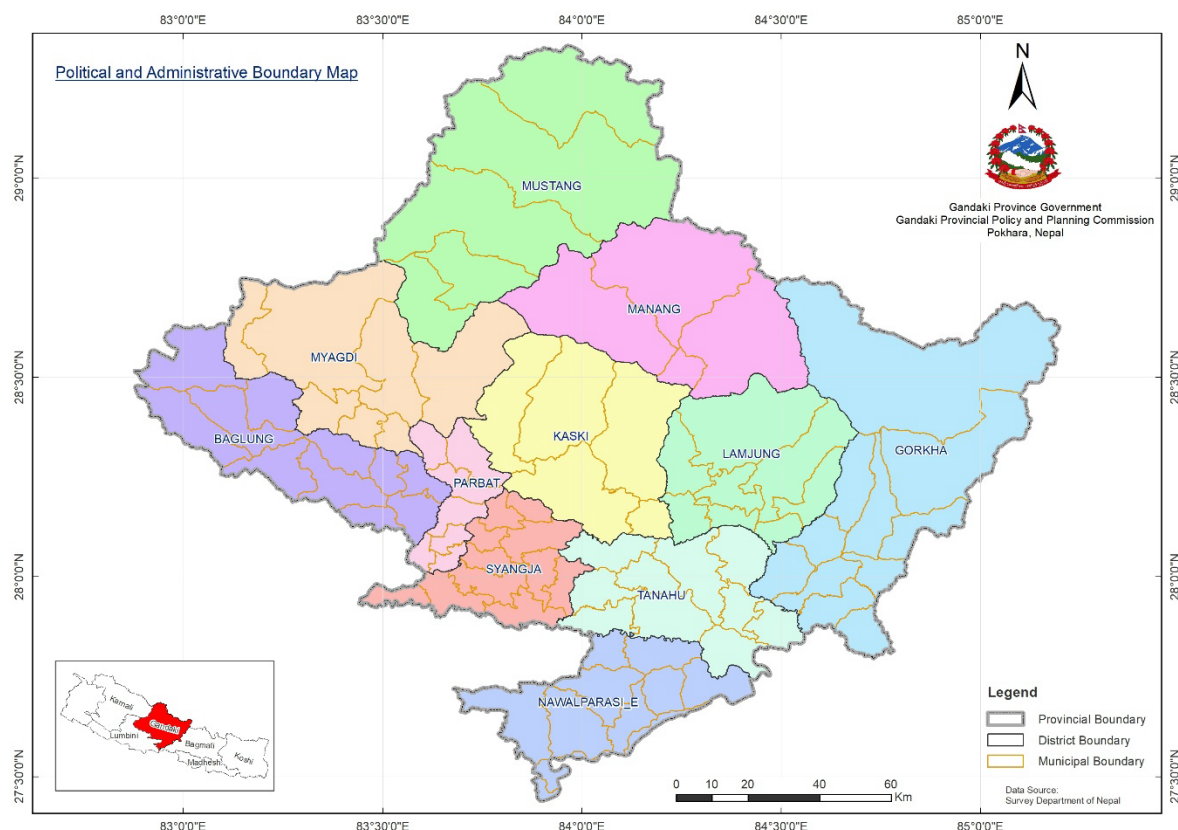


Figure 1.1: Political and administrative map of Gandaki province

Gandaki Province is situated in the heart of Nepal and exhibits varied topography from the Terai lowlands to the high Himalayas. Gandaki province covers 15% of the total area of the country and is divided into eleven districts: Baglung, Gorkha, Kaski, Lamjung, Manang, Mustang, Myagdi, Nawalpur, Parbat, Syangja, and Tanahun; and 85 local municipalities, including one metropolitan city, 26 municipalities, and 58 rural municipalities as shown in Figure 1.1. The landscapes extend from 104m above sea level in Nawalpur district to 8,167m Dhaulagiri peaks in Myagdi district in a distance of 150km (MoIAL Gandaki Province, 2019).

The high variability in topography in concert with climate change exposes the Gandaki province to a wide range of hazardous events, such as floods, landslides, droughts, avalanches, hailstorms, fires, lightning, epidemics, and other ecological risks. Steep inclines, hillslope geography, and clearance are enhancing susceptibility to landslide and land surface erosion, mainly under monsoonal climatic conditions. This makes the area very vulnerable due to a plethora of factors.

The Gandaki province is characterized by the interplay of complex physical, socio-economic exposures, and governance challenges, which all together make the region vulnerable. Such social vulnerabilities give birth to risks and work in so many ways: high poverty, food insecurity, low literacy rates, weak healthcare infrastructure whereby communities are unable to respond to disasters. Very high out-migration rates, especially that of young men, have left the women and elderly behind and hence more exposed to disasters. Inaccessibility of education and health facilities further enhances impact from hazards, thus slowing down recovery mechanisms and increasing long-term vulnerability. Over and above subsistence agriculture, for livelihoods, there is a problem of food insecurity because it is very vulnerable to climatic variability and extreme weather. Under this context, assessment of vulnerability and multi-hazard risk on a local scale goes a long way in drawing up sectoral plans and programs that reduce risk and build resilient communities in the region.

The dispersed settlement in the Gandaki province, remoteness, and limited access to technology and resources also pose challenges to effective response and recovery from disasters. Poor infrastructure and poor governance are also responsible for the difficulties, and Gandaki Province is one of the most disaster-susceptible locations in Nepal. Such vulnerabilities have to be addressed through a convergent approach of disaster risk reduction, climate change adaptation, and empowerment of individuals to develop resilience to mounting

risks from natural hazards. Vulnerability assessment and multi-hazard risk assessment of Gandaki province of Nepal are thus essential for evidence-based decision and policy making.

The vulnerability analysis should encompass socio-economy as a vital factor alongside physical aspects, reflecting community resiliency. Key demographic elements that influence climate change effects include population dynamics for males, females, indigenous peoples, and marginalized groups. This information includes growth patterns, trends, and urbanization progression, among others.

1.2 Study Area

Gandaki Province is a mid-hill province of Nepal which is diversified in terms of topography, socio-economic condition, and exposure to natural hazards. The province stretches from the low-lying Terai to the very highlands and high Himalayan peaks, which is shown in Figure 1.2. Thus, the terrain is complicated and susceptible to various hazards. These comprise floods, landslides, earthquakes, avalanches, drought, forest fires, and epidemics. The combination of tough terrain, deforestation, and poor infrastructure makes the local communities, particularly rural and isolated communities, more vulnerable. Furthermore, climate change has added to these threats by bringing in unpredictable rainfall, heightened flooding, and landslide events. Social vulnerabilities also exist aplenty in the area, where poverty, food insecurity, low literacy, and poor healthcare further enhance the effects of disasters. The weak economic progress, governance, and disaster management of the province also undermine its response and recovery capacity. Accordingly, Gandaki Province is significantly challenged in achieving resilience, which demands coordinated efforts in disaster risk reduction, climate change adaptation, and empowerment of people to cushion the impacts of such hazards.

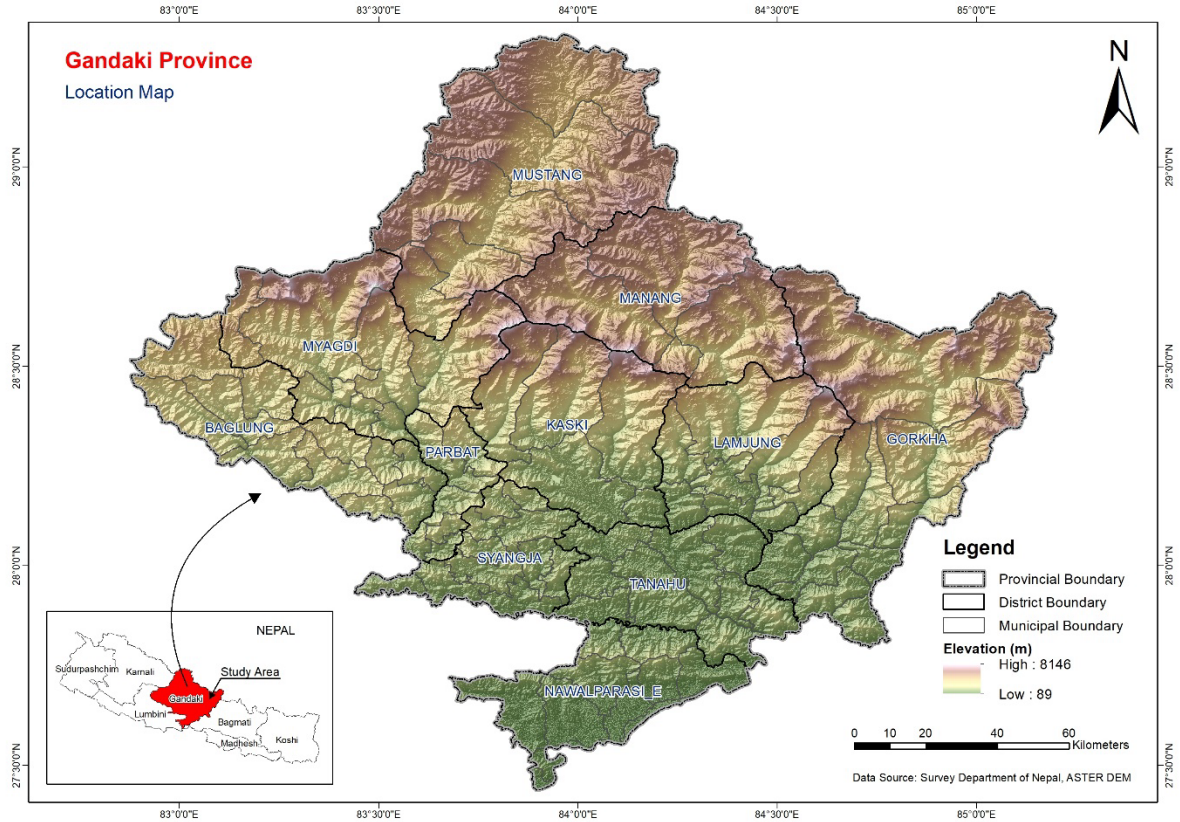


Figure 1.2: Location map of Gandaki Province

Gandaki Province is also susceptible to various natural disasters, compounded by its geography, climate change impacts, and socio-economic condition. With Gorkha district at the epicenter of the 2015 earthquake, the district had seen the widespread destruction of homes, infrastructure, and cultural heritage sites. The earthquake had set off several landslides in the hilly landscape, again adding to the devastation. A snowstorm caused by intense rainfall from Hudhud cyclone in October 2014 indirectly affected Nepal's Manang and Mustang high-altitude districts, triggering an unprecedented snowstorm and avalanche (Basnet & Bhandari, 2015). The event claimed the lives of 43 individuals, left 50 people missing, and injured 175. The incident emphasizes for a better early warning system, preparedness for such disasters, and sustainable tourism concepts in these risk-vulnerable destinations, which heavily rely on tourism and agriculture for their survival.

Pokhara sub-metropolitan city, being in a valley renowned for its beauty, is greatly exposed to flash floods and landslides, especially during the monsoon. Unplanned urbanization, encroachment of riverbanks, and absence of proper drainage facilities have heightened the

susceptibility of the city to these hazards. The 2012 flash flood in the Seti Gandaki River that took dozens of lives is a bitter reminder of the city's vulnerability (Gurung et al., 2015). District-level rankings of total impact of climate disaster-induced disasters drawn up by MoFE shows Kaski district as disaster-hotspots.

Myagdi District of Gandaki Province is very susceptible to natural disasters due to the hilly terrain, high elevation, and dependence on agriculture. The 2021 Marang landslide of Dhaulagiri Rural Municipality resulted in huge human loss, property damage, and displacement. A number of cases of human and economic losses in all the local units of the Myagdi district make it highly susceptible to landslides. Deforestation, unscientific farming, and road construction activities further destabilized the slopes, making the landslides more frequent and severe. Disaster response and recovery are hampered by inaccessibility and infrastructure vulnerability in this district. Apart from Myagdi, Baglung and Syangja districts are also one of the most landslide-prone districts of Nepal (MoFE, 2021d). The topography, unplanned land use and heavy downpours of these landslide prone zones are exposing the district to landslides, particularly where intensive road construction work or farming has been occurring in sloping lands.

During the past 49 years (1971-2019), 569 hailstorm events have been recorded in different districts of Nepal. Hailstorm hazards in Nepal have been found to be in an increasing trend and the most hailstorm-affected districts Kaski, Parbat, Tanahu, Syangja, and Myagdi lie in Gandaki province (MoFE, 2021d). The hailstorms disrupt farming schedules, ruin future harvests and dislocate daily life. Reducing this risk require collective action to better forecast weather, promote climate-resilient agriculture and provide farmers with crop insurance and other forms of financial support to lessen the impact of hailstorm losses.

Gandaki Province has immense socio-economic problems, which are among its disaster vulnerability. Poverty is widespread in remote and isolated areas, limiting the communities' capacity to prepare for disaster. The vulnerable communities are deprived of access to education, health and other key services. Out-migration of young men to work as laborers has left women, children, and older populations that are less resilient to hazards. It constricts the ability of the community to respond and recover from the potential hazards. An in-depth understanding of the region's topography, history of disasters, socio-economic condition, and climate change impacts are essential for risk reduction and adaptation intervention definition.

The aim of this research is to evaluate vulnerability and multi-hazard risk at the municipality level, with highly significant implications for evidence-informed policy and community-based disaster risk management.

1.3 Statement of Problem

Gandaki Province, characterized by its complex topography ranging from the Terai plains to the high Himalayan peaks, faces heightened vulnerability to a variety of natural and anthropogenic hazards. Its diverse physical landscape, intersected with fragile geological formations, steep slopes and monsoon rainfall, creates an environment highly prone to floods, landslides, forest fire, droughts, and avalanches. Simultaneously, socio-economic challenges such as poverty, food insecurity, gender disparity, outmigration, poor infrastructure, and limited access to healthcare exacerbate the exposure and sensitivity of communities, hindering their capacity to cope and recover from disasters. Despite experiencing multiple large-scale disaster events, including the monsoon-induced disasters of 2000 and 2024, forest fire at 467 locations, highest dengue infections in 2019, Gorkha earthquake in 2015 and the 2014 Manang snowstorm, there has been limited spatially detailed assessment of multi-hazard risks and vulnerabilities at the municipal level. The increasing frequency and intensity of extreme weather events attributed to climate change further amplify the province's risk landscape. In this context, the lack of systematic and integrated risk information has made it difficult for local governments to design targeted interventions or prioritize high-risk areas, which are essential for effective disaster risk reduction and climate adaptation planning in the province.

1.4 Rationale of the Study

This study is crucial for addressing the urgent need to understand and map multi-dimensional risks and vulnerabilities across Gandaki Province, which is one of the most hazard-prone regions in Nepal. With 85 local governments spread across varied terrains and climatic zones, there is a significant gap in localized, evidence-based risk information to guide disaster risk management and adaptation planning. As Gandaki Province continues to experience rapid urbanization, infrastructural expansion, and climate-induced hazards, a spatially explicit multi-hazard risk assessment becomes a fundamental tool for policymakers, planners, and local governments to allocate resources effectively, enhance preparedness, and build resilient

systems. The study uses nationally and internationally recognized frameworks to assess the social vulnerability indicators in conjunction with hazard exposure to develop a composite understanding of risk at the municipal level. It offers an opportunity to mainstream disaster risk reduction and climate adaptation into local development planning, especially in remote and marginalized areas of the province. Furthermore, this assessment supports the formulation of inclusive, gender-sensitive, and equity-based risk reduction strategies that reflect the province's complex socio-economic and environmental realities, ultimately contributing to the creation of safer, more resilient communities across Gandaki Province.

1.5 Objective of the study

The specific objectives of this assignment are:

- 1) To identify and analyze publicly available data related to social vulnerability in Gandaki province using the nationally and internationally adopted framework.
- 2) To conduct a spatially explicit multi-hazard vulnerability risks assessment at the scale of municipality of Gandaki province.
- 3) To compare vulnerability, and other factors using quantitative metrics and identify their spatial overlap at the municipality scale.

1.6 Limitation of the study

This study provides a valuable and timely multi-hazard risk and vulnerability assessment for Gandaki Province using widely available and reliable secondary data sources. The use of standardized indicators and spatial datasets has enabled a consistent, comparative analysis across all 85 local governments, offering critical insights into the patterns of risk and exposure at the municipal level. Additionally, municipal-level responses collected through structured questionnaires regarding hazards, training and resource allocation, and DRR budgeting as a supporting data - gathered from disaster focal persons or designated representatives, have added important local perspectives to the analysis. However, the study did not incorporate primary data collection methods such as field-based hazard inventories, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs), which could have enriched the analysis by capturing site-specific nuances, indigenous knowledge, and real-time local experiences of vulnerability and capacity. These qualitative methods would have strengthened

the findings by validating and contextualizing the secondary data. Therefore, it is recommended that future assessments integrate participatory and field-based approaches alongside secondary data to develop more comprehensive, community-centered risk profiles. Such a blended methodology will help deepen understanding of ground realities and support more inclusive, responsive, and localized disaster risk management strategies across Gandaki Province.

1.7 Organization of the report

This report is structured into five comprehensive chapters, each addressing a specific aspect of the multi-hazard risk assessment in Gandaki Province. The organization of the report is as follows:

Chapter 1: Introduction

This chapter provides the foundational context for the study. It includes the background of the project, a brief overview of the study area, the statement of the problem, and the rationale for undertaking the study. It also outlines the key objectives and discusses the limitations encountered during the assessment.

Chapter 2: Literature Review

This chapter reviews relevant national and international literature related to hazard, vulnerability, and risk assessment. It synthesizes existing studies, frameworks, and models to contextualize the current research and identify knowledge gaps that this study aims to address.

Chapter 3: Methodology

This chapter details the methodological framework used in the study. It describes the identification of key indicators for hazard, exposure, sensitivity, and adaptive capacity. It further explains the processes of data collection and pre-processing, data normalization, weight assignment, and the approach adopted for vulnerability and risk analysis, including the development of a composite risk index and ranking.

Chapter 4: Analysis, Results, and Discussion

This chapter presents the results derived from the analysis and discusses them in relation to the broader context. It begins with an overview of the socio-economic, topographic,

environmental, anthropogenic, and climatic scenarios of Gandaki Province. It then presents the findings of the vulnerability and risk assessments, covering various dimensions including exposure, sensitivity, adaptive capacity, and overall risk levels. A comparative discussion is also made with reference to previously published studies and national or regional reports to validate and contextualize the findings.

Chapter 5: Conclusion and Recommendation

The final chapter summarizes the key findings of the study and provides practical recommendations for future actions in risk reduction, planning, and policymaking. It also reflects on the study's contributions and suggests areas for further research and improvement.

CHAPTER 2: LITERATURE REVIEW

By reviewing existing research articles, published project reports and relevant case studies, the study ensures methodological rigor, enables comparison with similar contexts, and tailors approaches to the specific socio-environmental and topographical conditions of Gandaki Province. This is particularly important when dealing with a wide spectrum of hazards, such as floods, landslides, forest fires, epidemics, and technological threats, which require diverse analytical tools and data inputs. The literature review also aids in selecting relevant indicators, refining data collection strategies, and identifying institutional and knowledge gaps. The subsequent section presents a review of relevant published project reports and case studies.

Nepal Hazard and Risk Assessment, 2010

The Nepal Hazard and Risk Assessment 2010 (MoHA, 2010), conducted by ADPC with support from NGI and CECI, developed a comprehensive multi-hazard risk profile of Nepal by analyzing spatial distribution and severity of key hazards such as earthquakes, floods, landslides, droughts, and epidemics. It utilized return-period-based hazard mapping (e.g., 50-500 years for seismic and flood events) and considered sectoral vulnerabilities. The study emphasized a multi-hazard approach, identifying high-risk districts such as Gorkha, Lamjung, Nawalparasi, and Syangja. Gandaki Province was a significant focus due to its varied topography, where hill districts showed high landslide and earthquake susceptibility, while southern areas faced flood and epidemic risks.

A structured methodology was adopted, combining hazard modeling, exposure analysis, and vulnerability assessment using demographic, economic, and infrastructural indicators. GIS-based models integrated these layers to produce composite risk maps at the district level. Indicators such as population density, construction type, crop sensitivity, and health infrastructure were used to evaluate sector-specific vulnerabilities. While the approach remains highly relevant for current risk assessments, this project introduces a new dimension by applying the methodology down to the municipality level in Gandaki Province, enabling more localized and actionable insights for multi-hazard risk analysis.

Vulnerability and Risk Assessment and Identifying Adaptation Options, Sectoral Report: Disaster Risk Reduction and Management (DRRM), 2021

The 2021 report Vulnerability and Risk Assessment and Identifying Adaptation Options in Disaster Risk Reduction and Management (DRRM), published by the Government of Nepal's Ministry of Forests and Environment (MoFE), forms a critical part of the National Adaptation Plan (NAP) process. With support from the British Embassy Kathmandu and Oxford Policy Management, it evaluates 15 climate-induced hazards, including floods, landslides, droughts, and GLOFs using a structured approach based on the IPCC AR5 risk framework. This methodology integrates hazard frequency, magnitude, and spatial extent with exposure and vulnerability indicators, applying GIS tools for mapping and hotspot analysis. Historical climate data (1971-2019) and projections through extreme indices and the FAR approach guided the identification of risk-prone zones across Nepal.

Specifically, for Gandaki Province, districts like Myagdi, Baglung, Lamjung, Gorkha, Kaski, and Syangja emerged as landslide hotspots, with Kaski and Syangja also showing high composite disaster impacts. The study emphasizes adaptation strategies spanning infrastructure, governance, and livelihoods, while also recognizing key limitations - particularly the lack of granular, municipal-level data. This gap in localized assessment and the report's recommendation for more detailed VRA updates highlight the need for a focused analysis. The current project builds on this foundational approach but advances it by conducting a multi-hazard vulnerability risk assessment at the scale of municipalities within Gandaki Province.

An Analysis of Social Vulnerability to Natural Hazards in Nepal Using a Modified Social Vulnerability Index

This study (Aksha et al., 2018) aims to assess and map social vulnerability to natural hazards in Nepal using a modified Social Vulnerability Index (SoVI) framework tailored to the Nepali context. The study aimed to quantify vulnerability at the village and municipal levels and explore its spatial distribution. Using 39 indicators across themes like age, education, ethnicity, gender, infrastructure, and access to services, the authors included context-specific variables such as caste (Dalit), minority populations, and non-Nepali speakers. Gender-based indicators included female-headed households, proportion of females, and female ownership of land and

houses - highlighting systemic inequalities that increase disaster vulnerability among women. Methodologically, principal component analysis (PCA) was used to distill these variables into seven components that explained 63.02% of the data variance. Spatial distribution was analyzed using ArcGIS and Moran's I tests to identify statistically significant vulnerability clusters.

The study found that the highest levels of social vulnerability were concentrated in the central and western Mountain, western Hill, and central and eastern Tarai regions, while the eastern and central Hill regions were the least vulnerable. Components such as "Migration and Gender" revealed that areas with higher rates of female-headed households, absentee populations, and greater proportions of females faced elevated risks. This underscores the gendered dimension of vulnerability, as women are often left behind in resource-poor households with reduced adaptive capacity. Urban areas like Kathmandu and Butwal were surprisingly found to be highly vulnerable due to rapid population growth, informal settlements, and strained infrastructure. The inclusion of gender-based and marginalized caste indicators highlighted how deeply social stratification influences disaster resilience. The study concludes by emphasizing the need for localized disaster risk reduction policies that address underlying social inequalities and support targeted intervention for vulnerable groups - especially women, Dalits, and indigenous minorities - thus providing a crucial tool for equitable disaster planning in Nepal.

Vulnerability and risk mapping at the municipality level in Dailekh and Sarlahi districts of Nepal

The technical brief titled "Vulnerability and Risk Mapping at the Municipality Level in Dailekh and Sarlahi Districts of Nepal: Visualization through an Online Dashboard" was published in December 2024 by the International Water Management Institute (IWMI) under the RES-WASH project, supported by the Australian Government's Department of Foreign Affairs and Trade. The study aims to assess vulnerabilities and climate-induced risks to Water, Sanitation, and Hygiene (WASH) systems at the municipal level in Dailekh (Karnali Province) and Sarlahi (Madhesh Province), Nepal. With a focus on inclusive planning, the study incorporates gender equality, disability, and social inclusion (GEDSI) perspectives. It identifies gaps in localized data, particularly those relevant to climate hazards and community-level impacts and addresses the need for integrating climate resilience into WASH planning. The dashboard developed from

the study provides a user-friendly visualization tool that enables local authorities to prioritize interventions, especially for marginalized communities including women, girls, and people with disabilities.

The methodology adopts the Intergovernmental Panel on Climate Change (IPCC 2014) risk assessment framework, where risk is a function of hazard, exposure, and vulnerability (which itself comprises sensitivity and adaptive capacity). A total of 182 indicators were used-37 for exposure, 55 for sensitivity, 24 for adaptive capacity, and 66 for hazards-sourced from institutions like NSO, DHM, and NDRRMA. These indicators include climatic (floods, droughts, landslides) and non-climatic data (demographics, health, Dalit population, and female water collectors). The six-step methodology includes data normalization using the min-max approach, multicollinearity testing, standardization, and aggregation to generate composite maps for each risk component. Gender-based vulnerability is a notable dimension, captured through indicators such as the percentage of women and girls responsible for water collection and marginalized group representation, highlighting their disproportionate exposure to climate-related WASH disruptions.

The reviewed literature collectively provides a robust foundation for assessing social vulnerability and multi-hazard risk in Gandaki Province by utilizing nationally and internationally recognized frameworks. The studies employ a range of hazard-specific and cross-cutting indicators - demographic, socio-economic, health, infrastructure, and climate data, combined through spatial modeling and GIS-based methodologies to produce vulnerability and risk maps. Specific hazards assessed include floods, landslides, forest fire, and epidemics, with an emphasis on their spatial distribution and compounded effects in municipal level. Gender-based disparities and marginalized communities' exposure are highlighted through inclusion of gender, age-group, and economically engaged indicators. Methodologies range from AHP to multi-criteria risk mapping, offering comparable and scalable metrics for evaluating vulnerabilities across municipalities. The insights from these assessments enable spatially explicit analysis of vulnerability hotspots, exposure patterns, and adaptive capacities, making them essential for localized decision-making and resilience planning in Gandaki Province.

CHAPTER 3: METHODOLOGY

To facilitate the analysis, the study team has reviewed and assessed the methodology, quality, and content of existing Vulnerability Risk Assessments (VRAs) created by the Government of Nepal and other development agencies. During the analysis, the study team has identified extreme climatic conditions (MoFE, 2021d), (MoHA, 2010), hazard histories (<http://drrportal.gov.np/>, <https://www.desinventar.net/>), exposure, sensitivity, and adaptive capacity indicators (MoPE, 2017), (Regmi et al., 2023) through a literature review, expert consultations and other relevant sources. Secondary data were sourced from governmental and non-governmental organizations, including climate change scenarios from institutions such as International Centre for Integrated Mountain Development (ICIMOD), Department of Hydrology and Meteorology (DHM), Department of Survey (DoS), and the respective local units, among others. Vulnerability was quantified and ranked at the municipal level, and the results were validated through stakeholder discussions. Figure 3.1 illustrated the process flow of the proposed framework, which was implemented in the local units of Gandaki Province. The subsequent subsection elaborated the methodology in detail.

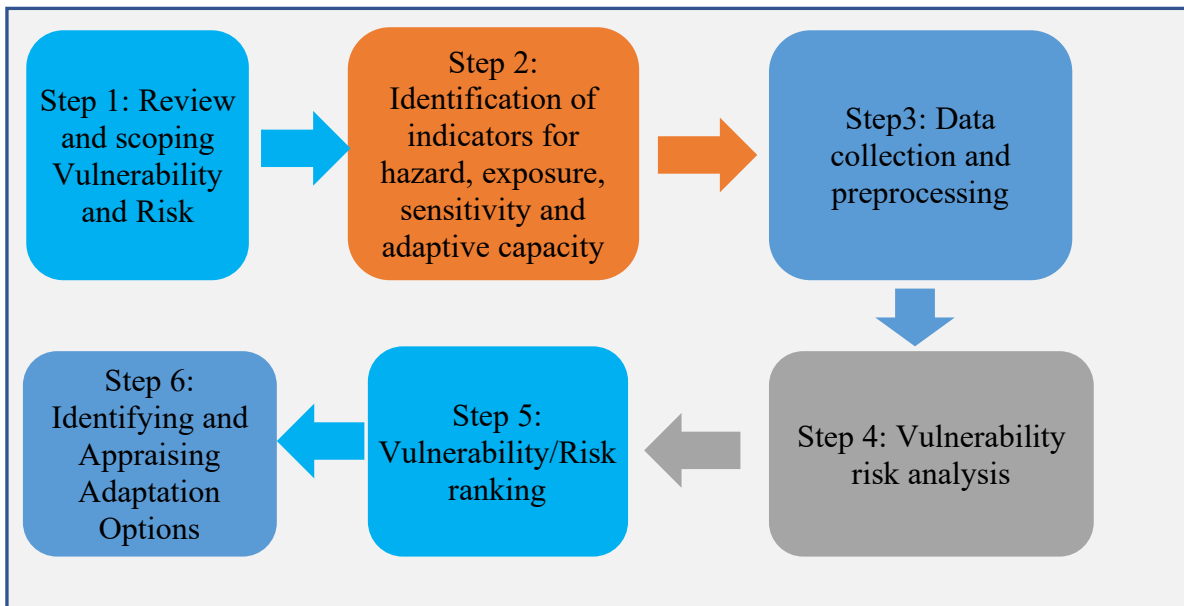


Figure 3.1: Methodology framework

3.1 Review and scoping the VRA

The review of Multi-hazard and Vulnerability Risk Assessments (VRAs) entailed a thorough analysis of their methodologies, data accuracy, vulnerability and risk identification, and overall quality at the local levels within the existing VRAs through a strength and weakness analysis. This review also included an in-depth content analysis to identify key findings and trends. It assessed the reliability of data sources and ensured consistency with established standards. The aim was not only to assess the current state of vulnerability assessment but also to provide a toolkit for improvement, thereby enhancing decision-making and risk mitigation efforts in Gandaki Province.

3.2 Identifying Key Indicators for Hazard, Exposure & Vulnerability

The main objective of this phase was to identify pertinent indicators for measuring and assessing trends in hazards, exposure elements, sensitivity status, and adaptive capacity of the people in Gandaki Province. These indicators served to quantify and qualify the extent, trends, and future projections of the assessment units. The hazard indicators included flood frequency and intensity, landslide frequency, extent and intensity of forest fires, and duration of epidemic periods. The exposure indicators included population density in hazard-prone areas, urbanization rate, road and transportation networks, and forests and agricultural lands in the hazard-prone areas.

3.2.1 Hazards, exposure, sensitivity and adaptive capacity

Hazards encompass incidents that could potentially harm the people within the region. The identification of major hazards or extreme climate events necessitates a comprehensive literature review of reports and database. Hydrometeorological hazards (Shah et al., 2020) are caused by extreme meteorological and climate events, such as floods, droughts, landslides, or mudslides. Geophysical hazards (Zhang et al., 2025) are natural events originating from the Earth's solid surface, including landslides, earthquakes, volcanic eruptions, and tsunamis. Forest fires (Manjari J.P., 2025) are a significant environmental hazard, leading to air and water pollution, habitat destruction, soil degradation, and increased greenhouse gas emissions, impacting human health and ecosystems. Biological hazards (Charnley et al., 2021) include infectious disease outbreaks and their potential to cause epidemic or pandemic situation.

Technological hazards (Mühlhofer et al., 2024) are risks arising from technological or industrial conditions, dangerous procedures, and infrastructure failures.

The primary hazards and activities posing threats in the region include floods, landslide, forest fires, droughts, climate change impacts such as temperature and precipitation variations, along with other extreme climatic conditions. Glacier and snow melt, outburst floods, and avalanches also need consideration. Extreme climatic conditions that might impact the region include occurrences such as extreme wet days, consecutive dry days, warm spell durations, cold spell durations, cold waves, heat waves, heavy rainfall, snowstorms, and thunderbolts. Similarly, activities contributing to these threats encompass unmanaged infrastructure and road networks, poaching, and unsustainable harvesting of non-timber forest products (NTFPs). These natural hazards, extreme climatic conditions, and human activities have exposed the identified targets.

Each target possesses its own set of exposure and sensitivity indicators concerning each hazard, and extreme climatic condition. Annex 1 provides the list of the hazards, exposure and sensitivity and adaptive capacity indicators that has been employed in the computation of vulnerability.

Assessing vulnerability to natural hazards like floods, landslides, and forest fires involves evaluating three key components: exposure, sensitivity, and adaptive capacity. Each component comprises specific indicators that help determine the degree of vulnerability. Below is an overview of these three indicators, particularly concerning health impacts:

3.2.2 Exposure Indicators

In Vulnerability Risk Assessments, exposure indicators quantify the degree to which people, assets, or systems are potentially affected by a hazard. These indicators measure the presence and extent of people, infrastructure, and ecosystems in areas susceptible to hazards. Population density is a key factor, as densely populated areas in hazard zones face higher risks of casualties and economic losses. Infrastructure vulnerability assesses the susceptibility of critical facilities such as hospitals, schools, and transportation networks to damage, which can disrupt essential services during disasters. Land use patterns also influence exposure, as urban expansion into floodplains, steep slopes, or fire-prone zones heightens the risk of disaster impacts. Additionally, environmental degradation - such as deforestation, wetland loss, and soil erosion

- weakens natural protective barriers, making communities more vulnerable to hazards like floods and landslides.

Hydrometeorological hazard – Flood

- **Proximity to Floodplain:** Areas closer to rivers and low-lying floodplains are at higher risk of inundation during heavy rainfall or river overflow. The extent of flooding depends on river dynamics, terrain, and precipitation intensity.
- **Infrastructure Exposure:** Roads, buildings, and critical infrastructure in flood-prone zones face potential damage, disrupting transportation, utilities, and essential services.
- **Land Use/Land Cover in Hazard zone:** The type of land use in flood-prone areas, such as urban settlements, forests, or wetlands, influences flood impact and water retention capacity. Built-up areas increase runoff, while natural landscapes may help absorb excess water.
- **Agricultural Land in Hazard zone:** Farmlands located in flood-prone regions are vulnerable to crop loss, soil erosion, and reduced agricultural productivity.
- **Population at Risk:** The number of people living in flood-prone areas determines the scale of potential human impact, including displacement, casualties, and livelihood disruptions.
- **Slope Steepness:** Gentle or flat slopes tend to slow down water drainage, allowing rainwater or overflow from rivers to accumulate and increase the likelihood of flooding. In contrast, steep slopes facilitate rapid runoff, reducing water accumulation but potentially increasing erosion and flash flood risks downstream.

Geophysical hazard – Landslide

- **Slope Steepness:** Steeper slopes increase the likelihood of landslides due to gravitational force and unstable geology. Areas with weak or fractured rocks are particularly vulnerable.

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- **Physiography Region:** The Chure range, with its fragile geology and steep terrain, is highly susceptible to landslides. Frequent soil erosion and weak rock formations contribute to instability.
 - **Vegetation:** Lack of vegetation reduces soil cohesion, making slopes prone to erosion and landslides. Tree roots help stabilize the soil and reduce water infiltration, preventing slope failure.
 - **Human Settlement Density in High-Risk Areas:** Settlements on hillsides or near cliff edges face higher landslide risks. Poorly planned urban expansion in such areas increases exposure to hazards.
 - **Land Use/Land Cover:** Deforestation, agriculture, and unplanned urbanization in landslide-prone areas disrupt natural drainage and soil stability, increasing susceptibility.
 - **Infrastructure Exposure:** Roads, buildings, and bridges built on unstable slopes can trigger or worsen landslides. Damage to critical infrastructure disrupts transportation, utilities, and safety.

Environmental hazard – Forest fire

- **Vegetation Type and Density:** Dense forests, shrubs, and grasslands provide abundant fuel for wildfires, increasing fire risk. The type and health of vegetation influence fire spread and intensity.
- **Weather Conditions:** High temperatures, low humidity, and strong winds create favorable conditions for ignition and rapid-fire spread. Extended dry periods and droughts further exacerbate fire risks.
- **Building Proximity to Forest Areas:** Structures near forests, known as wildland-urban interfaces (WUI), are highly vulnerable to wildfires.

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- **Fuel Load Density:** Accumulated dry vegetation, dead trees, and organic debris act as fuel, making certain regions more fire prone.
 - **Economic Assets:** Agricultural lands, industries, and infrastructure near forests are at risk of fire-related damage.

Biological hazard - Public Health / Epidemic

- **Population Density in Hazard Zones:** High population concentrations in disaster-prone areas increase the risk of mass casualties and strain emergency response systems.
- **Distance from Settlement:** Areas closer to settlements are more exposed to biological (health) hazards due to higher population density, poor sanitation, and greater potential for disease transmission.
- **Distance from River:** Proximity to rivers can increase exposure to waterborne diseases, especially in areas lacking proper sewage and waste management systems.
- **Distance from Road:** Regions near roads are more exposed to biological hazards due to increased human movement and vehicle emissions that may contribute to air and water pollution.

Technological hazard

- **Distance from Petrol Pump:** Areas close to petrol pumps are more exposed to technological hazards such as fire, explosions, and chemical leaks due to the presence of flammable substances.
- **Distance from Road:** Proximity to roads increases exposure to technological hazards such as vehicular accidents, hazardous material spills, and noise or air pollution.
- **Distance from Industry:** Settlements near industrial areas face higher exposure to technological hazards including toxic emissions, chemical leaks, and industrial accidents.

3.2.3 Sensitivity Indicators

Sensitivity indicators, used in vulnerability risk assessments, measure how susceptible a system is to harm from a hazard, encompassing factors like demographic, socioeconomic, and environmental conditions. These indicators assess the degree to which a system or population is affected by a hazard. Health status, including the prevalence of chronic diseases or malnutrition, can significantly impact an individual's ability to cope with emergencies. The age distribution of a population, particularly the presence of vulnerable groups such as the elderly and children are more sensitive to hazard. Socioeconomic status determines access to essential resources, with lower-income populations often facing greater challenges in rebuilding and adapting. Additionally, pre-existing health conditions, such as respiratory or cardiovascular diseases, can be aggravated by hazards like wildfires, increasing the severity of health impacts.

Hydrometeorological hazard – Flood

- **Age Vulnerability:** Children and the elderly face higher risks during floods due to physical limitations, weaker immune systems, and difficulty in evacuation. They are more prone to drowning, injuries, and post-flood diseases.
- **Gender Vulnerability:** Women may experience greater challenges due to caregiving roles, restricted mobility, and limited access to resources.
- **Socioeconomic Vulnerability:** Low-income households often reside in flood-prone areas with poor infrastructure, making them more susceptible to flood damage. Limited financial resources hinder their ability to prepare, evacuate, and recover effectively.
- **Access to Clean Water:** Floodwaters can contaminate drinking water sources, leading to outbreaks of waterborne diseases such as cholera and diarrhea. Reduced access to clean water exacerbates health risks and hygiene issues for affected communities.

Geophysical hazard – Landslide

- **Slope:** Steep slopes significantly increase the sensitivity to landslide hazards, as gravity more easily triggers the downward movement of soil and rock, especially when combined with heavy rainfall or seismic activity.

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- **Vulnerable Populations (Children/Elderly):** Communities in hilly or mountainous regions with limited mobility are at higher risk during landslides due to difficulty in evacuation. Children and elderly individuals are particularly vulnerable due to their physical limitations and dependency on external assistance.
 - **Infrastructural Sensitivity:** Roads, homes, and bridges in landslide-prone areas are at risk of collapse or blockage, disrupting transportation and access to essential services.
 - **Community Awareness:** The level of public knowledge and preparedness regarding landslide risks significantly affects response and resilience. Educated communities can implement early warning systems, evacuation plans, and preventive measures to reduce disaster impacts.

Environmental hazard – Forest fire

- **Age Distribution:** Children and the elderly have weaker respiratory systems, making them more vulnerable to smoke inhalation and heat stress. Their limited mobility also increases the risk of injury or death during evacuations.
- **Living in Fire-Prone Areas:** Communities in the wildland-urban interface (WUI) face a higher risk of property damage and loss of life due to wildfires.
- **Ecosystem Health:** Fragmented and degraded ecosystems lose natural firebreaks such as rivers, wetlands, or dense, healthy vegetation. This increases fire spread, reduces biodiversity, and weakens ecological resilience.
- **Infrastructure Exposure:** Critical infrastructure like powerlines, roads, and settlements in fire-prone areas can ignite or amplify fires, causing widespread damage.
- **Air Quality Sensitivity:** Poor air quality, especially with high levels of particulate matter and dry atmospheric conditions, increases the sensitivity to forest fire hazards by creating an environment where fires can ignite and spread more easily.

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- **Vegetation Condition Index (VCI):** Low Vegetation Condition Index values indicate stressed or dry vegetation, which significantly increases sensitivity to forest fire hazards by providing easily combustible fuel.

Biological hazard - Public Health / Epidemic

- **Age Distribution:** Populations with a higher proportion of children and elders are more sensitive to biological (health) hazards due to weaker immune systems and greater difficulty accessing or responding to medical care. Youth may be less physically vulnerable.
- **Access to Resources:** Adequate access to essential resources like food, clean water, and healthcare services are crucial in disaster situations. Lack of these resources can exacerbate the impact of the disaster.
- **Building Type:** well-designed structures with proper hygiene facilities can reduce vulnerability and improve resilience during health emergencies.
- **Slope:** Settlements on steep slopes may face increased sensitivity to biological hazards due to difficulties in accessing clean water, waste disposal, and healthcare services, especially during extreme weather events.

Technological hazard

- **Age Distribution:** Communities with a higher proportion of children and elders are more sensitive to technological hazards, as these age groups are less able to respond quickly to emergencies such as industrial accidents or toxic exposures.
- **Landcover (Builtup):** High built-up landcover increases sensitivity to technological hazards by concentrating people, infrastructure, and hazardous materials in a confined area, amplifying the potential impact of accidents.
- **Building Density:** High building density elevates sensitivity to technological hazards by increasing the likelihood of cascading failures, such as fires spreading quickly or toxic leaks affecting multiple structures.

3.2.4 Adaptive Capacity Indicators

In vulnerability risk assessments, adaptive capacity indicators focus on community or system's ability to adjust to potential damage, take advantage of opportunities, or respond to climate change consequences, including factors like financial resources, human resources, and adaptation strategies. These indicators evaluate the ability of a system or population to cope with and recover from hazards. Key indicators include healthcare system capacity, which assesses the availability and quality of medical facilities and personnel to provide care during a disaster. Emergency response plans focus on the existence and effectiveness of strategies in place to prepare for and respond to disasters, ensuring timely and coordinated action. Community networks measure the strength of social ties and community support systems, which are vital for providing assistance and fostering resilience during crises. Finally, access to information evaluates the availability of early warning systems and public awareness programs, ensuring that populations can take proactive measures and make informed decisions to minimize risks.

Hydrometeorological hazard – Flood

- **Disaster Response Capacity:** Involves the availability of safe flood shelters and clear emergency protocols to ensure timely evacuation and response. These systems help protect lives and reduce flood-related risks.
- **Infrastructure Resilience:** Refers to the ability of buildings, roads, and utilities to endure and recover from flood impacts. Resilient infrastructure minimizes damage and supports quick recovery during and after flood event.
- **Community Awareness Training:** Community awareness training enhances adaptive capacity to flood hazards by educating residents on preparedness, early warning systems, and emergency response, thereby reducing panic and improving coordinated action during floods.
- **Financial Resources:** Involves access to insurance, disaster recovery funds, and community grants to support recovery efforts.

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- **Economically Active Population:** A higher proportion of economically active population strengthens adaptive capacity to floods by providing labor, income, and resources necessary for preparedness, response, and recovery.

Geophysical hazard – Landslide

- **Community Awareness training:** Community awareness training improves adaptive capacity to landslide hazards by equipping people with knowledge on risk indicators, safe evacuation routes, and preparedness measures.
- **DRR Budget:** A dedicated Disaster Risk Reduction (DRR) budget enhances adaptive capacity by enabling investments in early warning systems, slope protection, and emergency preparedness for landslides. Sufficient funding ensures timely interventions and long-term resilience planning.
- **Building Type:** RCC bonded buildings have higher adaptive capacity to landslides due to their structural strength and durability, whereas mud bonded and wooden structures are more vulnerable to collapse.
- **Technology Access:** Access to technology, such as mobile communication, Radio/TV, computer and internet, greatly improves adaptive capacity to landslides by enabling timely alerts and informed decision-making.

Environmental hazard – Forest fire

- **National Park and conservation Area:** National parks and conservation areas often have dedicated management systems, trained personnel, and surveillance mechanisms, which enhance adaptive capacity to forest fires.
- **DRR Budget:** A well-allocated DRR budget strengthens adaptive capacity by funding fire control infrastructure, early warning systems, and community-based fire management programs.

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- **Community Awareness training:** Community awareness training enhances adaptive capacity to forest fire hazards by educating locals on fire prevention, safe practices, and emergency response, reducing the likelihood and impact of fires.

Biological hazard - Public Health / Epidemic

- **No. of Health Center:** A higher number of health centers improves adaptive capacity to biological (health) hazards by ensuring quicker access to medical treatment, disease diagnosis, and outbreak control.
- **DRR Budget:** An adequate DRR budget enhances adaptive capacity by enabling investments in health infrastructure, medical supplies, and emergency response training.
- **Education Level:** Higher education levels within a community increase adaptive capacity by promoting health literacy, hygiene practices, and informed decision-making during health emergencies.

Technological hazard

- **Length of Road:** A greater length of road infrastructure enhances adaptive capacity to technological hazards by improving access for emergency services, evacuation routes, and the transport of critical supplies.
- **Education Level:** Higher education levels improve adaptive capacity by enabling individuals to better understand technological risks, follow safety protocols, and respond appropriately during emergencies.
- **Health center distance:** Shorter distances to health centers increase adaptive capacity to technological hazards by ensuring timely medical attention for injuries or toxic exposures. Close proximity also supports rapid diagnosis and treatment in case of chemical or industrial accidents.

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- **Employed Population:** A higher proportion of employed individuals contributes to adaptive capacity by providing financial resources and stability needed for preparedness, insurance, and recovery.
 - **Community Awareness Training:** Community awareness training strengthens adaptive capacity by equipping people with knowledge on recognizing, preventing, and responding to technological hazards. Trained communities can take immediate and coordinated action, reducing casualties and damage during emergencies.

3.3 Data collection and pre-processing

The relevant datasets were systematically collected from credible secondary sources, which include government agencies like the National Statistics Office (NSO), Department of Survey, Department of Hydrology and Meteorology, and the Forest Research and Training Centre (FRTC), as well as pertinent ministries and local (rural) municipalities. Additionally, data from development organizations and international institutions such as ICIMOD and the World Bank's data repositories were utilized. For a significant portion of forestry and land-related datasets, the study team had used remote sensing sources like USGS and ESA. The historical disaster event records were collected from national platforms such as the BIPAD Portal (<https://bipadportal.gov.np/>) and municipal-level responses, collected through structured questionnaires prepared in google form as presented in **Error! Reference source not found.** and gathered from disaster focal persons or other municipal representatives. The refinement of data requirements was guided by the data indicators identified in the previous step, enabling to pinpoint the most relevant and reliable sources. The dataset outlined in Table 3.1 serves as the foundational data for analysis and base map development.

Table 3.1: Data description

SN	Data	Description	Data Source	Format	Spatial Coverage
1	Boundary	The political and administrative boundary of Gandaki province including district and municipal boundaries	DoS	Vector	Provincial level upto municipal detail

SN	Data	Description	Data Source	Format	Spatial Coverage
2	Landuse Landcover (LULC)	Land cover data of Gandaki province of year 2020	ICIMOD, FRTC	Raster	Provincial level
3	Infrastructure	Roads, buildings, and critical infrastructure including hospitals, schools	DoS, OSM	Vector	Provincial level
4	Transportation (Road Network)	The road alignment data including road class, width, surface types	DoR, OSM	Vector	Provincial level
5	Building Type	The building database includes types of building construction (RCC, mud..)	NSO, OSM	Tabulated, Vector	Provincial level
6	Settlement	It includes the name and distribution of major settlements	DoS, OSM	Vector	Provincial level
7	Elevation	It represents terrain elevation data, generated from satellite imagery	USGS ASTER DEM	Raster	Provincial level
8	Slope	Slope and steepness of land	ASTER DEM	Raster	Provincial level
9	River Network	Distribution of river alignments	ASTER DEM	Vector	Provincial level
10	Physiography Region	Division of physiographic region within Gandaki province	DMG	Vector	Provincial level
11	Vegetation	Spatial distribution of vegetation pattern	NDVI (Remote Sensing)	Raster	Provincial level
12	Weather	Satellite based weather information and extreme events	DHM, NOAA	Tabulated, Raster	Provincial level
13	Hydrological Data	Historical hydrological data from DHM hydrological stations	DHM	Tabulated	Provincial level
14	Population	Total population data	NSO	Tabulated, Vector	Local level
15	Population Density	Population density distribution	NSO	Tabulated, Vector	Local level
16	Population (Age group)	Population by age group	NSO	Tabulated, Vector	Local level
17	Population (Gender)	Population by gender	NSO	Tabulated, Vector	Local level
18	Socioeconomic	Income per capita	NSO	Tabulated, Vector	Local level

SN	Data	Description	Data Source	Format	Spatial Coverage
19	Clean Water	Database of water infrastructures	NSO, NWASH	Tabulated, Vector	Local level
20	Historical Hazard	Historical records of different hazards (flood, landslide and forest fire)	DRR Portal	Tabulated, Vector	Local level
21	Historical Epidemic Events	Historical records of public health issues (pandemic, epidemic)	Municipal Health Sector	Tabulated	Local level
22	Financial Resources	Annual budget allocation	Municipal Office	Questionnaire survey	Local level
23	Disaster Response Capacity	Emergency response frameworks, and infrastructure ready to respond hazards	Municipal Office	Questionnaire survey	Local level
24	Community Preparedness	Implementation of training awareness program	Municipal Office	Questionnaire survey	Local level
25	Early Warning System (EWS)	Installation of Early Warning System	Municipal Office	Questionnaire survey	Local level
26	Building Codes and Land Use Planning	Implementation of Building codes and Landuse planning	Municipal Office	Questionnaire survey	Local level

3.4 Data normalization and assign of weightage

The filtering, cleaning, and normalization processes were carried out to ensure that the collected or compiled data were accurate, complete, relevant, non-duplicate, consistently formatted, and expressed in a uniform unit. For normalization of the quantitative dataset, the min-max method was applied, which scales the values between 0 and 1 by subtracting the minimum value and dividing by the range of the indicator values as shown in equation a.

$$X_{normi} = \frac{X_i - X_{min}}{X_{max} - X_{min}} \dots\dots\dots (a)$$

where,

X_{normi} is the normalized value of an indicator,

X_i is the actual value of the same indicator,

X_{max} and X_{min} are the maximum and minimum values of the same indicators respectively.

Each normalized dataset was assigned a weight using pair-wise comparison as outlined in the Analytical Hierarchy Process (AHP) model to prioritize the relevant decision indicators. A slight modification to the standard AHP approach was made to accommodate the prioritization of a large number of indicators. Given the extensive list of indicators in this study, conducting a full pairwise comparison between every indicator was not feasible. Therefore, selected sets of indicators were presented to experts. To ensure a robust and contextually relevant prioritization of indicators, two subject-matter experts were selected based on their expertise in relevant thematic areas. Dr. Bhoj Raj Ghimire, a Remote Sensing and Geospatial Specialist, and Dr. Shobha Poudel, a Climate Change Expert, were consulted to assign weights to the selected indicators. Using Saaty's 9-point scale, each expert independently evaluated the relative importance of the indicators within their domain of expertise. Their expert judgments provided the basis for deriving consistent and informed weight values used in the multi-criteria analysis.

3.5 Vulnerability risk analysis

Social vulnerability was identified by assessing the capacity of individuals and communities to prepare for, respond to, and recover from hazards, based on a range of socio-economic, demographic, and infrastructural factors. The indicators included poverty level, age group ratio, literacy rate, access to health services, housing quality, and availability of water and sanitation. In vulnerability risk analysis, social vulnerability was integrated with hazard exposure and sensitivity data to assess overall disaster risk.

Each datum was assigned a specific weight, and composite values were computed based on these assigned weights during the analysis stage. The criteria and weight indices were identified through stakeholder consultations and experts' evaluations using pairwise comparison of indicators, employing the Saaty Scale to gauge their relative importance. The outcomes of the pairwise comparison was subjected to verification through the consistency index ($CI < 0.1$) to assess the overall consistency of the comparison process. The weight attributed to a particular indicator varied across different applications. For instance, the weight assigned to the soil erosion hazard index in a forest scenario was relatively lower compared to its weight in a malaria risk index scenario. In such cases, distinct identifiers were assigned to indicators for different applications.

The comparison adhered to the Saaty scale detailed in Table 3.2. Within the pairwise comparison methodology, each feasible pair of criteria was assessed and ranked relative to the other using a scale ranging from "equal importance" to "extremely important." The assessment of all potential pairs generated a ratio matrix. The numerical weights were ascertained through the normalization of the eigenvector linked to the highest eigenvalue of the ratio matrix.

Table 3.2: 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 strong to extremely strong importance
9	Extreme importance

Aggregation

A weighted average was adopted for the aggregation. It includes a linear combination of standardized value by means of weights as shown in equation (i).

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

The aggregated indicator AC, such as the combined adaptive capacity, is derived from individual indicators like x_i , which represents the adaptive capacity of a vulnerability element. The corresponding weight assigned to indicator x_i is represented by w_i . The optimal choice is the one that yields the lowest AC value. This process was applied uniformly to all components, including exposure, sensitivity, and adaptive capacity.

According to the IPCC-AR5, vulnerability is influenced by both Sensitivity and Adaptive Capacity, while the risk is shaped by Hazard Intensity, Exposure, and Vulnerability, as depicted in equations (ii) and (iii).

$$V = S - AC \quad \dots\dots\dots (ii)$$

Where,

V is the composite vulnerability indicator,

S is the sensitivity component of vulnerability and

AC is the adaptive capacity component of vulnerability

And,

$$R = H_{intensity} \times V \times E \quad \dots\dots\dots (iii)$$

Where,

R is the risk index,

$H_{intensity}$ is the hazard intensity,

V is the vulnerability and

E is the exposure

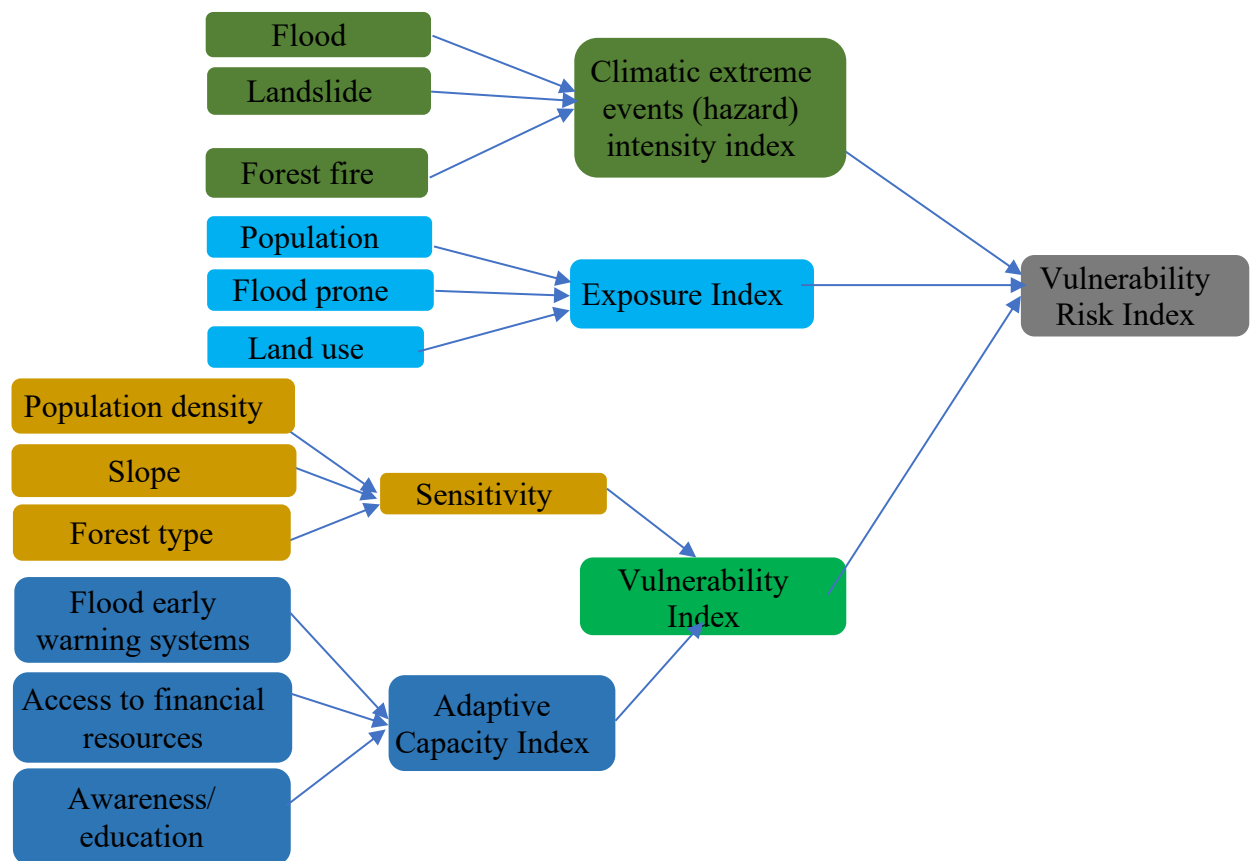


Figure 3.2: A typical process to compute the vulnerability risk indices

3.6 Vulnerability Risk Rank

The vulnerability risk indexes were categorized into five classes: (a) Very Low, (b) Low, (c) Moderate, (c) High, and (d) Very High, determined by the risk index. The index was converted to percentiles, and these percentile values were then be translated into the respective classes using a percentile scale division. It aided in formulating appropriate local-level policies in accordance with the identified risk classes. This approach enabled to identify the most vulnerable local levels and hotspots, facilitating the planning of subsequent steps with effective adaptation and mitigation measures.

CHAPTER 4: ANALYSIS, RESULTS AND DISCUSSION

4.1 Socio-economic Scenario

In the context of vulnerability and risk assessment in Gandaki Province, the socio-economic indicators are vital for identifying communities most at risk from climate-induced hazards such as floods, landslides, and droughts. Populations with limited education, poor housing infrastructure, inadequate access to basic services, and low economic resilience are generally more vulnerable and less capable of coping with disasters. In particular, remote and low-income households in hilly regions often lack timely access to information, emergency services, and resilient infrastructure, increasing their susceptibility during crises. Assessing socio-economic conditions enables policymakers and disaster risk managers to prioritize high-risk areas, design inclusive and context-specific disaster response strategies, and allocate resources more effectively. Furthermore, integrating socio-economic data into disaster planning supports long-term resilience by guiding targeted capacity-building, infrastructure improvement, and the development of social safety nets that address underlying vulnerabilities across the province.

4.1.1 Population and Population Density

Gandaki Province has a diverse population spread across mountainous, hilly, and valley regions. The population distribution is heavily influenced by topography and accessibility. Densely populated areas such as Pokhara Metropolitan City of Kaski district and its surrounding regions are hubs of economic activity, education, and services. In contrast, districts like Mustang and Manang have significantly lower population distribution as shown in Figure 4.1 due to their mountainous terrain, limited infrastructure and arable land, harsh climatic conditions and seasonal migration patterns. This uneven distribution directly affects the province's vulnerability profile. Highly populated areas are more likely to experience intense impacts during disasters such as floods, landslides, or fires, as a greater number of people and assets are at risk. On the other hand, sparsely populated, remote regions may face challenges in terms of delayed response, poor communication, and inaccessibility during emergencies. Understanding how populations are spatially distributed enables targeted disaster preparedness strategies, efficient resource allocation, and inclusive planning. For instance, in Pokhara, where population concentration is high, there is a critical need for robust infrastructure, effective early

warning systems, and urban resilience planning, while remote areas require improved access and decentralized risk management systems.

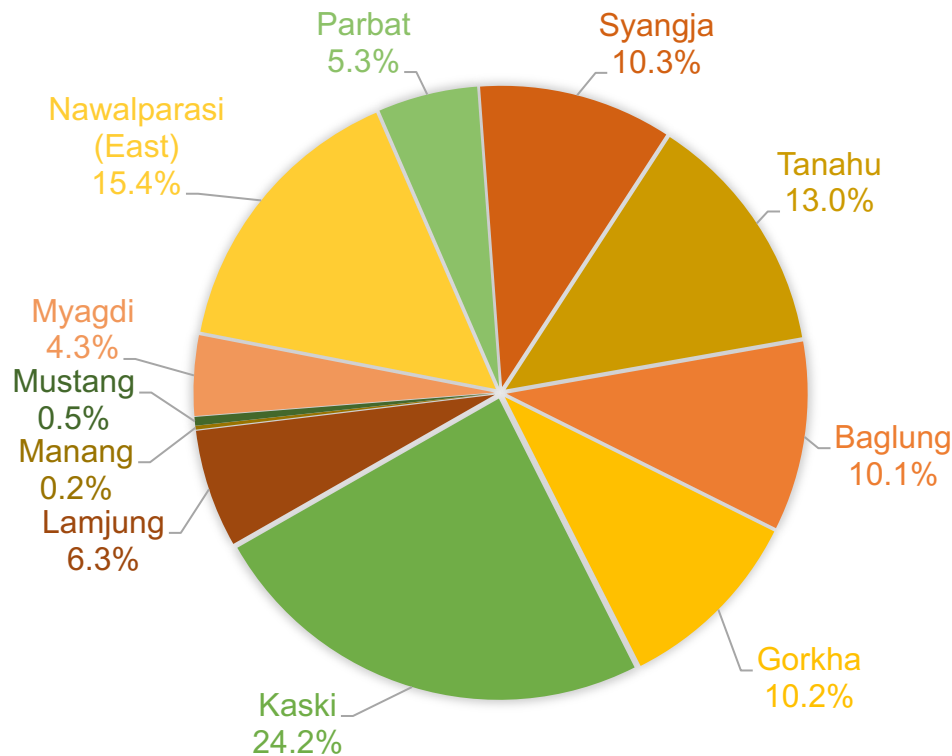


Figure 4.1: Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021

Population density is a key parameter in vulnerability assessment, as it helps determine the potential scale of human impact, resource demand, and logistical complexity during emergency situations. The population density map of Gandaki Province reveals stark contrasts across its districts, with Pokhara Metropolitan City emerging as the most densely populated area. This high-density zone faces unique disaster risks, particularly related to urban flooding, housing congestion, and infrastructural strain. In contrast, districts like Manang, with very low population densities, pose different challenges such as limited emergency response services and isolation during disasters. Densely populated areas require tailored interventions such as vertical evacuation strategies, rapid mobility planning, and resilient building codes. Meanwhile, for low-density regions, emphasis must be placed on accessibility, pre-positioning of relief materials, and community-based preparedness. Integrating population density data into disaster risk management ensures balanced attention to both urban and rural vulnerabilities across Gandaki Province.

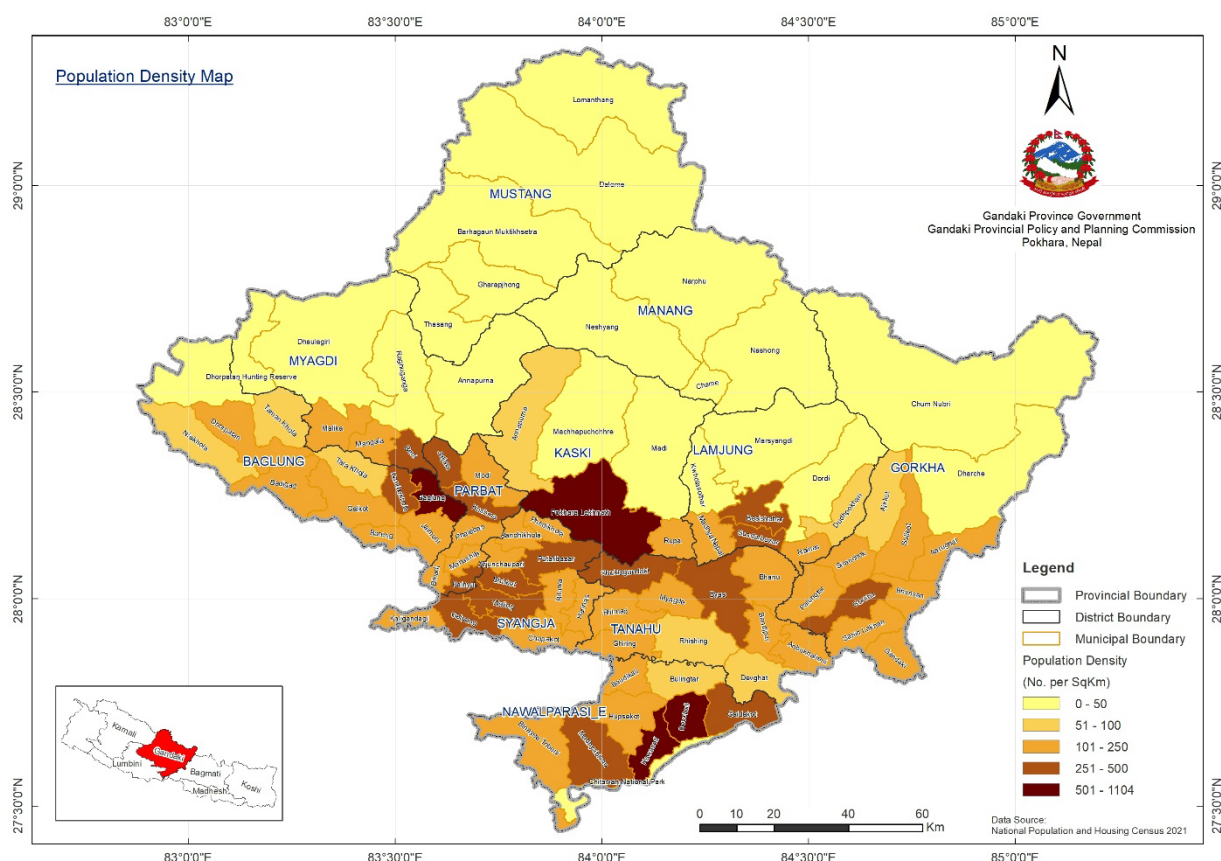


Figure 4.2: Population Density map of Gandaki Province

4.1.2 Gender based population

The gender-based population distribution of Gandaki Province, as shown in Figure 4.3, reveals a slightly higher proportion of females compared to males in many districts, primarily due to male out-migration for employment opportunities. This trend is especially noticeable in rural and highland areas, where a significant number of men move to urban centers or abroad, leaving women to manage households, agriculture, and caregiving responsibilities. As a result, the demographic structure becomes female-dominant in several communities. This shift has important implications for disaster preparedness and recovery, as women often lack equal access to resources, decision-making roles, and emergency information. These gender disparities can increase social vulnerability during disasters, especially when women are left with dependents and limited means of protection.

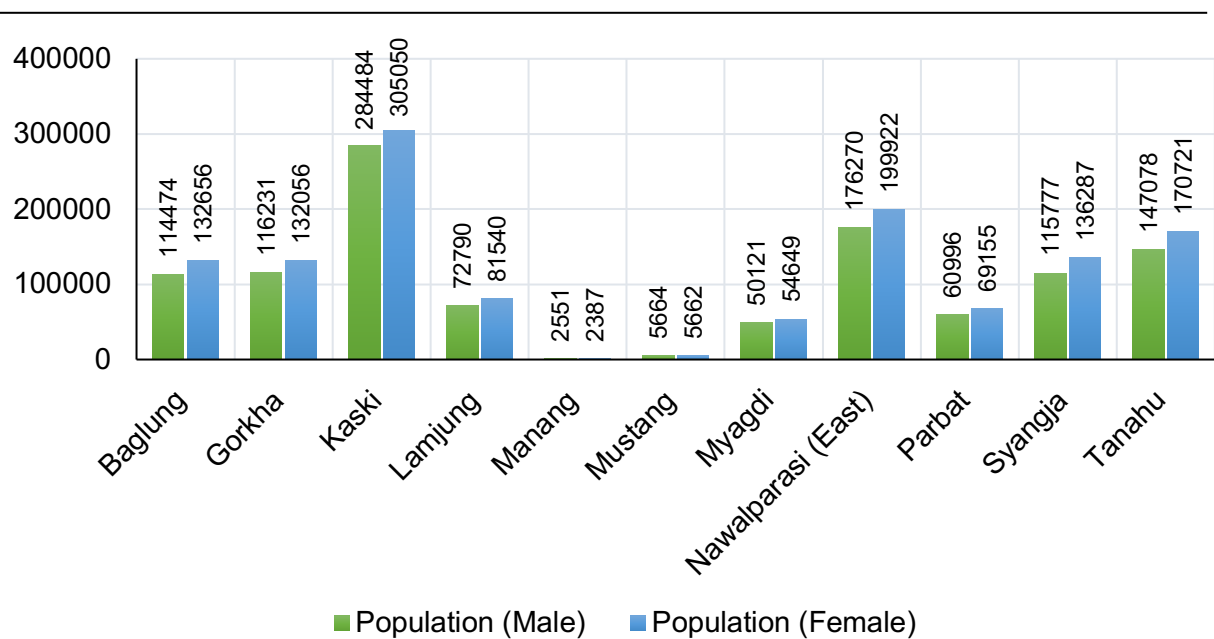


Figure 4.3: Gender based Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021

In terms of hazard exposure and sensitivity, male populations are often more exposed to direct physical risks due to their involvement in labor-intensive outdoor activities such as construction, agriculture, or transportation in high-risk zones. However, women tend to be more sensitive to the impacts of disasters due to existing socio-cultural constraints, such as restricted mobility, lower economic independence, and limited access to healthcare and education. This sensitivity is heightened when women are responsible for children and elderly family members during emergencies, making evacuation and recovery more challenging. Therefore, incorporating gender-based analysis into vulnerability and risk assessments is crucial to ensure that disaster risk reduction strategies in Gandaki Province are equitable, context-specific, and responsive to the distinct roles and challenges faced by both men and women.

4.1.3 Age group Population

The age group population distribution data of Gandaki Province reveals demographic patterns across its 11 districts, categorized into three age groups: below 15 years, between 16–60 years, and above 60 years, with further gender-wise segregation. The working-age group (16–60 years) dominates the population structure in all districts, particularly in Kaski, Tanahu, and Nawalparasi East. Children below 15 years also constitute a significant portion, with districts like Kaski and Baglung showing high numbers. The elderly population (>60 years) is relatively

lower but notable in districts like Kaski and Syangja. Smaller and remote districts like Manang and Mustang have low population counts across all age groups, reflecting sparse settlements and limited migration. The detail distribution of age group population of Gandaki province is shown in Figure 4.4.

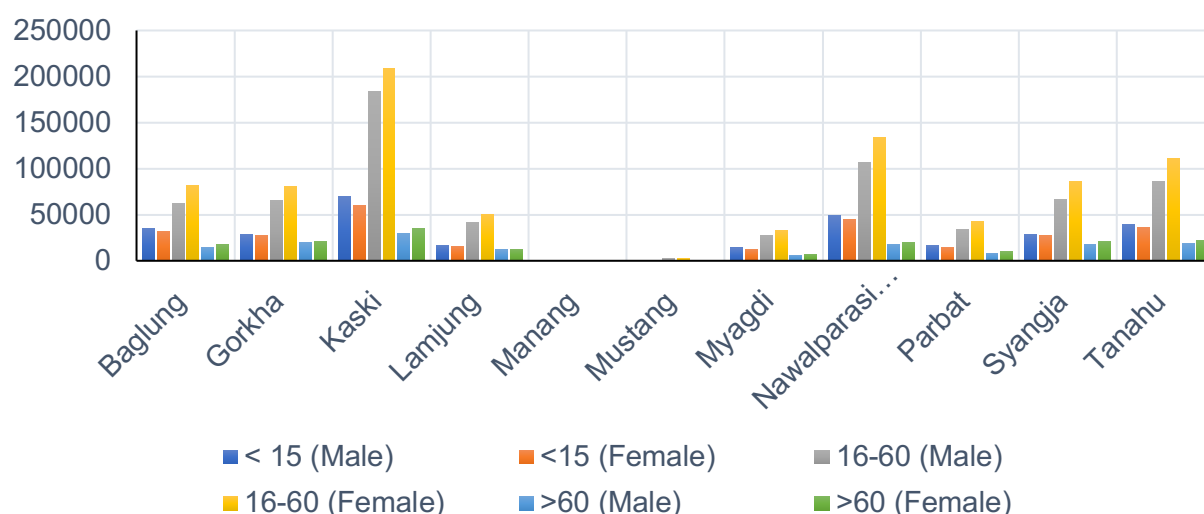


Figure 4.4: Age Group Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021

This demographic data is crucial for vulnerability and risk assessment. Understanding the age and gender distribution helps identify population segments more susceptible to climate-induced hazards, health risks, or limited mobility during emergencies. For example, high concentrations of elderly populations may indicate a need for targeted health and evacuation planning, while large child populations require educational continuity and nutritional support in disaster scenarios. Additionally, a high working-age population presents opportunities for community-based disaster preparedness and resilience-building programs. The data also supports resource allocation, infrastructure planning, and the design of age-sensitive risk reduction strategies tailored to the specific needs of each district.

4.1.4 Economically Active Population

The economically active population distribution in Gandaki Province, as shown in Figure 4.5, highlights the employment status of males and females across its 11 districts. The highest numbers of employed individuals are recorded in Kaski, followed by Tanahu and Nawalparasi East. Even in rural and mountainous districts like Mustang and Manang, there is notable economic participation, though the overall numbers are smaller. Unemployment figures are generally lower, with Kaski having the highest number of unemployed individuals, which may

reflect a larger urban workforce seeking opportunities. Across most districts, female economic participation is substantial and, in some cases, nearly equal to or surpassing male employment, as seen in Gorkha and Tanahu.



Figure 4.5: Economically Active Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021 (Table 53)

This data is vital for vulnerability and risk assessment in Gandaki Province as it provides insights into the capacity of the population to respond to and recover from disasters. Economically active populations, particularly those employed, are generally more resilient due to their income stability and potential access to resources. However, high unemployment, especially among women and youth, indicates economic vulnerability and limited coping capacity during crises. Understanding which districts have a high proportion of economically inactive or unemployed individuals helps in targeting interventions such as job creation, livelihood support, and skill development programs. It also supports planning for inclusive disaster risk reduction strategies that empower economically marginalized groups and enhance the resilience of communities across diverse geographic and socioeconomic contexts.

4.1.5 Wealth

The wealth status-based population distribution of Gandaki Province as shown in Figure 4.6, expressed in percentage terms across districts, reveals significant socioeconomic disparities. Districts like Baglung, Mustang, and Myagdi have a high proportion of their population in the

poorest and poorer categories-Baglung with 26.99% poorest and 43.71% poorer, and Mustang with 32.10% poorest and 29.85% poorer. In contrast, districts such as Nawalparasi East and Tanahu show relatively better wealth distribution, with 24.77% and 20.11% of their populations in the richest category, respectively. Kaski stands out for having a relatively balanced wealth profile, with 13.56% poorest, 17.32% richest, and significant middle-income representation. Manang and Parbat also show high percentages of people in the poorest and poorer categories, indicating limited wealth concentration. Overall, most districts have a sizable portion of their populations in the lower-income brackets, reflecting widespread economic vulnerability.

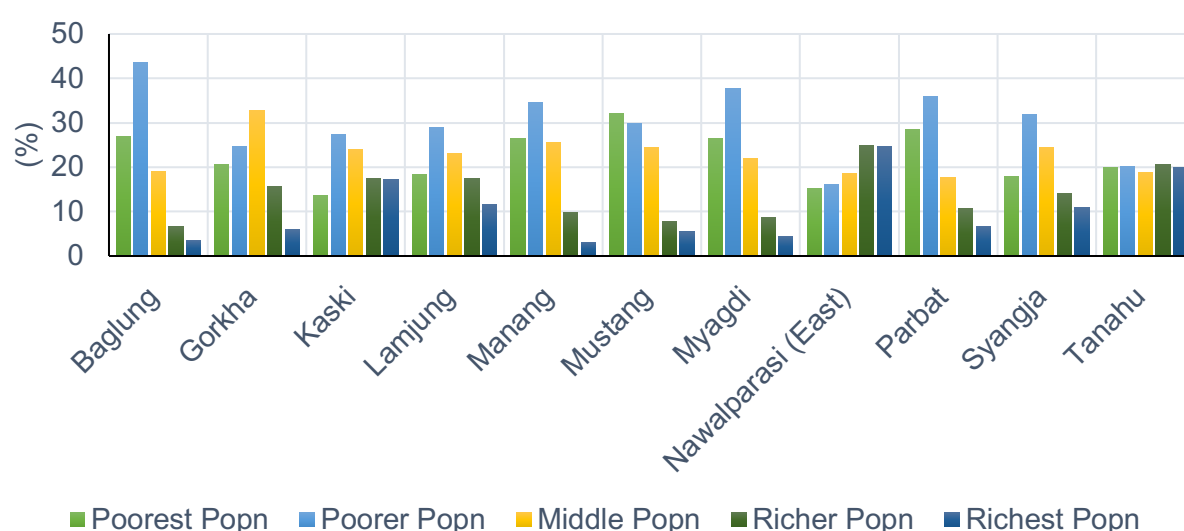


Figure 4.6: Wealth Status based Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021 (Table 32)

This wealth distribution data is critically important for vulnerability and risk assessment, as it helps identify communities most at risk during disasters. Poorer populations typically live in more hazard-prone areas, have limited access to quality housing, healthcare, and early warning systems, and face challenges in recovering from shocks. The data allows planners and policymakers to prioritize social protection programs, targeted aid, and resilience-building initiatives in districts with a higher concentration of poor households. It also informs inclusive disaster risk reduction strategies by ensuring that resources reach the most vulnerable groups, thereby reducing inequality and enhancing the overall adaptive capacity of the province.

4.1.6 Education Level

The education level-based population distribution of Gandaki Province reveals significant variation across its districts. The majority of the population has attained primary-level education, with districts like Kaski, Nawalparasi East, and Tanahu showing the highest figures. Kaski also leads in higher education, substantially more than any other district - indicating a strong academic profile. In contrast, remote districts such as Manang and Mustang have significantly fewer individuals with higher education; for instance. The provincial totals show that out of the total educated population, 28% are at the primary level, 21% at lower secondary, 17% at upper secondary, and only around 2% have attained postgraduate-level education as shown in Figure 4.7. This reflects a narrowing educational pipeline, with progressively fewer individuals reaching higher academic milestones, particularly in rural and mountainous districts.

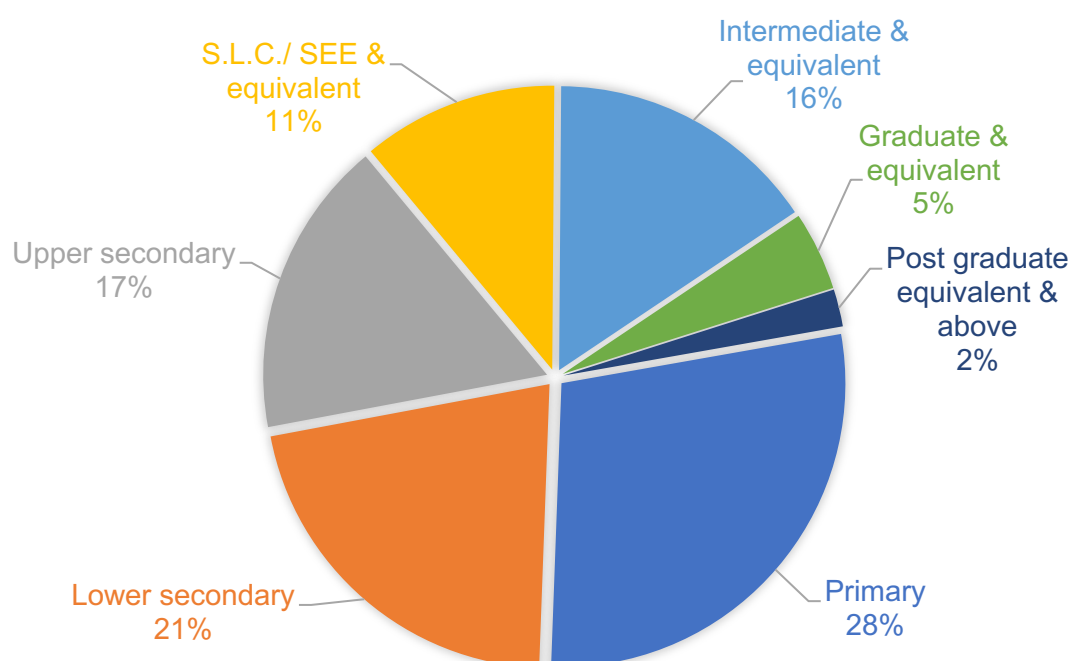


Figure 4.7: Education Level based Population Distribution of Gandaki Province
Source: National Population and Housing Census 2021 (Table 18)

This education data is essential for vulnerability and risk assessment in Gandaki Province as it directly relates to awareness, decision-making capacity, and access to critical information during disasters. Populations with lower education levels may struggle to interpret early warning messages, understand preparedness measures, or access essential services, increasing their vulnerability. Conversely, higher education levels are associated with better employment,

stronger coping mechanisms, and greater engagement in community resilience initiatives. Identifying districts with lower educational attainment helps inform targeted awareness campaigns, disaster education programs, and long-term strategies that build community knowledge and adaptive capacity, thereby strengthening overall disaster preparedness and resilience across the province.

4.1.7 Drinking Water Availability

The drinking water availability data in Gandaki Province, based on household distribution, shows that a majority of households in all districts have access to piped water. Districts like Manang (98.19%), Parbat (94.10%), and Kaski (93.05%) have the highest reliance on piped water, indicating well-established water supply systems. Conversely, Gorkha (76.72%) and Nawalparasi East (80.07%) have lower piped water coverage and relatively higher dependence on underground sources - 22.76% and 19.26% respectively. Mustang stands out for having the highest percentage (3.41%) of households depending on untreated surface water as shown in Table 4.1, suggesting limited access to safe drinking water in some areas. On average, the reliance on untreated surface water across the province is low, but pockets of vulnerability remain in specific locations, particularly in remote or mountainous regions.

Table 4.1: Drinking Water Availability of Gandaki Province

District	Piped Water	Underground Source	Surface/untreated Water
Baglung	92.71%	6.64%	0.65%
Gorkha	76.72%	22.76%	0.52%
Kaski	93.05%	6.27%	0.69%
Lamjung	91.86%	7.22%	0.91%
Manang	98.19%	1.68%	0.13%
Mustang	90.21%	6.38%	3.41%
Myagdi	90.82%	8.68%	0.50%
Nawalparasi (East)	80.07%	19.26%	0.66%
Parbat	94.10%	5.66%	0.24%
Syangja	89.54%	9.93%	0.53%
Tanahu	87.01%	12.32%	0.66%

Source: National Population and Housing Census 2021 (Table 6)

This data is crucial for vulnerability and risk assessment as access to safe and reliable drinking water directly influences community health, sanitation, and overall resilience to hazards. Households depending on underground or untreated surface water are more vulnerable to

contamination during floods, landslides, or droughts, increasing the risk of waterborne diseases and health emergencies. Understanding these patterns helps identify high-risk areas needing urgent infrastructure improvements or water quality monitoring. It also guides the planning of disaster-resilient water supply systems, especially in districts with limited piped water access, thereby enhancing public health protection and adaptive capacity across Gandaki Province.

4.1.8 Housing system

The housing system-based household distribution in Gandaki Province reveals significant differences in construction types across districts. Traditional mud-bonded houses are still prevalent in many areas, especially in Syangja, Tanahu, and Baglung, indicating a reliance on less durable structures. In contrast, urbanized districts like Kaski and Nawalparasi East have the highest numbers of cement/RCC bonded houses, reflecting modern, more disaster-resilient construction. Some districts, such as Mustang and Manang, still have a notable number of wooden and other types of structures as shown in Figure 4.8, which are generally less resilient to hazards and extreme weather. Overall, while some districts show a transition toward stronger housing systems, many rural areas still depend heavily on traditional, risk-prone construction types.

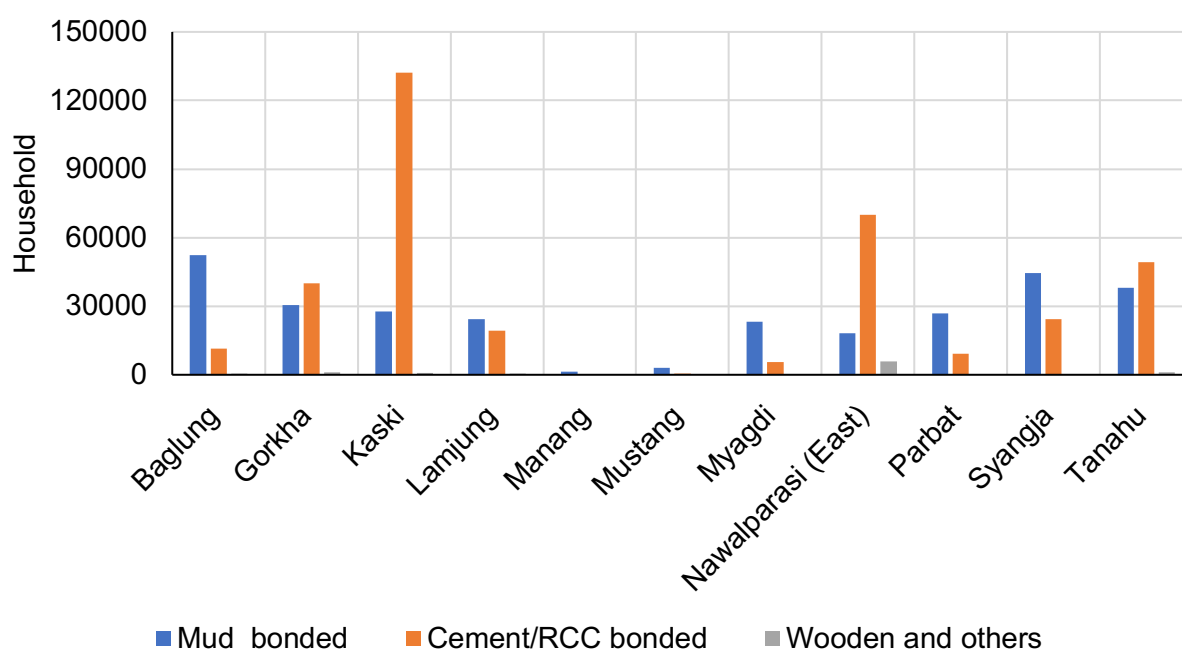


Figure 4.8: Housing system-based Household Distribution of Gandaki Province
Source: National Population and Housing Census 2021 (Table 2)

This data is critical for vulnerability and risk assessment in Gandaki Province because the type of housing significantly affects a community's exposure and resilience to hazards such as

rainfall, landslide, and fire. Mud-bonded and wooden houses are more likely to collapse during seismic events or suffer damage in heavy rains, posing greater risks to inhabitants. Identifying districts with high concentrations of such vulnerable housing allows for targeted retrofitting, awareness programs, and safer reconstruction efforts. Furthermore, the data supports planning for emergency shelter needs and resilience-focused housing policies, ultimately aiming to reduce structural vulnerability and enhance safety in disaster-prone areas of the province.

4.1.9 Technology Access

The technology access-based household distribution in Gandaki Province highlights the varying levels of digital and communication infrastructure across its districts. Mobile phone usage is nearly universal, with both ordinary and smart phones widely used - Kaski has the highest smart phone ownership and mobile access overall. Television and internet access are also highest in Kaski, followed by Nawalparasi East and Tanahu. In contrast, remote districts like Manang and Mustang show the lowest levels of access across all categories. Across the province, smart phone access surpasses ordinary phones, indicating a shift toward more connected devices, while internet access and computer/laptop ownership still lag behind. Landline telephone usage is minimal across all districts, showing a technological shift toward mobile communication. Overall, the provincial scenario of Gandaki shows high access to mobile phones and televisions, moderate to high internet access and computer/laptop ownership, while landline telephone use remains very low as shown in Table 4.2.

Table 4.2: Technology Access (Household) Distribution of Gandaki Province

District	Radio	TV	Land line telephone	Mobile phone (ordinary)	Mobile phone (smart)	Computer/ Laptop	Internet
Baglung	22884	28820	1898	47979	47277	6098	24115
Gorkha	24071	37542	1892	55417	41203	4366	18367
Kaski	58300	116923	18726	99810	141684	48353	105747
Lamjung	21859	24843	1228	34389	32133	4776	17472
Manang	290	914	75	1064	1178	195	584
Mustang	880	1980	313	2532	2782	338	1730
Myagdi	7319	11740	757	20123	21427	2418	13040
Nawalpa rasi (East)	39964	55569	3022	63236	79143	16099	57070
Parbat	14775	21306	1383	29706	26516	4168	12291
Syangja	23002	43734	1792	55096	52278	8065	25100

District	Radio	TV	Land line telephone	Mobile phone (ordinary)	Mobile phone (smart)	Computer/ Laptop	Internet
Tanahu	29352	51191	3102	61207	69069	12258	41491

Source: National Population and Housing Census 2021 (Table 10)

This data is crucial for vulnerability and risk assessment in Gandaki Province, as access to technology directly influences communication, disaster preparedness, and response. Households with internet and smartphones are more likely to receive early warnings, access critical information, and communicate during emergencies. Areas with low digital connectivity - especially in remote districts like Manang and Mustang—face higher vulnerability due to delayed information flow and limited access to online education, telemedicine, or e-governance services. Mapping technology gaps helps in planning digital inclusion, ensuring that even the most underserved populations can participate in disaster risk reduction efforts. Improving technological access across all districts enhances community resilience, supports real-time data collection, and facilitates coordinated emergency responses throughout the province.

4.2 Topographic and Environmental Scenario

4.2.1 Elevation

The elevation distribution of Gandaki Province, based on Digital Elevation Model (DEM) data from the United States Geological Survey (USGS), reveals a diverse topographic structure ranging from 89 meters in the southern lowlands to 8,146 meters in the northern Himalayas as shown in Figure 4.9. The terrain is categorized into six elevation zones: 22.17% of the province lies below 1000 meters, mainly in the southern districts; 17.37% falls within 1000–2000 meters; 13.17% within 2000–3000 meters; 13.93% within 3000–4000 meters; 15.69% within 4000–5000 meters; and 17.67% is located above 5000 meters as shown in Table 4.3, encompassing the high mountain regions including the Annapurna range. This altitudinal variation reflects the province’s transition from the Terai and mid-hills to the rugged Himalayan belt, influencing climate, vegetation, land use, and settlement patterns across the region.

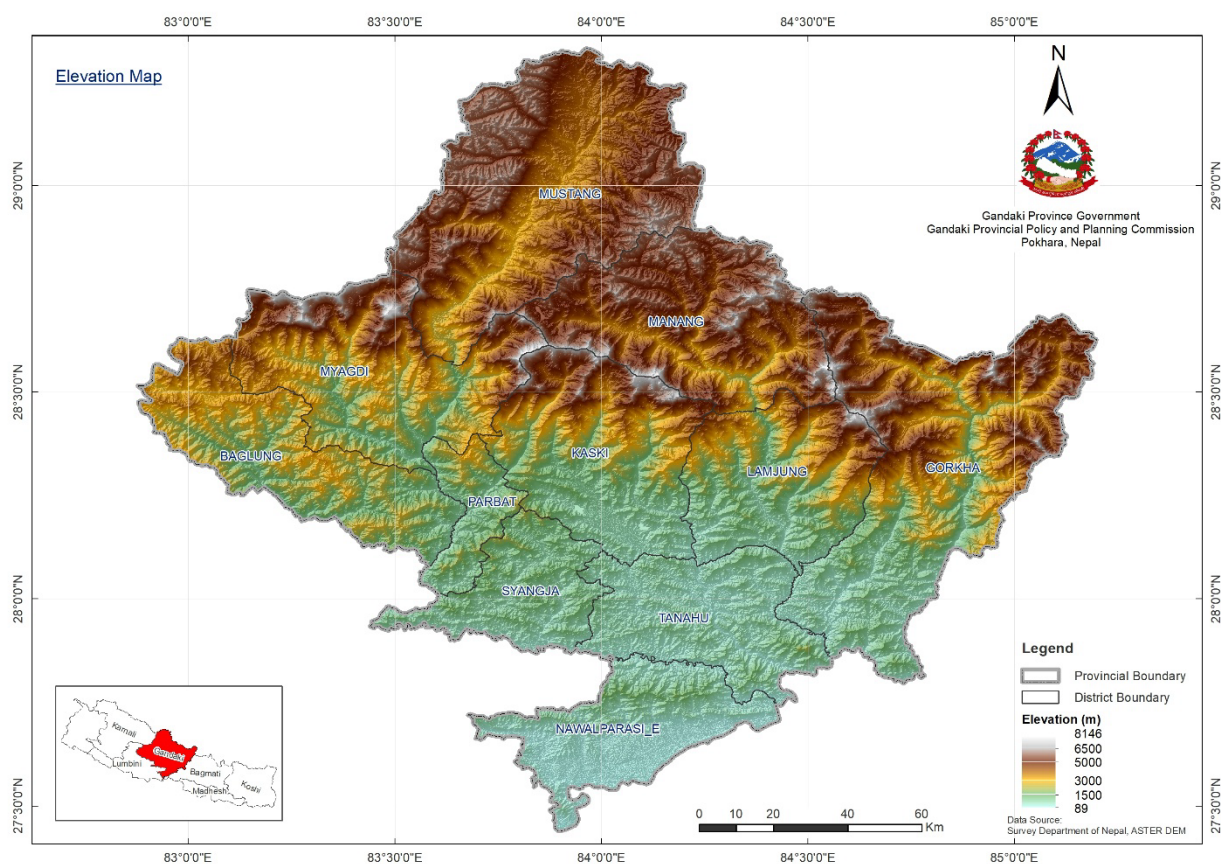


Figure 4.9: Elevation map of Gandaki province

Table 4.3: Distribution of area by elevation range

SN	Altitude (meter)	Area (%)
1	Below 1000 m.	22.17
2	1000-2000 m.	17.37
3	2000-3000 m.	13.17
4	3000-4000 m.	13.93
5	4000-5000 m.	15.69
6	Above 5000 m.	17.67
Total		100.00

Source: Reclassification of ASTER DEM Data

This elevation data is crucial for vulnerability and risk assessment in Gandaki Province, as altitude significantly influences the region's topographic and climatic characteristics. Although elevation itself was not directly used as an indicator, it played a foundational role in generating key derivative datasets such as slope, stream network, and proximity to stream network—critical components in hazard and exposure modeling. These derived layers were integrated into various indicators used in the vulnerability and risk assessment. In addition, physiographic

regions of Gandaki Province were delineated based on elevation zones, which guided spatial comparisons and adaptation planning. Accurate elevation profiling helps identify hazard-prone zones, support land-use planning, and design elevation-specific adaptation strategies. It also informs infrastructure development, emergency preparedness, and risk communication efforts to enhance community resilience across the diverse terrain of the province.

4.2.2 Physiographic Region

Gandaki Province exhibits a diverse physiographic distribution, encompassing five distinct regions that reflect its complex terrain. The High Mountain region occupies the largest portion at 44.81%, followed by the Hill region at 30.01% and the Middle Mountain region at 22.37%. The Siwalik region covers 4.65%, while the Tarai accounts for the smallest area. This variation in landform, from the flat southern plains to the rugged Himalayan mountains in the north, shapes the province's ecological zones, settlement patterns, and livelihood practices. These physiographic units serve as the basis for classifying land use, vegetation, accessibility, and development planning in the region.

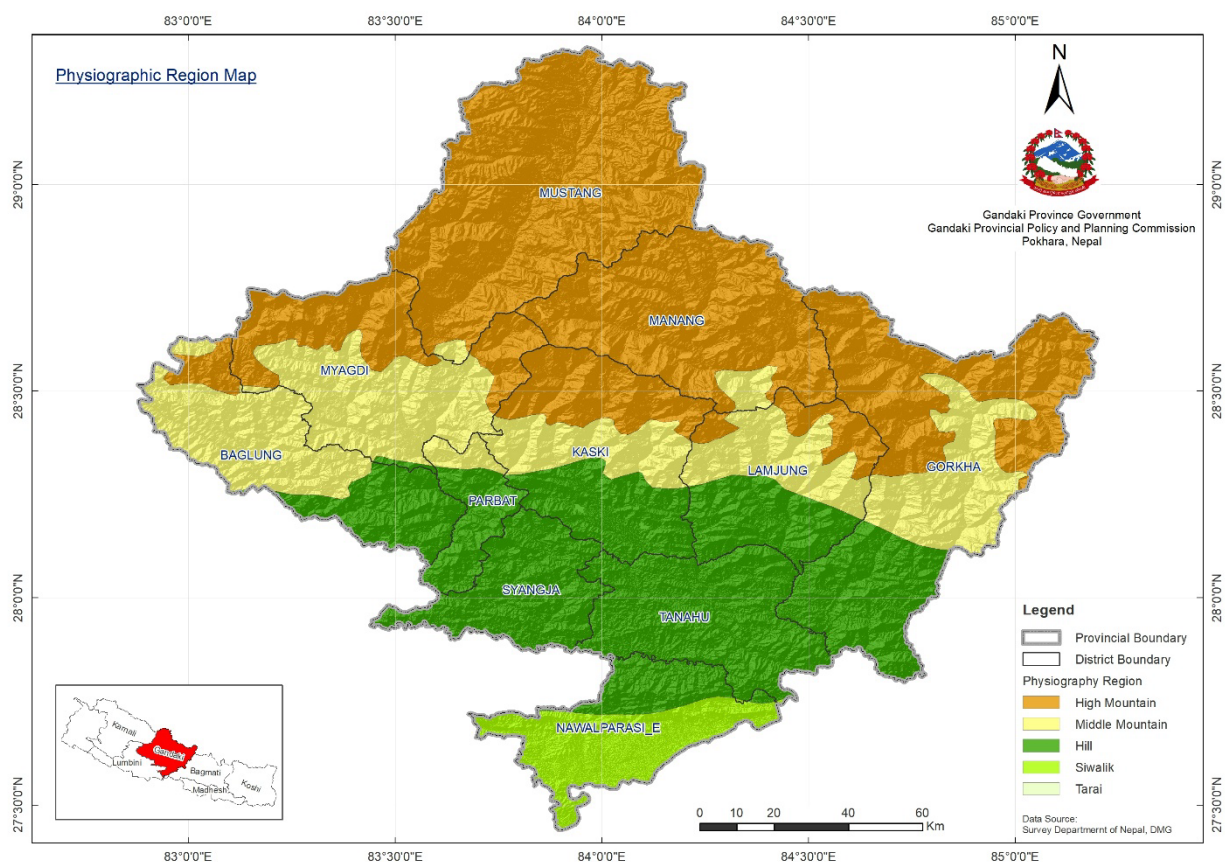


Figure 4.10: Physiographic region map of Gandaki province

Understanding the physiographic region distribution is vital for effective vulnerability and risk assessment in Gandaki Province. Each region is associated with specific hazard types: the High Mountain areas are prone to glacial lake outburst floods (GLOFs), avalanches, and extreme cold; Middle Mountain and Hill regions face frequent landslides, soil erosion, and seismic risks; while the Siwalik and Terai zones, though limited in area, are exposed to floods, sedimentation, and riverbank erosion. Recognizing these regional characteristics allows for tailored disaster risk reduction strategies and resilience planning. It ensures that resources are prioritized based on terrain-specific vulnerabilities, enabling more effective preparedness, mitigation, and adaptation efforts across the physiographically diverse landscape of Gandaki Province.

4.2.3 Slope

The slope distribution of Gandaki Province illustrates a predominantly hilly and mountainous terrain, with varying degrees of steepness. The largest share of land, 44.56%, falls within the 15–30° slope category, followed by 33.47% with slopes between 30–45°, indicating widespread moderately to steeply sloped areas. Gentle slopes of 5–15° account for 17.40%, while flat terrain with slopes less than 5° makes up only 4.97%. The most rugged terrain - slopes greater than 45° - covers 8.76% as shown in Figure 4.11. This slope pattern reflects the province's mountainous landscape, with limited lowland areas and a predominance of steep slopes that influence agriculture, infrastructure, and settlement development.

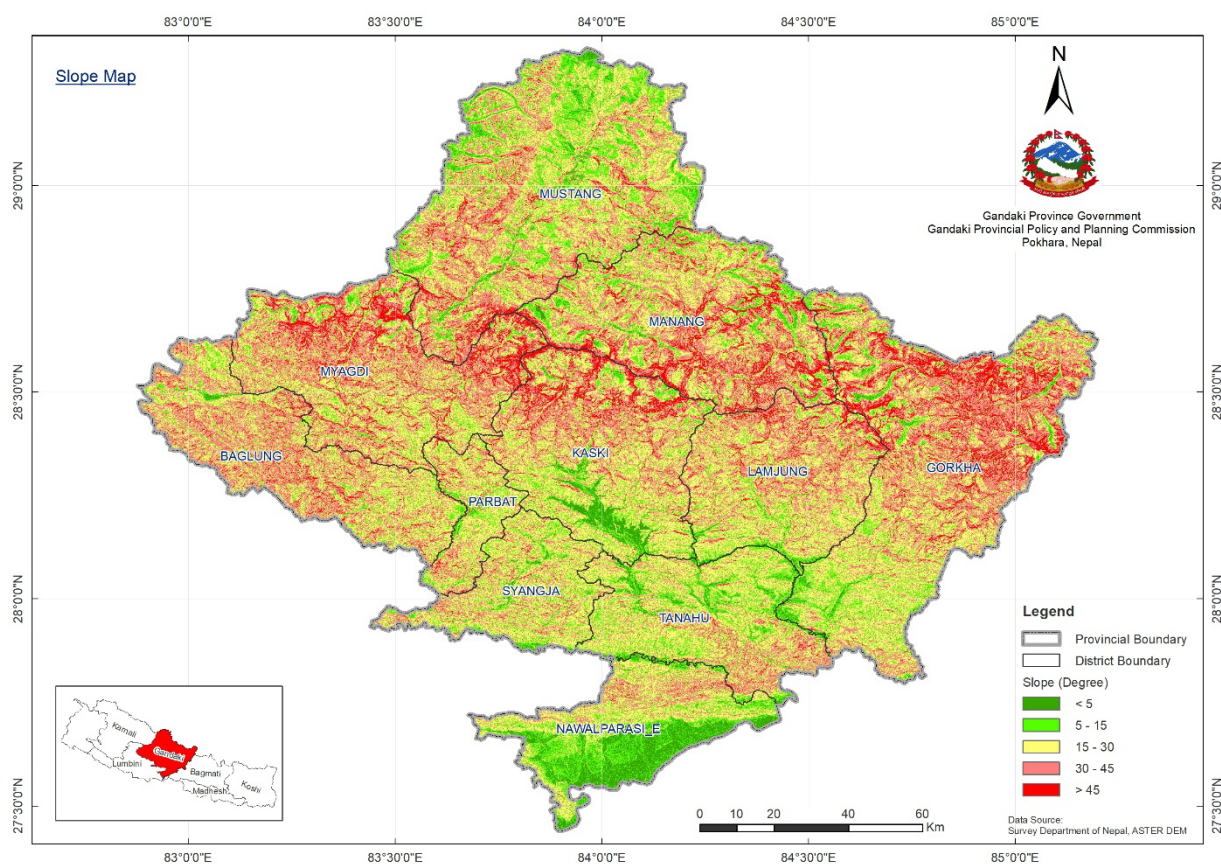


Figure 4.11: Slope map of Gandaki province

Slope data is a critical component in vulnerability and risk assessment in Gandaki Province. Steep slopes -particularly those above 30°- are highly prone to landslides, erosion, and slope instability, especially during intense rainfall or seismic activity. These areas pose significant risks to settlements, roads, and agricultural land. In contrast, flatter and gently sloped areas are less hazard-prone and more suitable for development and cultivation. Knowing the slope distribution helps planners identify high-risk zones, guide land-use planning, design safe infrastructure, and implement effective soil conservation and slope stabilization measures. It also aids in prioritizing disaster mitigation and climate adaptation strategies that account for the physical landscape and associated hazards.

4.2.4 River Network and proximity to River

Gandaki Province is characterized by a dense and diverse river network shaped by its unique topography and hydrological features. The province's rivers can be broadly categorized into three groups based on their origin. The first group comprises snow-fed rivers like the Kali

Gandaki, Myagdi, Seti, Modi, Mardi, Madi, Marsyangdi, Daraudi, and Budhigandaki, originating in the high Himalayan glaciated zones. These rivers have perennial flow, governed largely by glacial melt, ensuring water availability throughout the year. The second group includes rivers from the middle mountains and hilly regions, such as Aandhikhola, Suraudikhola, Phursekhola, Arunkhola, Daramkhola, and others. Their flow is influenced by monsoon precipitation and groundwater recharge, making them somewhat reliable even during dry periods. The third group consists of small hill-origin streams that are rain-fed and experience drastic seasonal variation, often drying up or flowing at very low levels outside the monsoon period. During the monsoon season (July–September), 60–85% of the annual runoff occurs, significantly increasing flow levels and disaster risks.

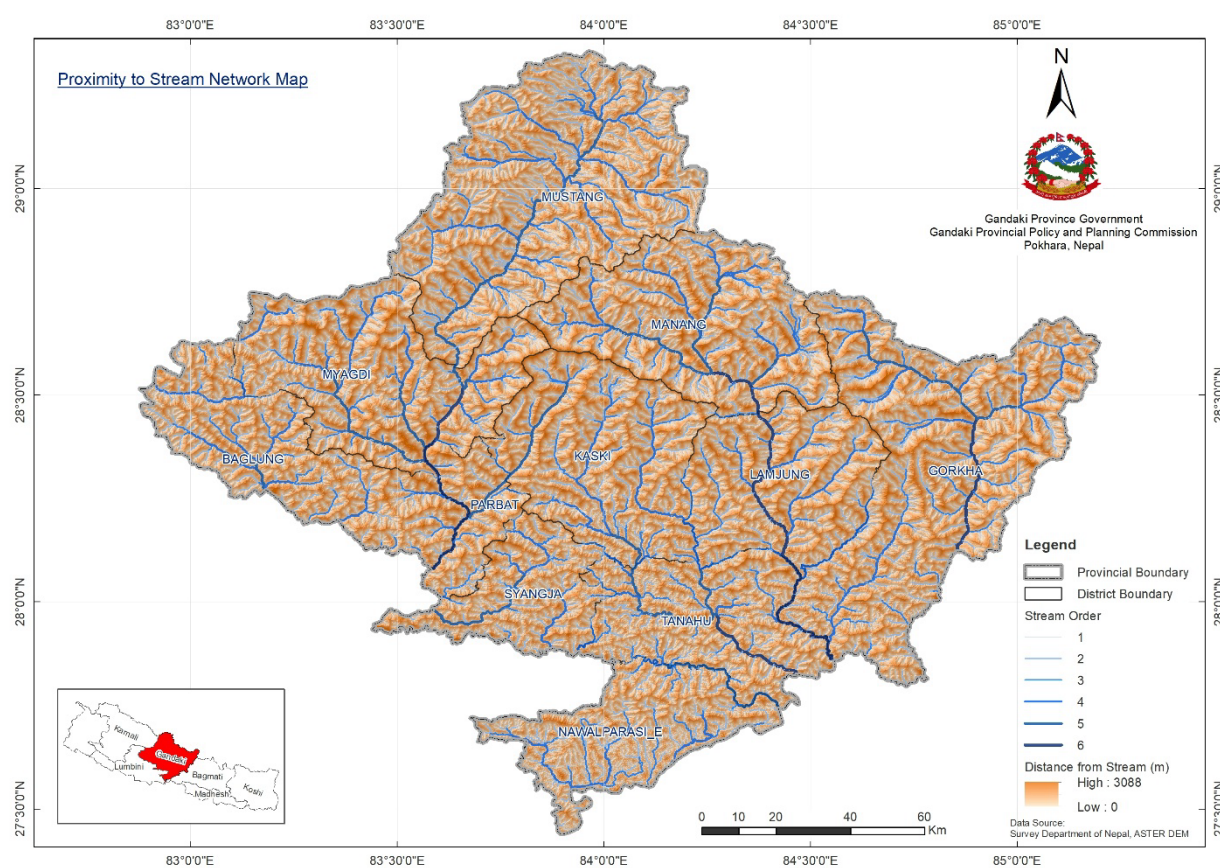


Figure 4.12: Proximity to river network map

The river network and proximity to rivers in Gandaki Province as shown in Figure 4.12, are vital elements in understanding regional vulnerability and disaster risk. Settlements, roads, agricultural fields, and critical infrastructure located near rivers, especially in steep or erosion-prone areas are highly susceptible to floods, riverbank erosion, debris flows, and landslides,

particularly during intense monsoon events. Snow-fed rivers, although perennial, can also cause glacial lake outburst floods (GLOFs) in the high mountains, posing catastrophic threats downstream. In contrast, rain-fed streams are prone to flash flooding during sudden storms. Mapping river networks and proximity helps identify hazard-prone zones, assess exposure levels, and design effective early warning systems, buffer zones, land-use policies, and flood protection infrastructure. It is a crucial input in spatial planning and sustainable development to reduce disaster losses in Gandaki Province.

4.2.5 Forest Type coverage

The forest type coverage distribution in Gandaki Province is diverse and extensive, reflecting the province's varied topography and climatic conditions. Forests span from subtropical Sal forests in the lower elevations to temperate and alpine forests in the mid-hills and high mountain regions. The forests are primarily categorized into broadleaf, coniferous, and mixed types, depending on altitude and precipitation. The dense forest covers are concentrated in mid-hill regions, while alpine forests are scattered in the northern mountainous belts. The distribution of forest types is crucial for ecological balance and natural disaster mitigation. Forest type coverage data plays a vital role in vulnerability and risk assessment in Gandaki Province. Forests act as natural buffers by stabilizing slopes, absorbing excess rainfall, and preventing rapid runoff that can lead to landslides and floods - hazards prevalent in this mountainous province. Forests also help reduce soil erosion and maintain watershed health, directly benefiting downstream settlements and infrastructure. Understanding the spatial extent and types of forests allows for the identification of ecologically sensitive zones and helps guide land use planning, conservation efforts, and community-based disaster risk reduction strategies. Preserving and managing forest areas enhances resilience and supports sustainable development across the province.

4.3 Anthropogenic Scenario

Anthropogenic parameters include land use and land cover, which reflect the extent of built-up areas, forests, agricultural lands, and barren zones, each varying in susceptibility to hazards like landslides or floods. Key infrastructures such as schools, hospitals, and government buildings represent critical assets whose proximity to hazard zones determines the urgency of protection and preparedness measures. Similarly, the road network and proximity to roads are

vital in risk assessment, as roads serve both as lifelines during emergencies and as potentially vulnerable elements prone to disruption. The distribution of settlements and their proximity to hazardous areas like steep slopes or floodplains directly affect population vulnerability and evacuation efficiency. Together, these anthropogenic indicators provide a comprehensive understanding of human-induced factors influencing risk, enabling targeted interventions for resilience building and disaster risk reduction across Gandaki Province.

4.3.1 Landuse / Landcover

The land use and land cover (LULC) distribution of Gandaki Province, based on ICIMOD 2020 data, reflects a terrain dominated by natural landscapes with limited human settlements. Among the major land cover types, tree-covered areas are the most extensive, comprising 38.93% of the total area, indicating significant forest presence across the province. This is followed by shrub/scrub land, covering 29.78%, largely found in middle hills and degraded forest zones. Bare ground, representing rocky, barren, or non-vegetated terrain, makes up 16.27%, mainly in high-altitude and arid zones such as Mustang and Manang. Snow and ice account for 8.72% as shown in Figure 4.13, reflecting the glaciated Himalayan areas in the northern part of the province. Other land cover types like built-up areas, crops, grasslands, water bodies, and flooded vegetation occupy relatively smaller proportions. The detail statistics of each landcover type are shown in Table 4.4. This diverse LULC composition highlights both the ecological richness and the environmental challenges of the province.

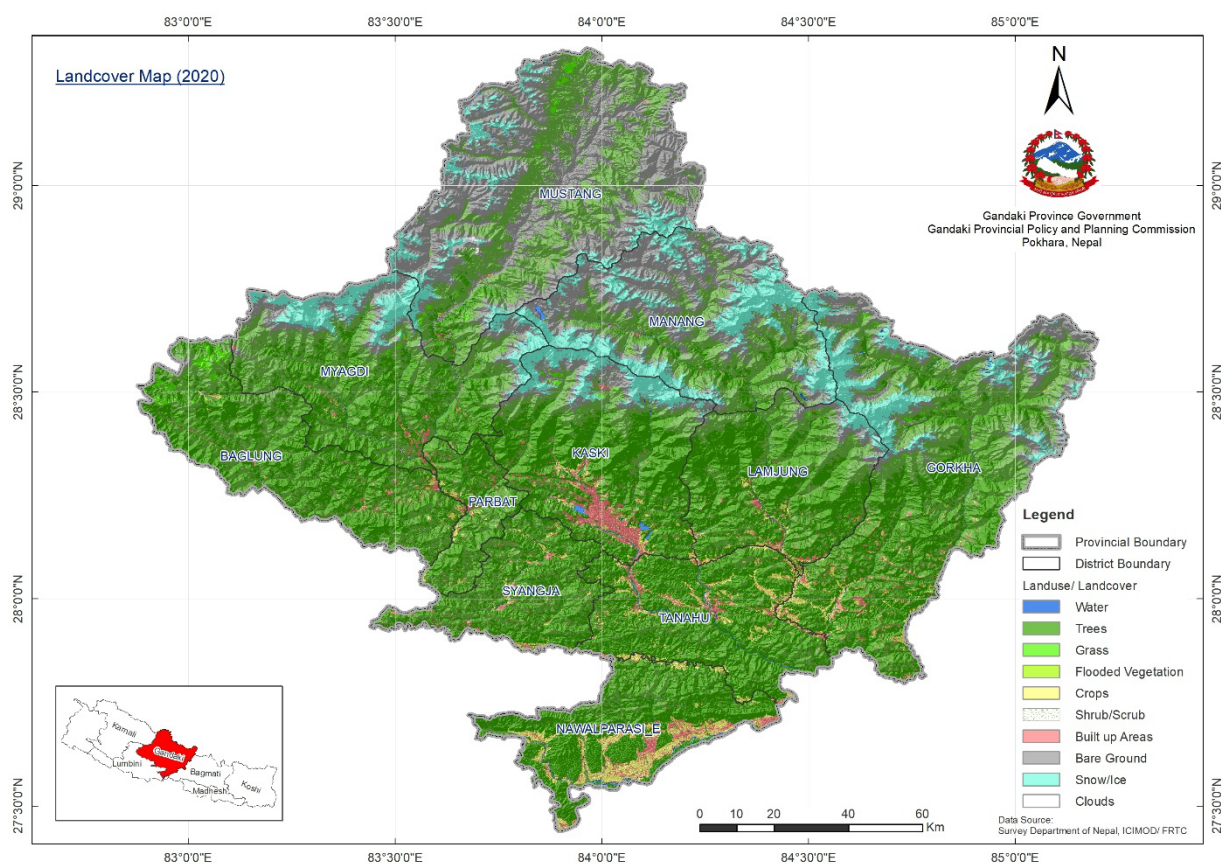


Figure 4.13: Landcover map of Gandaki province

Table 4.4: Landcover statistics of Gandaki province

SN	Landuse / landcover	Area (Sq Km)	Percentage
1	Water	136.05	0.62%
2	Trees	8543.30	38.93%
3	Grass	149.07	0.68%
4	Flooded Vegetation	1.35	0.01%
5	Crops	523.04	2.38%
6	Shrub/Scrub	6536.77	29.78%
7	Built up Areas	552.71	2.52%
8	Bare Ground	3569.95	16.27%
9	Snow/Ice	1914.13	8.72%

Source: ICIMOD Landcover 2020

Land use and land cover data are essential in vulnerability and risk assessment as they directly influence the exposure and sensitivity of different areas to hazards. For instance, forested areas (trees) help reduce landslide risk and maintain ecological stability, whereas bare ground and shrublands are more prone to erosion and degradation. Snow and ice-covered zones are susceptible to glacial lake outburst floods (GLOFs), especially under climate change pressures.

Built-up areas and agricultural land near rivers or steep slopes are at higher risk from floods and landslides. Monitoring LULC change helps identify trends such as deforestation, urban expansion, and land degradation, all of which increase vulnerability. Therefore, incorporating LULC into hazard mapping and resilience planning enables more accurate identification of at-risk zones and supports the formulation of targeted risk reduction strategies in Gandaki Province.

4.3.2 Road Network and proximity to road

The road network and proximity to roads in Gandaki Province reveal a pattern of increasing connectivity, particularly in the Middle Hills and urbanizing areas. While district headquarters and major municipalities are connected by established highways, many rural villages rely on informal and rapidly expanding feeder roads. These roads, often built through community initiatives or remittance-funded projects, frequently traverse unstable hill slopes without adequate engineering or environmental safeguards. As a result, the spatial distribution of road proximity shows dense clustering in accessible mid-hill districts such as Kaski, Tanahun, and Syangja, while the high mountain regions like Mustang and Manang have sparser networks due to difficult terrain. The population lives within 500 meters of a road, reflecting both improved access and increased exposure to slope-related hazards.

In the context of vulnerability and risk assessment, road network and proximity to roads are key indicators due to their dual role in enabling development and amplifying hazard risk. Informal roads, especially in hilly and mountainous terrain, often accelerate slope instability by undercutting steep gradients, altering natural drainage patterns, and allowing water infiltration into landslide-prone areas. These factors significantly raise the risk of landslides during monsoon months. Moreover, road proximity data helps in identifying critical lifelines for evacuation, emergency response, and service delivery. Understanding where populations and infrastructure are concentrated near vulnerable road corridors supports targeted mitigation measures, such as slope stabilization, controlled road planning, and community-based disaster preparedness in Gandaki Province.

4.3.3 Settlement and proximity to settlement

The distribution of settlements and proximity to settlements in Gandaki Province is highly influenced by the topography and accessibility of the region. Settlements are densely clustered

in the lowland and mid-hill areas such as Tanahun, Syangja, Kaski, and Nawalpur districts, where terrain is relatively gentle and suitable for agriculture, infrastructure, and economic activity. Conversely, the high mountainous districts like Mustang and Manang have sparse settlements due to harsh climate, rugged terrain, and limited accessibility. The proximity analysis reveals that a significant portion of the population lives within close range of clustered settlements, especially along valleys, riverbanks, and road corridors.

In vulnerability and risk assessment, settlement and proximity to settlement data are critical for identifying at-risk populations and planning effective disaster response. Dense settlement areas in steep and flood-prone regions are particularly vulnerable to landslides, floods, and other hazards, especially where informal construction and land use changes have occurred without proper planning. Proximity to settlements also indicates exposure levels of communities to nearby hazards and helps in prioritizing mitigation interventions such as early warning systems, safe evacuation routes, and resilient infrastructure planning. Understanding settlement distribution supports targeted risk reduction strategies and ensures resources are allocated effectively in both urban and rural areas of Gandaki Province.

4.4 Climate Scenario

The climate of Gandaki Province is primarily influenced by two major weather systems: the summer monsoon circulation, which occurs from June to September, and the westerly circulation, dominant from November to May. These systems bring distinct seasonal variations across the province. The summer monsoon, originating from the Bay of Bengal, brings heavy rainfall particularly to the southeastern part of the province, accounting for approximately 80% of the total annual precipitation. On the other hand, the westerly disturbances contribute significantly to winter precipitation, especially in the northwestern highland areas. This spatial variation in precipitation patterns results in diverse climatic conditions across Gandaki from humid subtropical zones in the south to cold alpine climates in the high Himalayas shaping local ecosystems, agriculture, and water resources.

4.4.1 Maximum and Minimum Temperature

The temperature distribution in Gandaki Province is strongly influenced by seasonal cycles and elevation gradients, ranging from tropical lowlands to alpine high mountains. The annual

maximum mean temperature in the province varies widely, from as low as -2.53°C in the northern high-altitude areas to as high as 45.87°C in the southern lowland regions as shown in Figure 4.14 derived from WorldClim dataset of 1970 to 2020. Similarly, the annual minimum mean temperature ranges from a frigid -30.09°C in the Himalayan zones to a milder 18.87°C in the southern Terai and mid-hill zones as shown in Figure 4.15. These figures reflect the province's significant topographical and climatic diversity, with the southern belt being the hottest and the northern Himalayas being the coldest throughout the year.

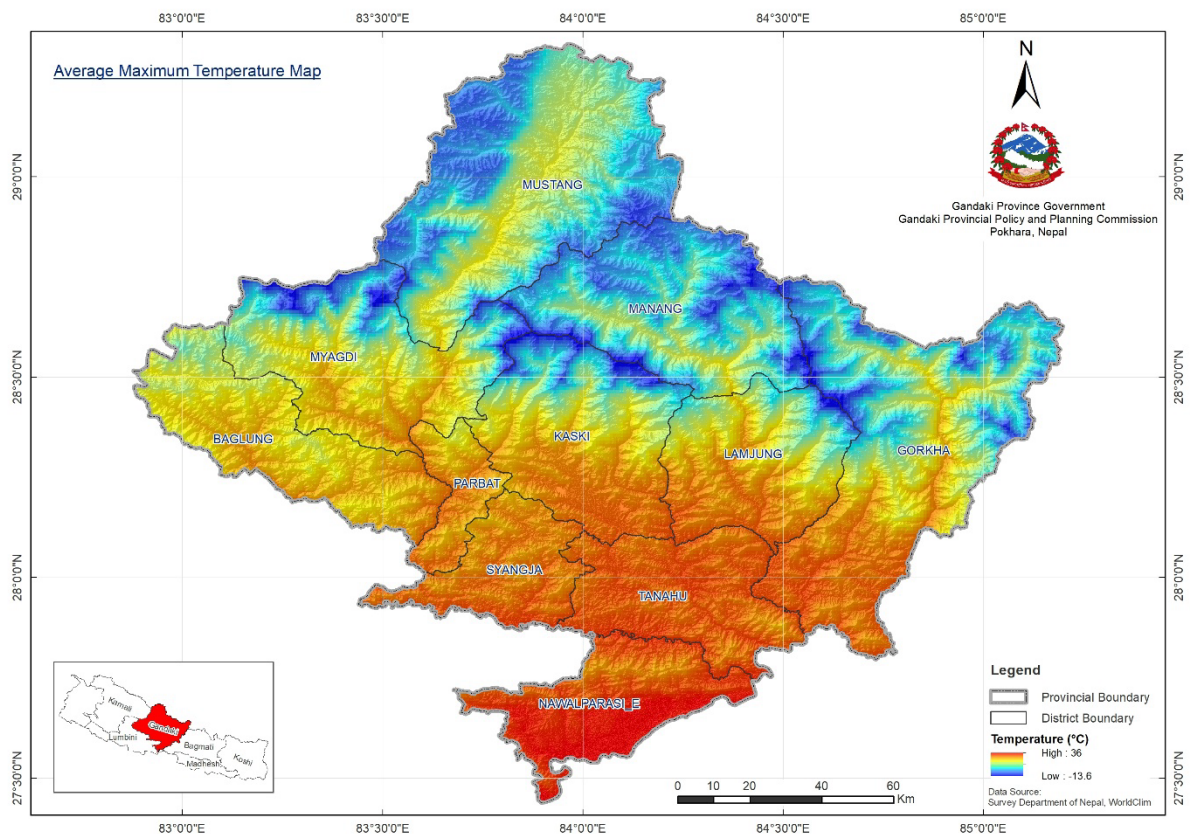


Figure 4.14: Annual maximum mean temperature map (WorldClim 1970 – 2020)

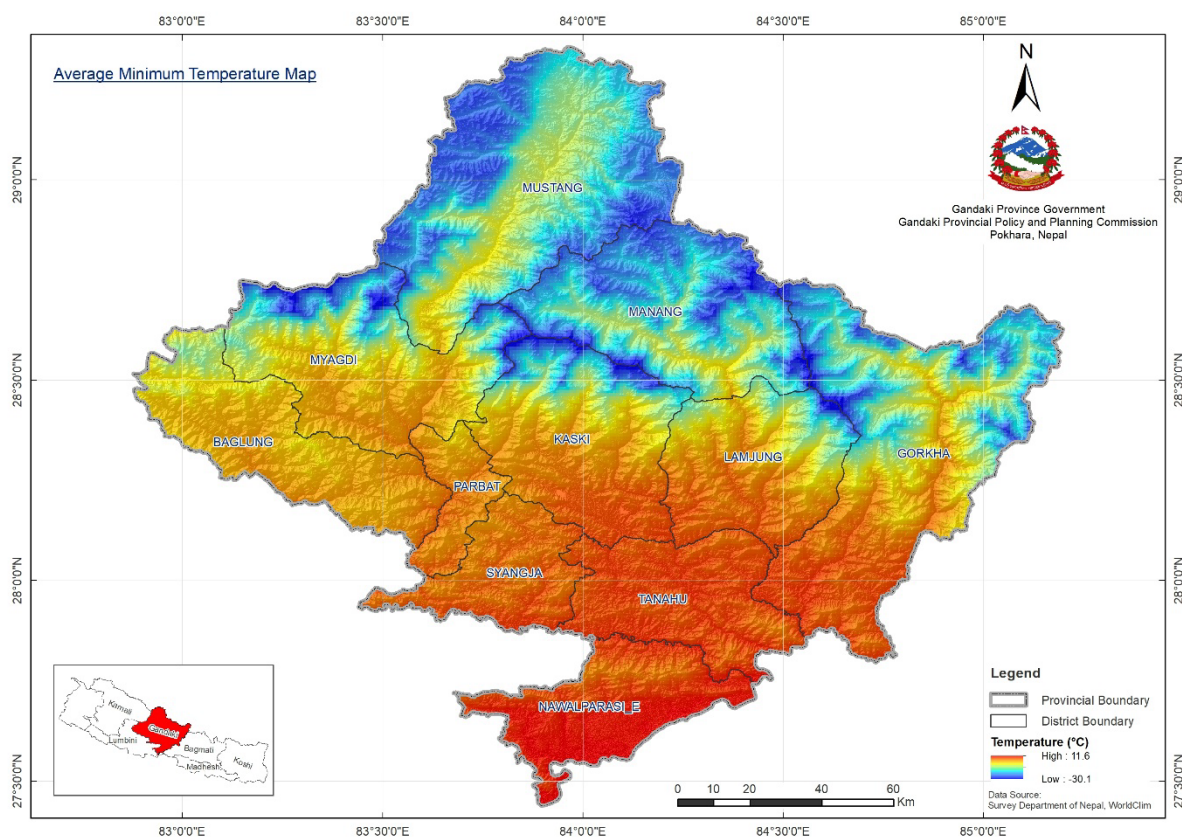


Figure 4.15: Annual minimum mean temperature map (WorldClim 1970 – 2020)

This temperature data is crucial for vulnerability and risk assessments in Gandaki Province, as extreme temperatures can significantly impact human health, agriculture, infrastructure, and ecosystems. High maximum temperatures in the lowlands can intensify heatwaves, droughts, and water scarcity, affecting crop yields and increasing health risks. On the other hand, extremely low minimum temperatures in the high mountain areas can lead to frost damage, permafrost melting, glacier retreat, and pose challenges for communities dependent on subsistence agriculture and livestock. Understanding temperature extremes and their spatial distribution helps in planning climate-resilient infrastructure, early warning systems, and adaptive strategies to reduce climate-induced vulnerabilities in the region.

4.4.2 Total Annual Precipitation

The mean annual precipitation in Gandaki Province demonstrates significant spatial variability due to its complex topography and the interaction of monsoonal and westerly weather systems. The province receives an average of around 1800 mm of rainfall annually (MoIAL Gandaki Province, 2019), with precipitation ranging from as low as 187 mm in the rain-shadow area of

Lomanthang in Upper Mustang to as high as 3173 mm as shown in Figure 4.16, with extreme cases like Lumle in Kaski District receiving over 5500 mm annually derived from WorldClim dataset of 1970 to 2020. The southern and windward mountain slopes receive the highest rainfall due to monsoon winds from the Bay of Bengal, whereas northern leeward regions like Upper Mustang remain arid due to rain-shadow effects. This contrast highlights the province's climatic extremes, especially within the Annapurna Conservation Area.

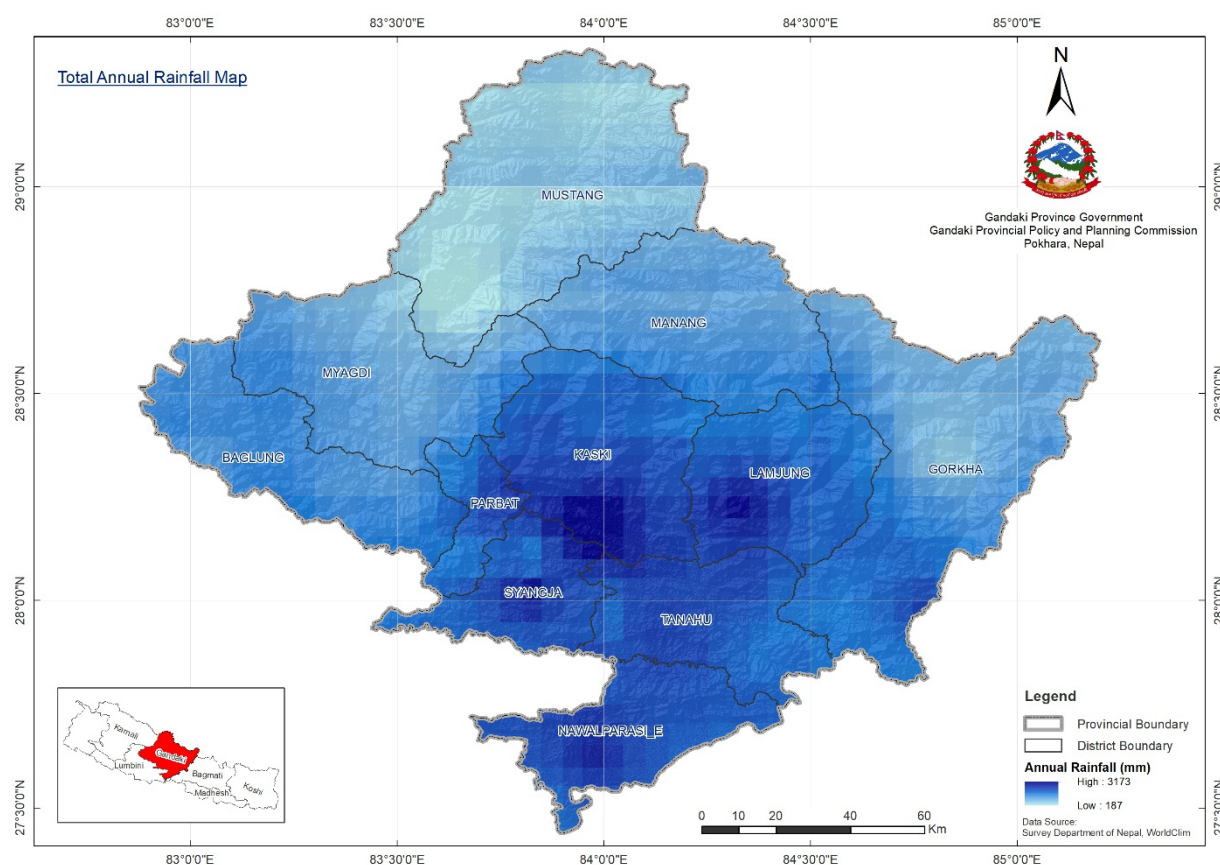


Figure 4.16: Total annual rainfall map (WorldClim 1970 – 2020)

This precipitation data is critical for vulnerability and risk assessments in Gandaki Province because both excessive and insufficient rainfall present significant challenges. High precipitation zones are more susceptible to landslides, flash floods, soil erosion, and infrastructure damage, especially during the monsoon season. Conversely, low rainfall areas, particularly in Upper Mustang, are vulnerable to drought, water scarcity, and declining agricultural productivity. Accurate knowledge of rainfall distribution aids in planning for climate-resilient water management, disaster preparedness, land use planning, and

infrastructure design, all of which are essential for reducing disaster risk and enhancing adaptive capacity in the province.

4.5 Hazards

In this Vulnerability Risk Assessment (VRA), five types of hazards were included: hydrometeorological, geophysical, environmental, biological, and technological hazards. Data were collected through a combination of methods to ensure comprehensive hazard identification and analysis. This included reviewing historical disaster event records from national platforms such as the BIPAD Portal (<https://bipadportal.gov.np/>) and municipal-level responses collected through structured questionnaires prepared in google form as presented in **Error! Reference source not found.** and gathered from disaster focal persons or other representatives. These approaches provided both quantitative and qualitative insights, enabling a detailed assessment of hazard types, their frequency, severity, and spatial distribution across the region.

Flood hazards, categorized under hydrometeorological risks, are among the most significant threats in the Gandaki Province. Based on the flood hazard map (detailed calculation shown in Annex 2), areas such as central Kaski, southern Syangja, and parts of Nawalparasi East are marked as very high flood risk zones, with municipalities like Pokhara-Lekhnath facing acute vulnerability as presented in Figure 4.17. The flood hazard ranking is derived from historical flood events. These areas are prone to recurrent inundation, often resulting in damage to infrastructure, displacement of communities, and agricultural losses. Low-lying and river-adjacent municipalities are particularly exposed due to unregulated settlement growth and weak drainage infrastructure.

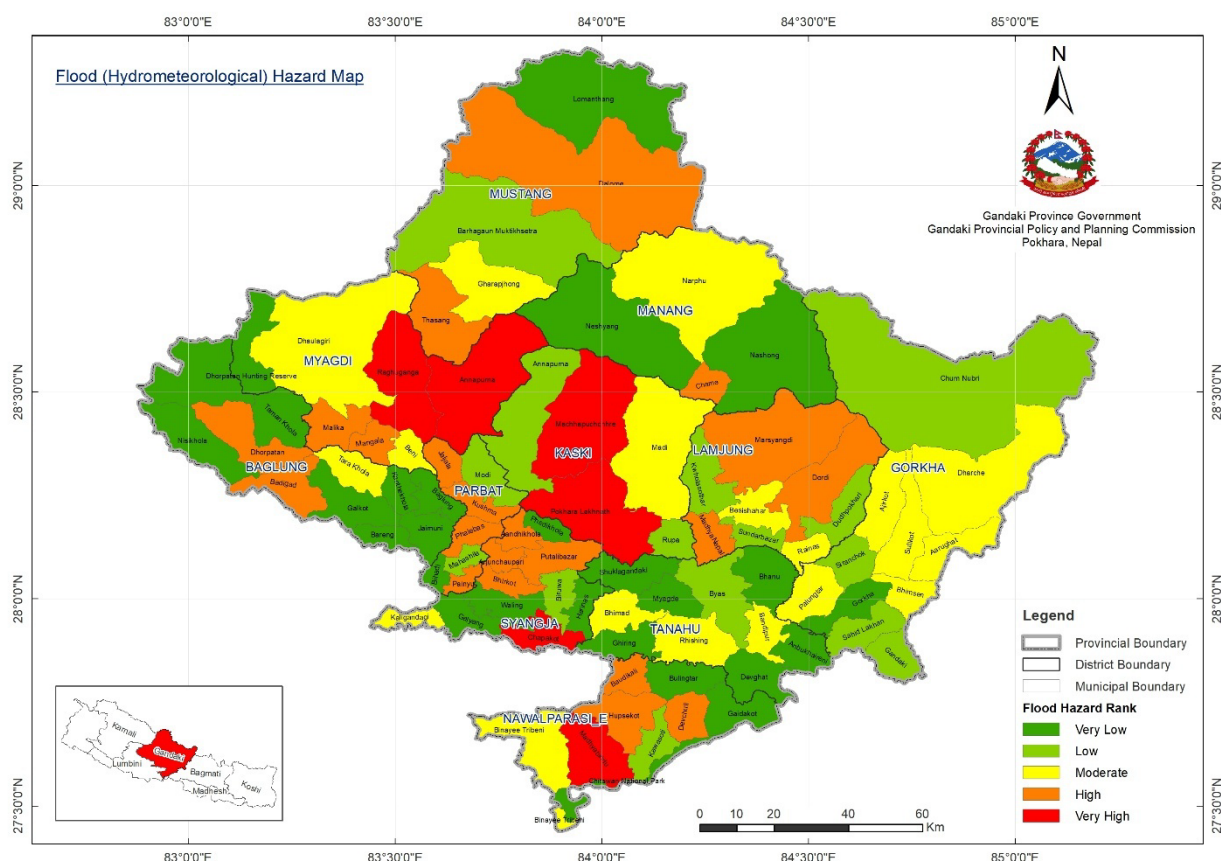


Figure 4.17: Flood hazard map

Landslide hazards, under geophysical hazards, are notably severe in mid-hill and mountainous regions of the province. According to the landslide hazard map (detailed calculation shown in Annex 3) as presented in Figure 4.18, municipalities like Raghuganga (Myagdi), Dordi (Lamjung), and Dharche (Gorkha) exhibit very high landslide risk. These areas are characterized by steep slopes, fragile geology, and intense rainfall, which trigger frequent landslides, especially during the monsoon season. Landslides can lead to the destruction of roads, homes, and agricultural land, isolating communities and disrupting access to essential services. Such events also pose significant threats to transportation networks and emergency response capabilities.

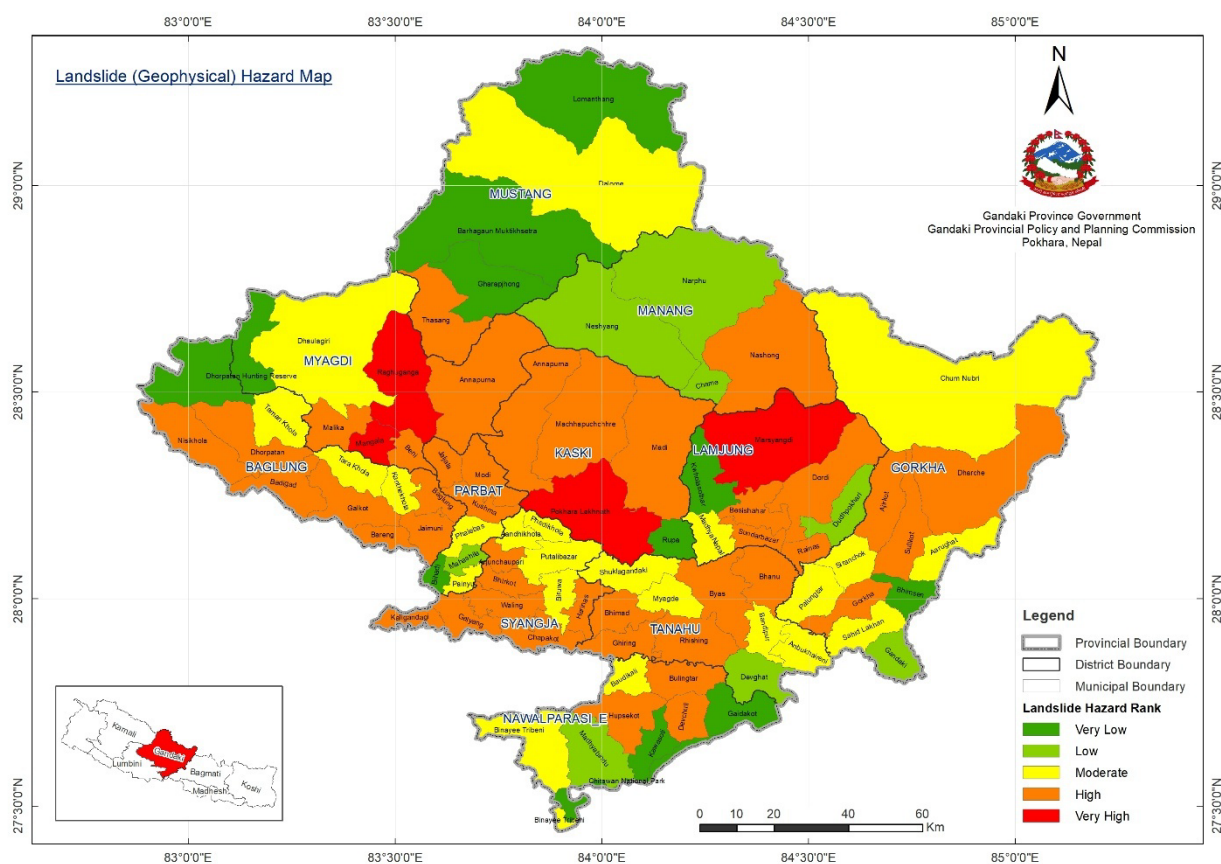


Figure 4.18: Landslide hazard map

Fire hazards, falling under environmental hazards, show a different pattern (detailed calculation shown in Annex 4), with very high-risk zones spread across several southern and western municipalities, such as Nawalparasi East, Baglung, and Parbat as presented in Figure 4.19. The fire hazard map reveals that dense forest cover, dry conditions, and human activities like slash-and-burn agriculture significantly elevate fire risk in these regions. The impact of forest fires includes loss of biodiversity, air pollution, and damage to farmland and settlements.

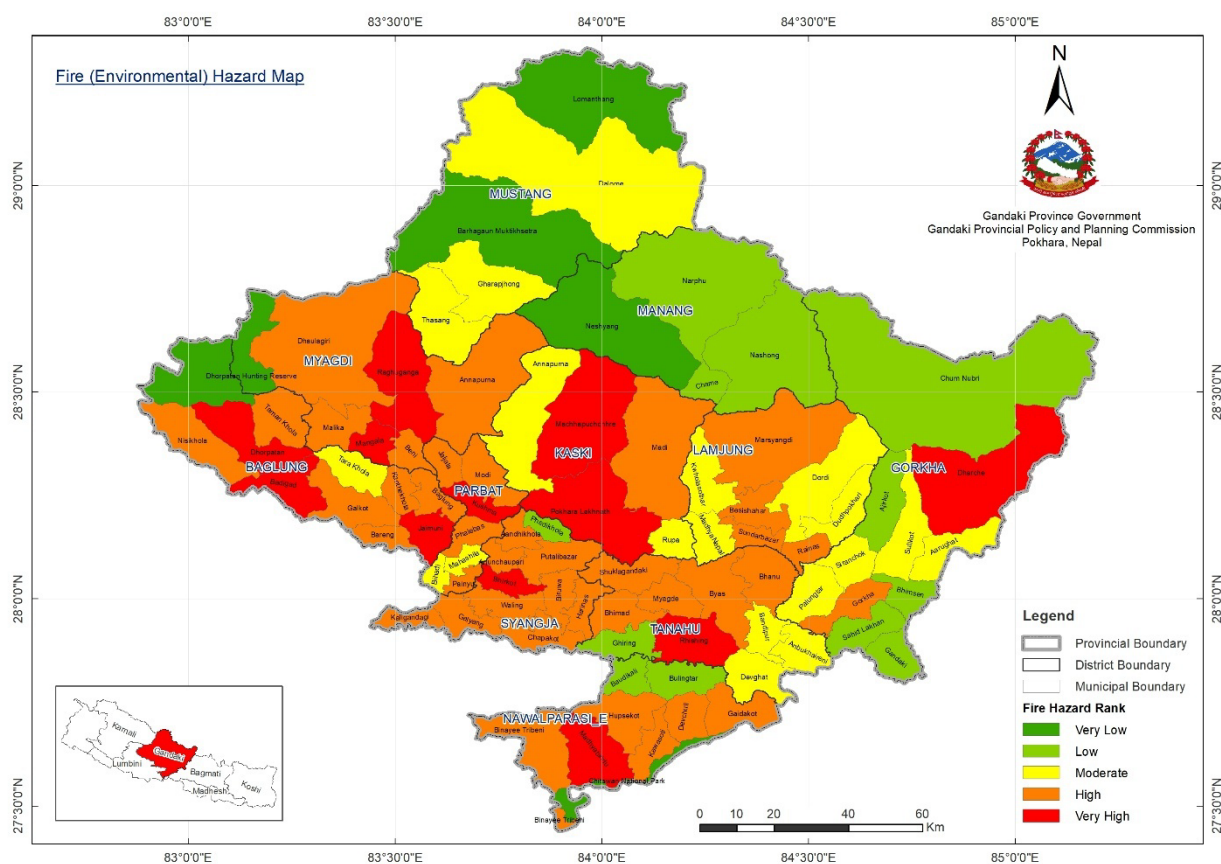


Figure 4.19: Fire hazard map

Biological hazards, such as disease outbreaks and epidemics, have gained importance especially after the COVID-19 pandemic. These include infectious diseases such as dengue, cholera, and respiratory illnesses, which are often exacerbated by poor sanitation, stagnant floodwaters, and post-disaster conditions. According to the Epidemic (Biological) Hazard Map (detailed calculation shown in Annex 5) as presented in Figure 4.20, municipalities in Baglung, Syangja, Parbat, and Lamjung exhibit high to very high health hazard risks. The spatial distribution of these risks correlates with population density, healthcare accessibility, and urban-rural mobility patterns. For instance, Baglung and parts of Syangja are marked in red, indicating very high risk, likely due to urban concentration and limited health infrastructure. Stakeholder discussions and health data from district health offices indicate that public health emergencies can strain local resources, especially during epidemic outbreaks or post-disaster recovery phases.

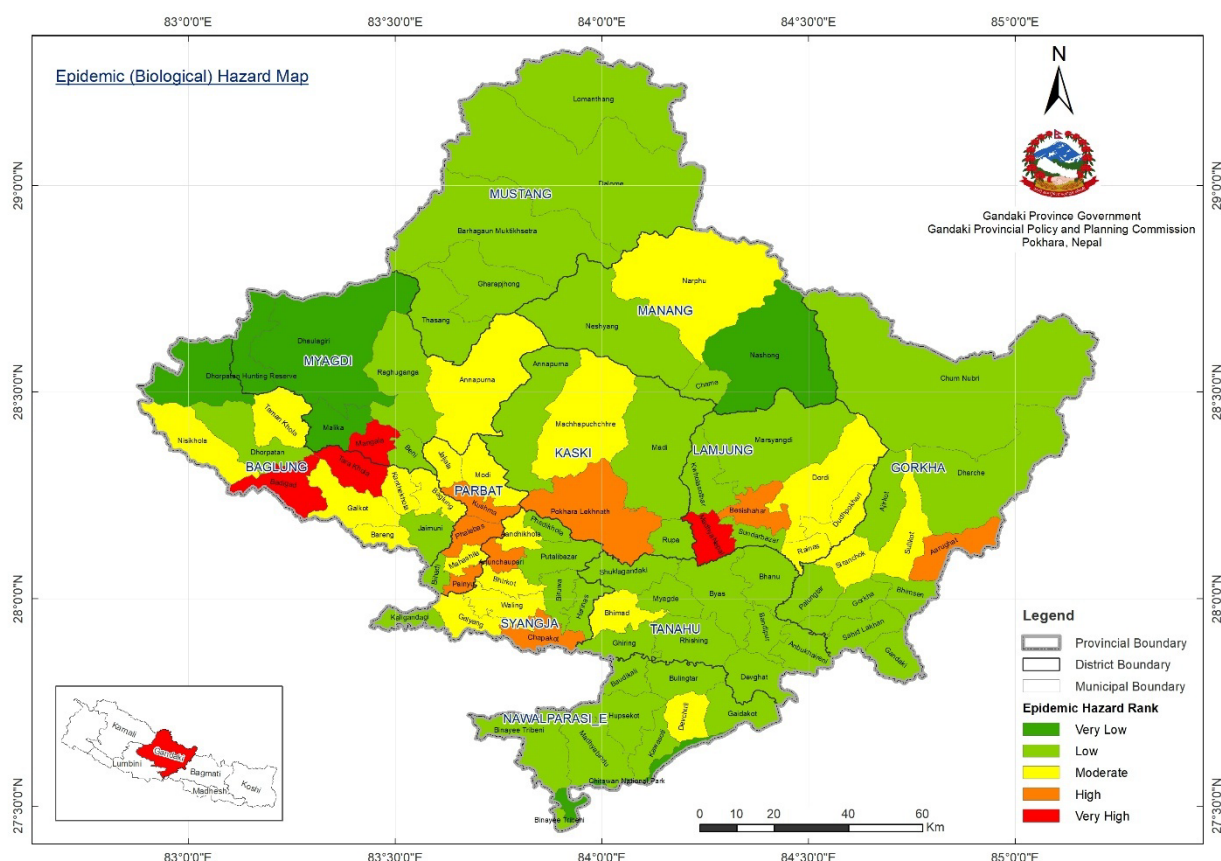


Figure 4.20: Health hazard map

Technological hazards stem from human-made risks including industrial accidents, transport crashes, chemical spills, or infrastructure failure. As illustrated in the Technological Hazard Map (detailed calculation shown in Annex 6), while most municipalities in Gandaki Province fall under low risk, there are notable high-risk zones in Pokhara Lekhnath (Kaski) and Devchuli (Nawalparasi East) as presented in Figure 4.21. These areas host significant urban and industrial activity, increasing the probability of technological failures. Risk mitigation strategies include strengthening regulatory oversight, industrial safety standards, and disaster response capabilities.

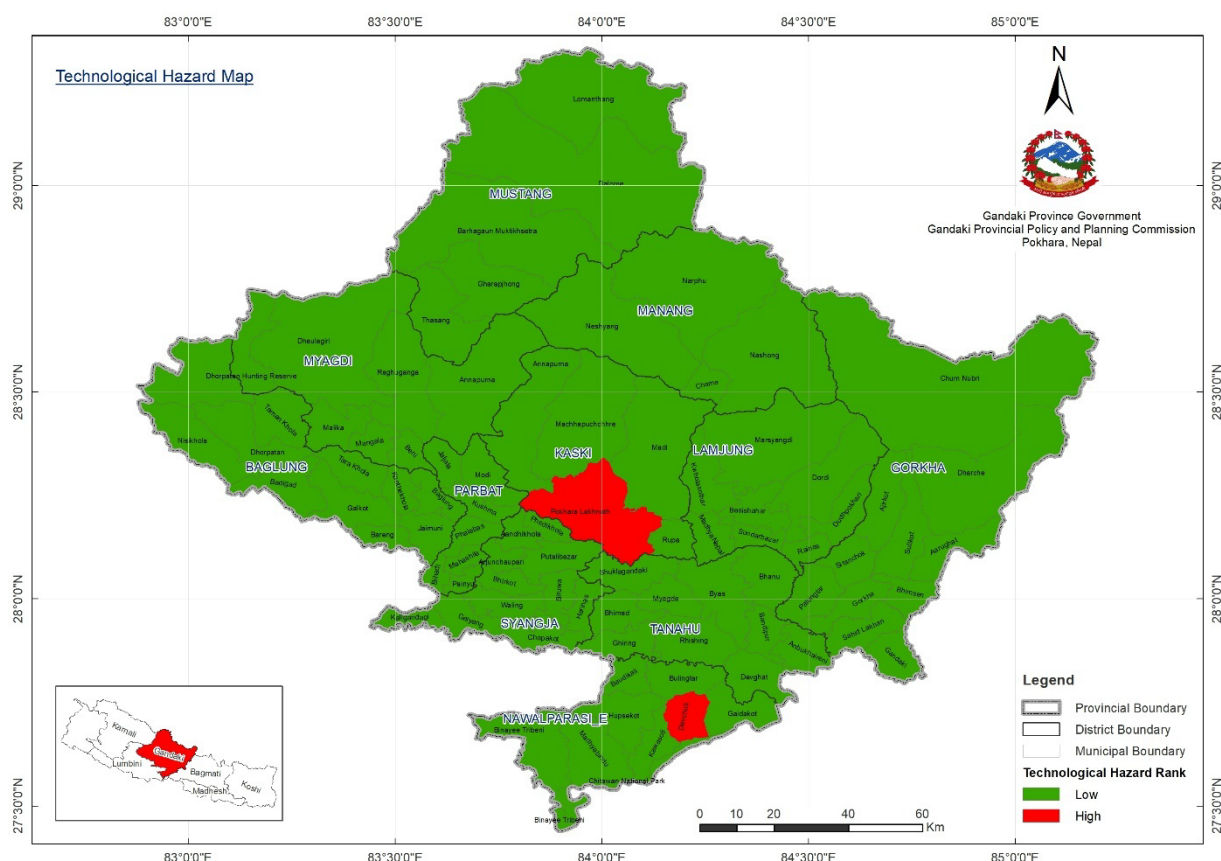


Figure 4.21: Technological hazard map

4.6 Exposures

In this Vulnerability Risk Assessments (VRAs), exposure analysis quantifies how much of a population or infrastructure lies within a hazard-prone area and enables decision-makers to prioritize intervention in the most at-risk locations. It also contributes to the development of composite indices, offering a comprehensive picture of the region's vulnerability landscape across different hazards.

A structured framework of exposure indicators and their respective weights were designed and used for multi-hazard vulnerability and risk assessment in Gandaki Province. It categorizes exposure into five hazard types - flood (hydrometeorological), landslide (geophysical), fire (environmental), health (biological) and technological hazard - and assigns a relative weight to each contributing criterion and sub-criterion. For instance, flood exposure is influenced most heavily by population and slope, with landcover types like built-up areas and proximity to rivers also being significant. In landslide exposure, slope and physiographic regions such as high and middle mountains play crucial roles, reflecting the terrain's sensitivity. Fire exposure

considers factors like forest type, climate variables, and biomass load, while health exposure prioritizes population distribution, distance to health centers, and accessibility (via roads and rivers). Sub-criteria further refine the analysis; for example, within total population for health exposure, females are given a higher weight than males, acknowledging gender-based vulnerability. This comprehensive weighting system ensures that exposure assessments are data-driven, spatially informed, and context-sensitive, thereby enhancing the accuracy of disaster risk management strategies. The detailed weights of each category and their further subcategories are shown in the Table 4.5.

Table 4.5: Structured framework of exposure indicators

Component	Criteria	Weight	Sub-criteria	Weight
Hydrometeorological hazard (Flood) Exposure	Distance to River (m)	0.15		
	Infrastructure exposure (m)	0.1		
	Landcover (Sqm)	0.2	Forest and Vegetation	0.1
			Crops	0.2
			Built up Areas	0.5
			Water	0.15
			Bare Ground	0.025
			Snow/ Ice	0.025
	Population (Nos)	0.25		
Geophysical hazard (Landslide) Exposure	No of infrastructure (Nos)	0.1		
	Slope (Degree)	0.2		
	Slope (Degree)	0.3		
	Physiographic Region (Sqm)	0.2	High Mountain	0.3
			Middle Mountain	0.3
			Hill	0.2
			Siwalik	0.15
			Tarai	0.05
	Landcover (Sqm)	0.2	Forest and Vegetation	0.15
			Crops	0.2
			Built up Areas	0.4
			Water	0.1
			Bare Ground	0.1
			Snow/ Ice	0.05
	Population Density (No per SqKm)	0.15		
	No of infrastructure (Nos)	0.15		

Component	Criteria	Weight	Sub-criteria	Weight
Environmental hazard (Fire) Exposure	Forest Type (Sqm)	0.2	Tropical Deciduous Forest	0.4
			Subtropical Pine Forest	0.3
			Temperate Coniferous Forest	0.2
			Temperate Broadleaf and Mixed Forest	0.1
	Max Temperature (°)	0.1		
	Min Temperature (°)	0.1		
	Total Annual Precipitation (mm)	0.2		
	Building to forest distance (m)	0.2		
	Fuel load density – biomass (Mg/ha)	0.2		
Biological hazard (Health) Exposure	Total Population	0.3	Male	0.6
			Female	0.4
	Distance from Settlement (m)	0.3		
	Distance from River (m)	0.2		
	Distance from Road (m)	0.2		
Technological hazard Exposure	Distance from Petrol Pump (m)	0.4		
	Distance from Road (m)	0.2		
	Distance from Industry (m)	0.4		

In the case of flood exposure, the indicators include proximity to rivers, landcover type, infrastructure proximity, population, slope, and number of infrastructures. According to the flood exposure map (detailed calculation shown in Annex 2) as presented in Figure 4.22, southern parts of Gandaki Province, particularly parts of Parbat, Tanahu, Syangja, and Nawalparasi East district along with Pokhara Sub metropolitan City, show moderate to very high exposure levels. This is largely influenced by built-up areas close to rivers, flat terrains with dense populations, and concentrated infrastructure such as roads and settlements. These

areas, due to their low elevation and land use patterns, are more vulnerable to inundation during heavy rainfall events or river overflow.

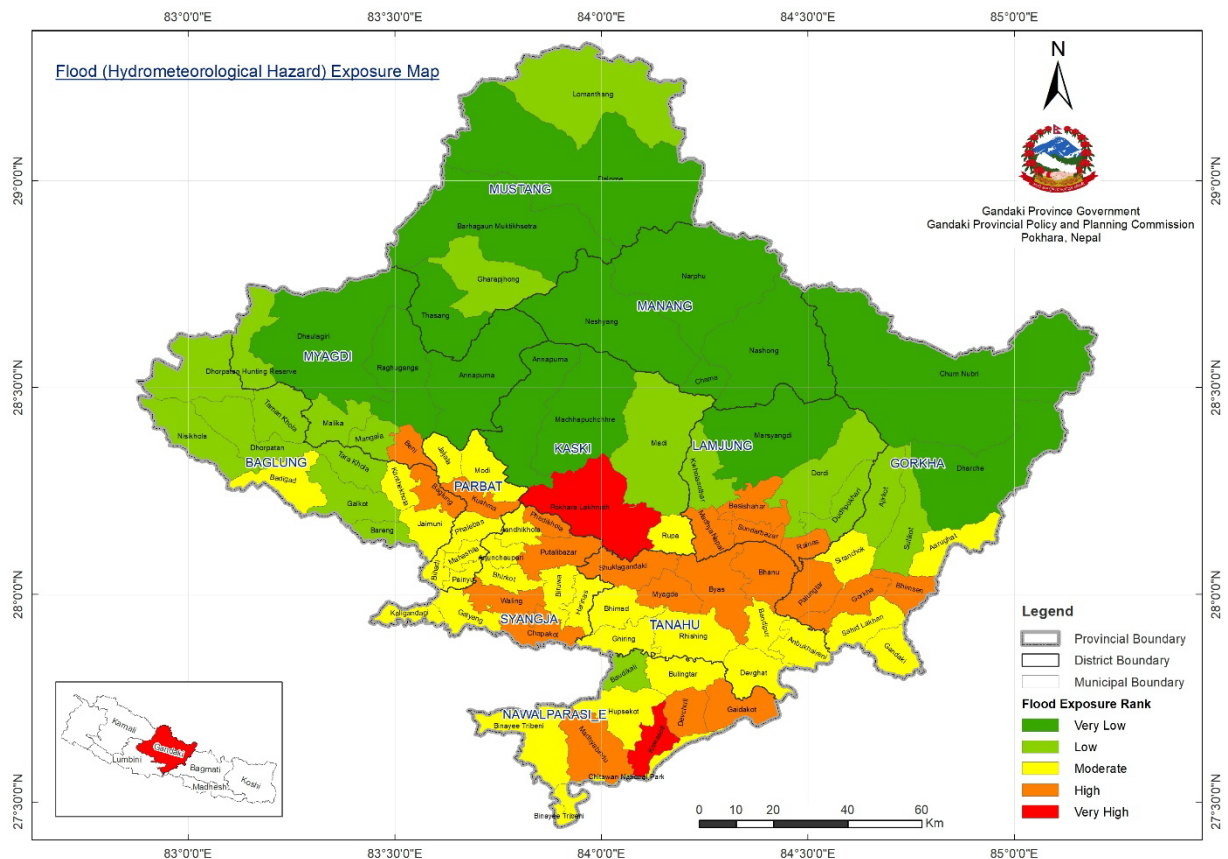


Figure 4.22: Flood exposure map

Landslide exposure is assessed using indicators such as slope, physiographic region, landcover, population density, and infrastructure distribution. The landslide exposure map (detailed calculation shown in Annex 3) as presented in Figure 4.23, shows central hilly regions such as Parbat, Myagdi, Baglung, and parts of Kaski and Lamjung districts to be at high to very high exposure levels. These regions have steep slopes, fragile geological formations, and deforested areas, making them highly susceptible to landslides during the monsoon. The concentration of infrastructure in these slope-prone zones increases the potential for severe damage.

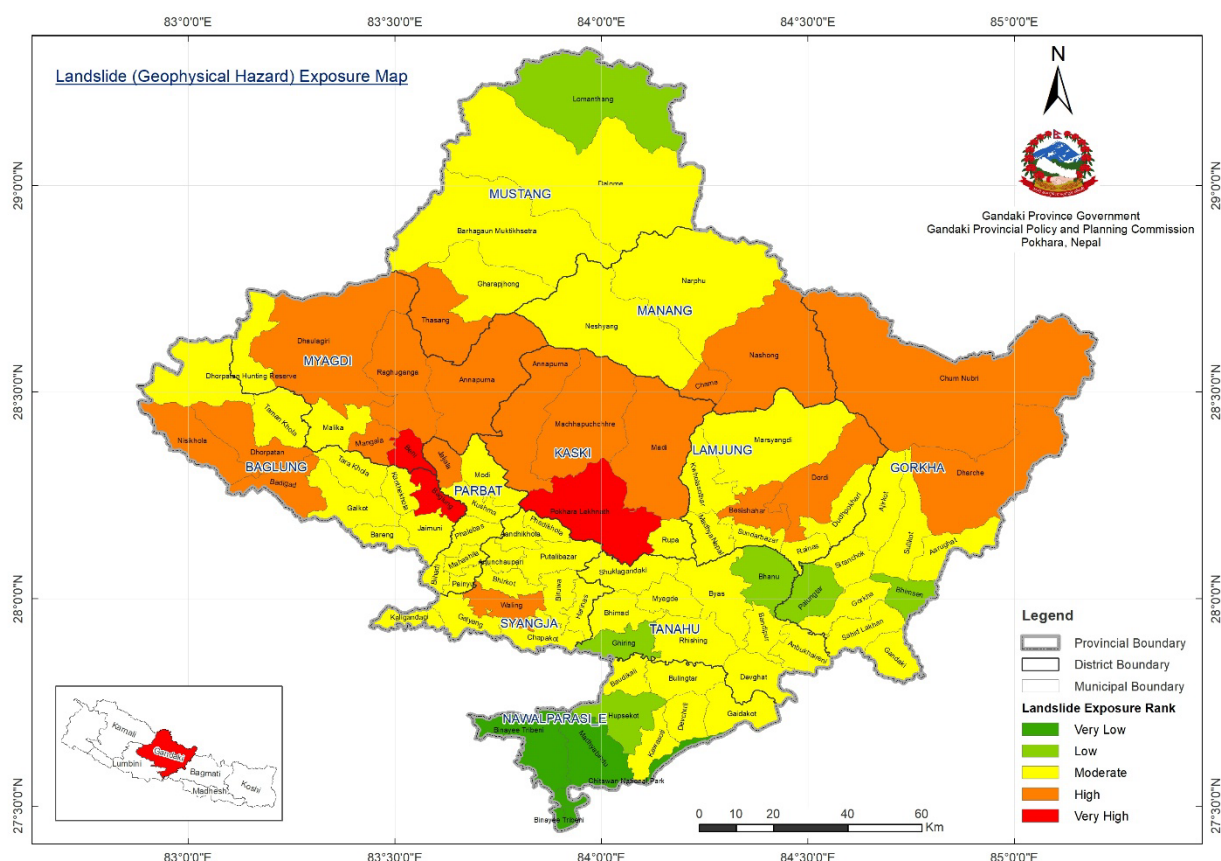


Figure 4.23: Landslide exposure map

For environmental hazards like forest fires, exposure indicators include forest type, temperatures (max and min), precipitation, distance between buildings and forest, and biomass density. The criteria suggest that areas with Tropical Deciduous or Subtropical Pine Forests, combined with high biomass and proximity to settlements, would face higher exposure. These forest types are more flammable during dry seasons, and if coupled with nearby infrastructure, they pose a serious risk. The fire exposure map (detailed calculation shown in Annex 4) highlights moderate to high exposure in the forested and buffer zone areas of Tanahu, Palpa, and Nawalparasi East districts as presented in Figure 4.24, where human activities, such as slash-and-burn agriculture or firewood collection, coincide with dry vegetation. Settlements adjacent to community forests are particularly at risk during dry pre-monsoon periods.

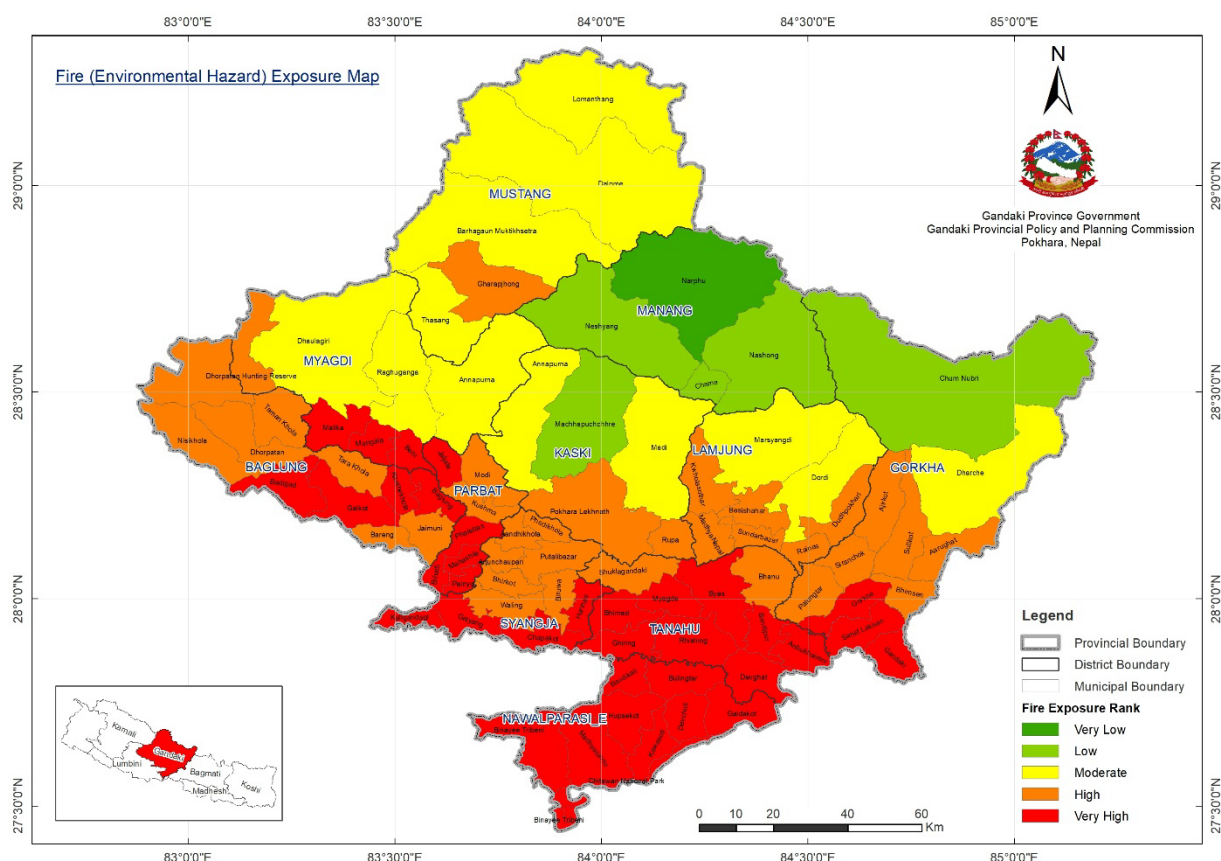


Figure 4.24: Fire exposure map

Health (biological) hazard exposure is influenced by total population, distance from settlements, proximity to roads, and rivers. The indicators emphasize vulnerability in densely populated. In rural or mountainous parts of the province such as Mustang, Manang, and parts of Gorkha district as presented in Figure 4.25, are in higher exposure to health risks (detailed calculation shown in Annex 5). Further, urban and semi-urban regions with poor sanitation near rivers may also experience elevated exposure due to waterborne diseases.

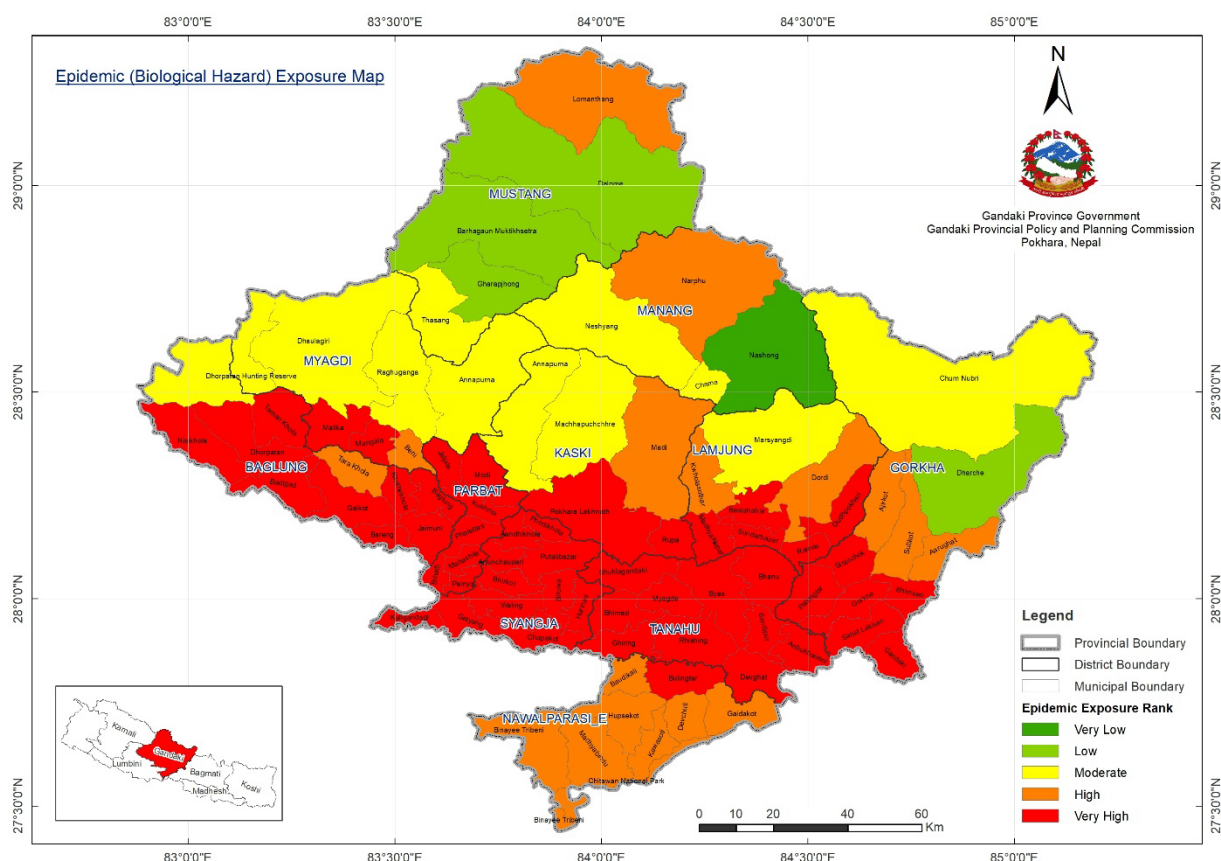


Figure 4.25: Health exposure map

The Technological Hazard Exposure Map (detailed calculation shown in Annex 6) of Gandaki Province reveals a significant concentration of very high exposure in the southern municipalities, particularly in Kaski, Syangja, Tanahun, Parbat, Lamjung, and Nawalparasi East. These areas, marked in red, are hubs of urbanization, industrial activity, dense road networks, and growing population centers—factors that increase vulnerability to technological hazards such as industrial accidents, electrical fires, and transport mishaps. The moderate to high-risk zones, shown in orange and yellow, extend into Baglung, Myagdi, Gorkha, and parts of Mustang and Manang as presented in Figure 4.26, indicating expanding infrastructure and service sectors. In contrast, the very low to low exposure areas, mostly in northern rural or protected regions like Chumnubri (Gorkha), Lomanthang (Mustang), and Narpa (Manang), exhibit limited technological development and minimal industrial footprint. The significance of this exposure lies in the potential for large-scale human, economic, and environmental impacts due to cascading failures in densely developed areas.

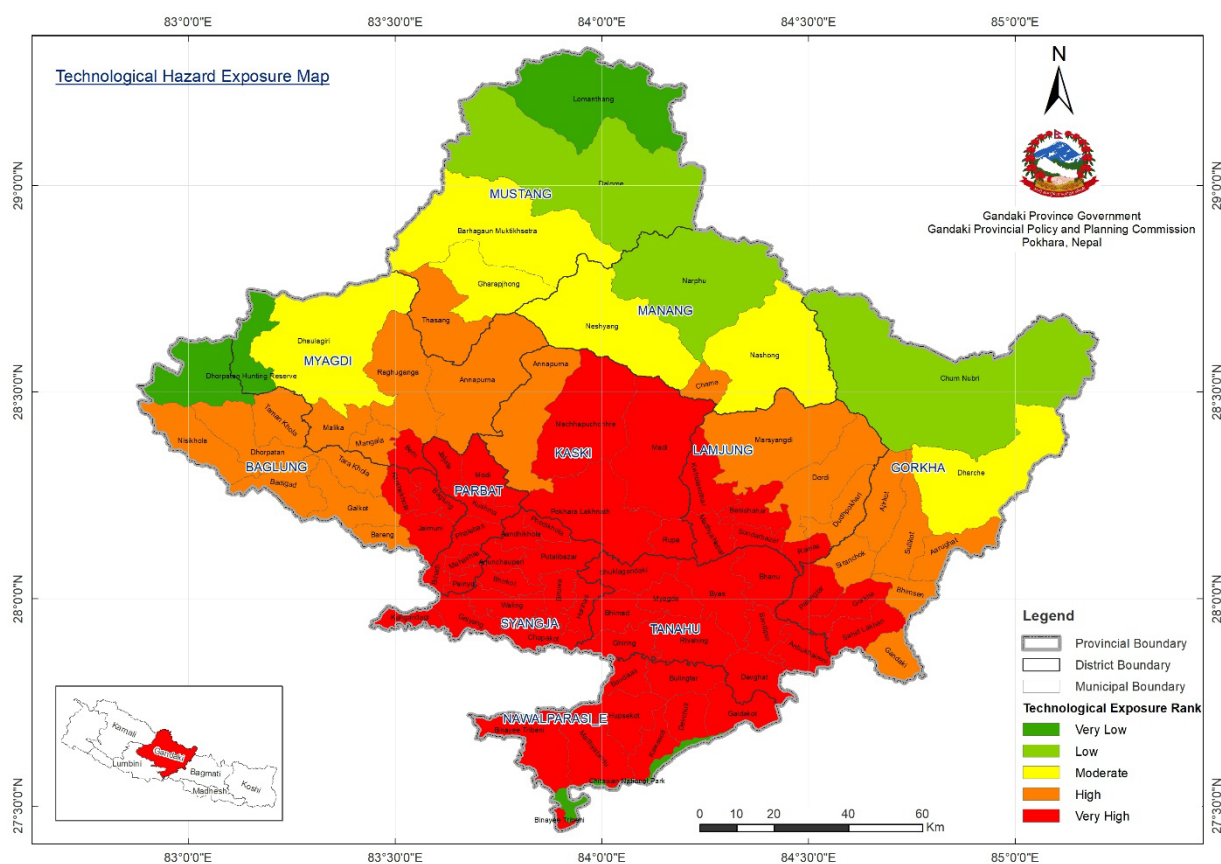


Figure 4.26: Technological hazard exposure map

4.7 Sensitivity

Sensitivity indicators are measurable variables that help assess how susceptible a population or system is to harm from hazards, based on intrinsic social, economic, environmental, and physical characteristics. For flood sensitivity, indicators include age groups (below 15 and above 60, especially females), wealth quintiles (with poorer communities more vulnerable), and drinking water sources (surface/untreated water indicating higher sensitivity). In landslide sensitivity, key indicators are slope steepness, physiographic regions (high and middle mountains being more sensitive), building concentration on slopes, and population demographics, particularly age and gender. The socioeconomic conditions - such as income level, infrastructure type, and access to resources - amplify or reduce risk exposure. Gender disparities, where females often bear more burden during disasters, are also embedded within these indicators. Women, girls, children, and the elderly are physically and socially highly vulnerable (MoFE, 2021b). Other indirect indicators like community awareness, access to healthcare, and housing type (e.g., informal settlements) further refine the sensitivity profile.

The detailed weights of each category and their further subcategories are shown in the Table 4.6.

Table 4.6: Structured framework of sensitivity indicators

Component	Criteria	Weight	Sub-criteria	Weight
Flood Sensitivity	Below 15 Population	0.2	Male	0.4
			Female	0.6
	16 - 60 Population	0.05	Male	0.4
			Female	0.6
	Above 60 Population	0.2	Male	0.4
			Female	0.6
	Wealth Quintile (%)	0.35	Poorest	0.35
			Poorer	0.25
			Middle	0.2
			Richer	0.1
			Richest	0.1
	Drinking Water Availability	0.2	Piped Water	0.2
			Underground Water	0.3
			Surface/ untreated Water	0.5

Landslide Sensitivity	Slope (Degree)	0.15		
	Physiographic Region	0.15	High Mountain	0.3
			Middle Mountain	0.3
			Hill	0.2
			Siwalik	0.2
	Below 15 Population	0.15	Male	0.4
			Female	0.6
	16-60 Population	0.05	Male	0.4
			Female	0.6
	Above 60 Population	0.15	Male	0.4
			Female	0.6
	Building on Slope (Nos)	0.25	< 5	0
			5-15	0.1
			15-30	0.2
			30-45	0.3
			>45	0.4
	Community Awareness	0.1		

Fire Sensitivity	Below 15 Population	0.15	Male	0.4
			Female	0.6
	16-60 Population	0.05	Male	0.4
			Female	0.6
	Above 60 Population	0.15	Male	0.4

Component	Criteria	Weight	Sub-criteria	Weight
			Female	0.6
	Settlement distance to forest (m)	0.2		
	Air Quality Sensitivity	0.1		
	Vegetation condition index	0.15		
	Infrastructure exposure from forest (m)	0.2		

Health Sensitivity	Below 15 Population	0.15	Male	0.4
			Female	0.6
	16-60 Population	0.05	Male	0.4
			Female	0.6
	Above 60 Population	0.15	Male	0.4
			Female	0.6
	Health center distance (m)	0.25		
	Building Type (Nos)	0.2	Mud bonded	0.35
			Cement/RCC bonded	0.15
			Wooden and others	0.5
	Slope (Degree)	0.2		

Technological Sensitivity	Population Density	0.2		
	Below 15 Population	0.2		
	16 - 60 Population	0.1		
	Above 60 Population	0.2		
	Landcover (Builtup)	0.15		
	Building Density (Nos per SqKm)	0.15		

Flood sensitivity is assessed using multiple demographic and socioeconomic indicators such as population age distribution, wealth quintiles, and drinking water availability. Younger (under 15) and older (above 60) populations, particularly females, are marked as highly sensitive due to mobility and health limitations. Areas with poorer wealth quintiles and access to untreated or surface water sources are more vulnerable due to reduced resilience. According to the flood sensitivity map (detailed calculation shown in Annex 2) as presented Figure 4.27, northern regions like Mustang and Manang show very high sensitivity, while southern districts such as Nawalparasi East and Tanahu are marked with low or very low sensitivity. This spatial pattern suggests that sparsely populated, high-altitude regions may have lower coping capacities due to remoteness, inadequate infrastructure, and socio-economic challenges.

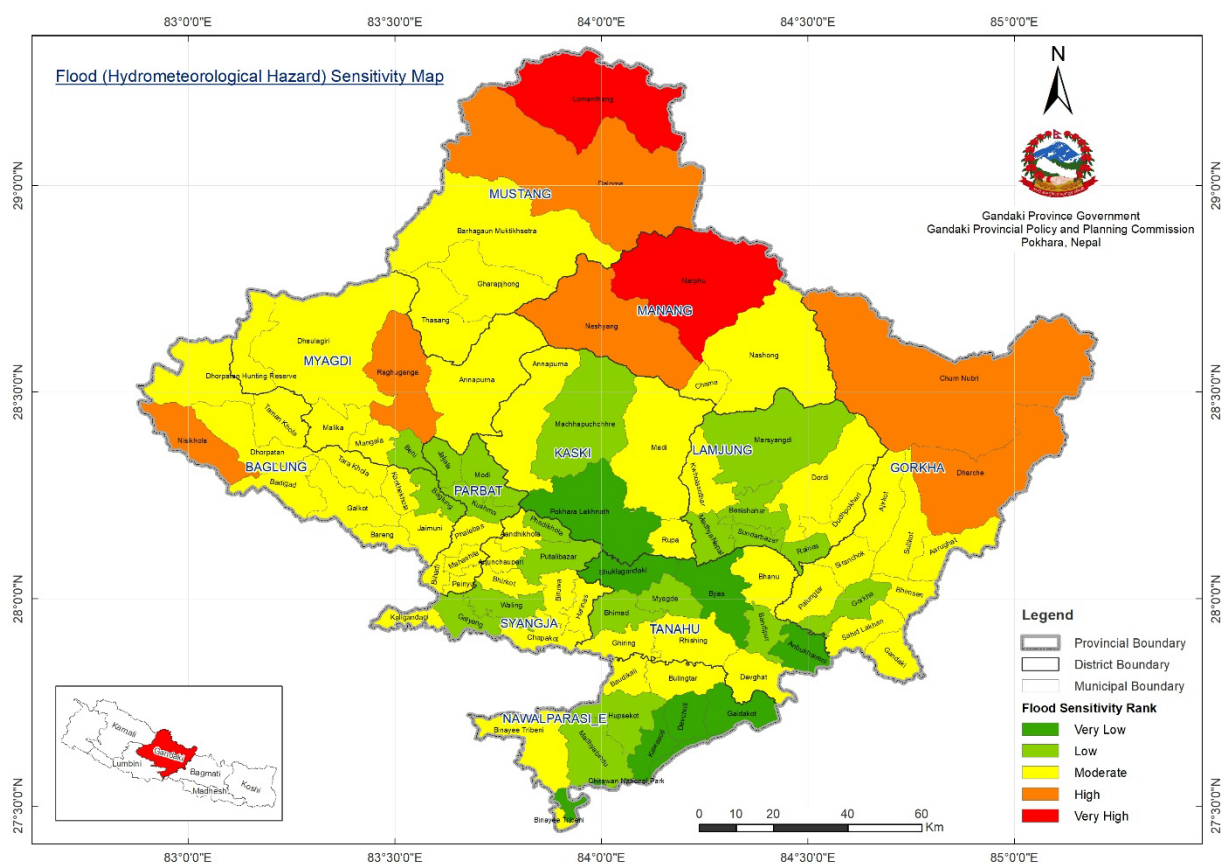


Figure 4.27: Flood sensitivity map

Landslide sensitivity encompasses environmental and structural factors such as slope, physiographic region, and infrastructure (e.g., buildings on slopes), in addition to demographic attributes. Steeper terrains (high slope values), regions located in the high or middle mountains, and communities with a large number of buildings constructed on steep slopes are more prone to landslide impacts. From the landslide sensitivity map (detailed calculation shown in Annex 3) as presented in Figure 4.28, western and northern districts like Baglung, Myagdi, and Gorkha show very high sensitivity, reflecting their rugged topography and built environment. Conversely, southern districts like Nawalparasi East and parts of Tanahu show low to very low sensitivity, indicating safer terrain and potentially better awareness or urban planning practices.

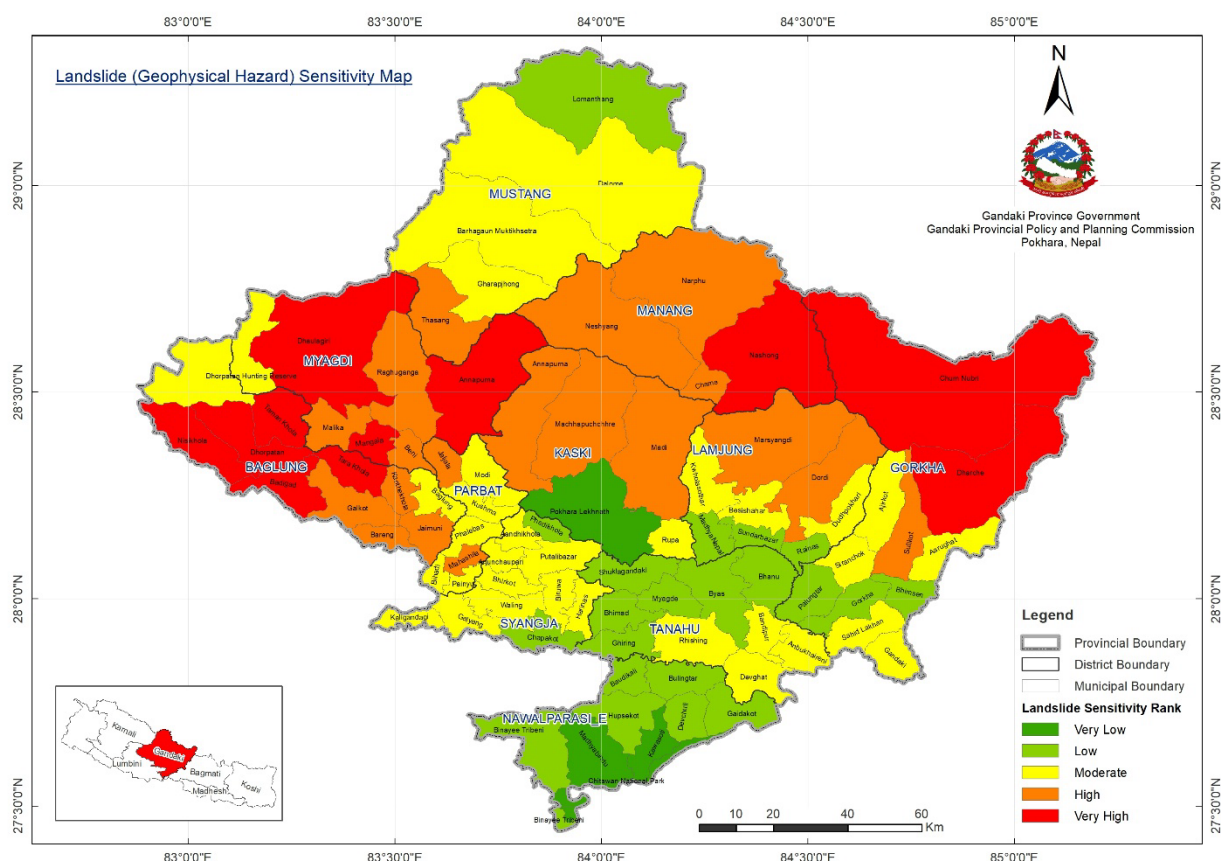


Figure 4.28: Landslide sensitivity map

Fire sensitivity encompasses environmental and human-related factors such as population density, settlement proximity to forests, air quality, vegetation condition index, and infrastructure exposure near forested areas. Regions with dense populations, settlements located close to forests, degraded vegetation, poor air quality, and infrastructure highly exposed to forest areas are more prone to fire hazards. From the fire sensitivity map (detailed calculation shown in Annex 4) as presented in Figure 4.29, central and southern districts like Syangja, Parbat, and Tanahu show very high sensitivity, reflecting close settlement-forest interfaces, stressed vegetation, and greater infrastructure exposure. Conversely, northern districts like Mustang and Manang show low to very low sensitivity, indicating sparse populations and greater settlement-forest distance that reduce fire risk.

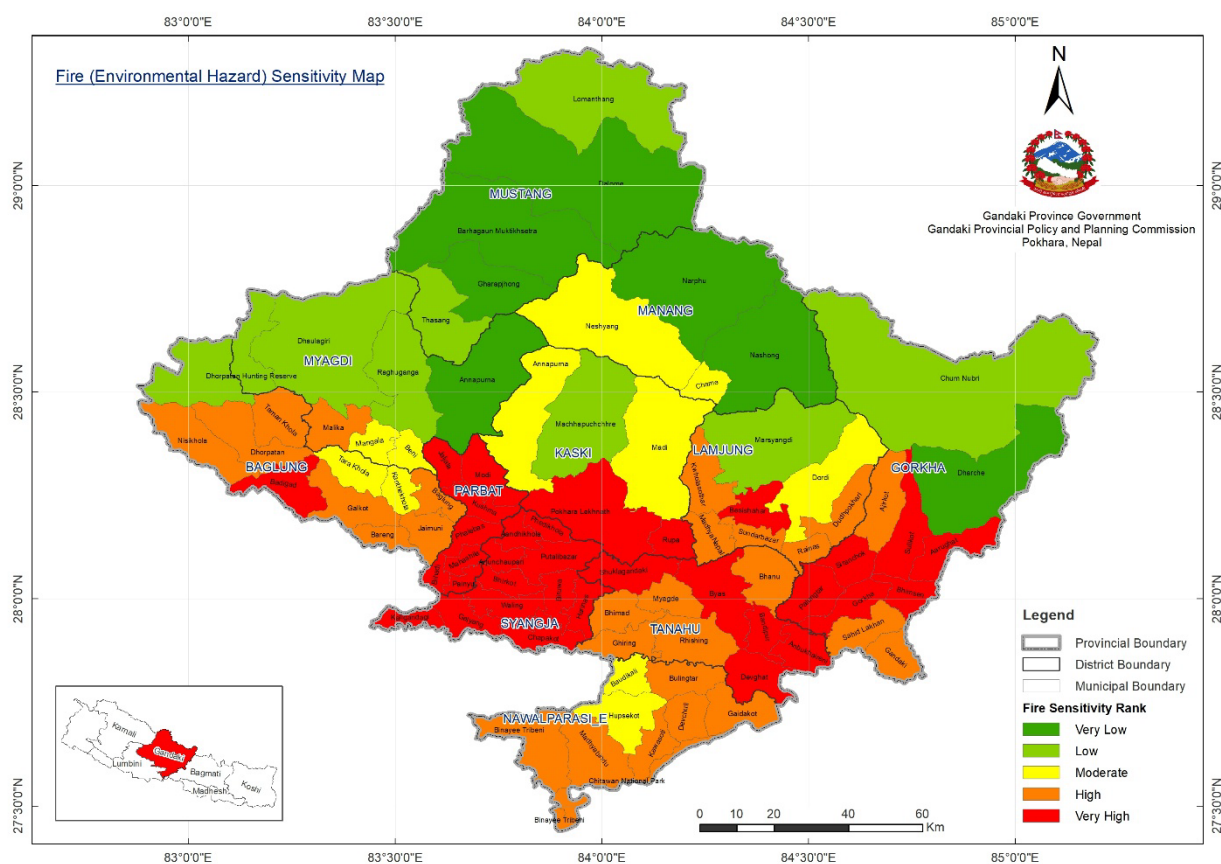


Figure 4.29: Fire sensitivity map

Health sensitivity encompasses demographic, infrastructural, and topographic factors such as population density, distance to healthcare facilities, building type, and terrain slope. Areas with high population concentrations, limited access to nearby health services, and vulnerable building structures more susceptible to epidemic impacts due to challenges in healthcare delivery and emergency response. From the epidemic sensitivity map (detailed calculation shown in Annex 5) as presented in Figure 4.30, northern and southern districts like Mustang, Gorkha, and Nawalparasi show very high sensitivity, reflecting poor health service accessibility, and high-risk building types. In contrast, central districts like Kaski and Lamjung show low to very low sensitivity, indicating better healthcare access, and more resilient infrastructure that support effective public health interventions.

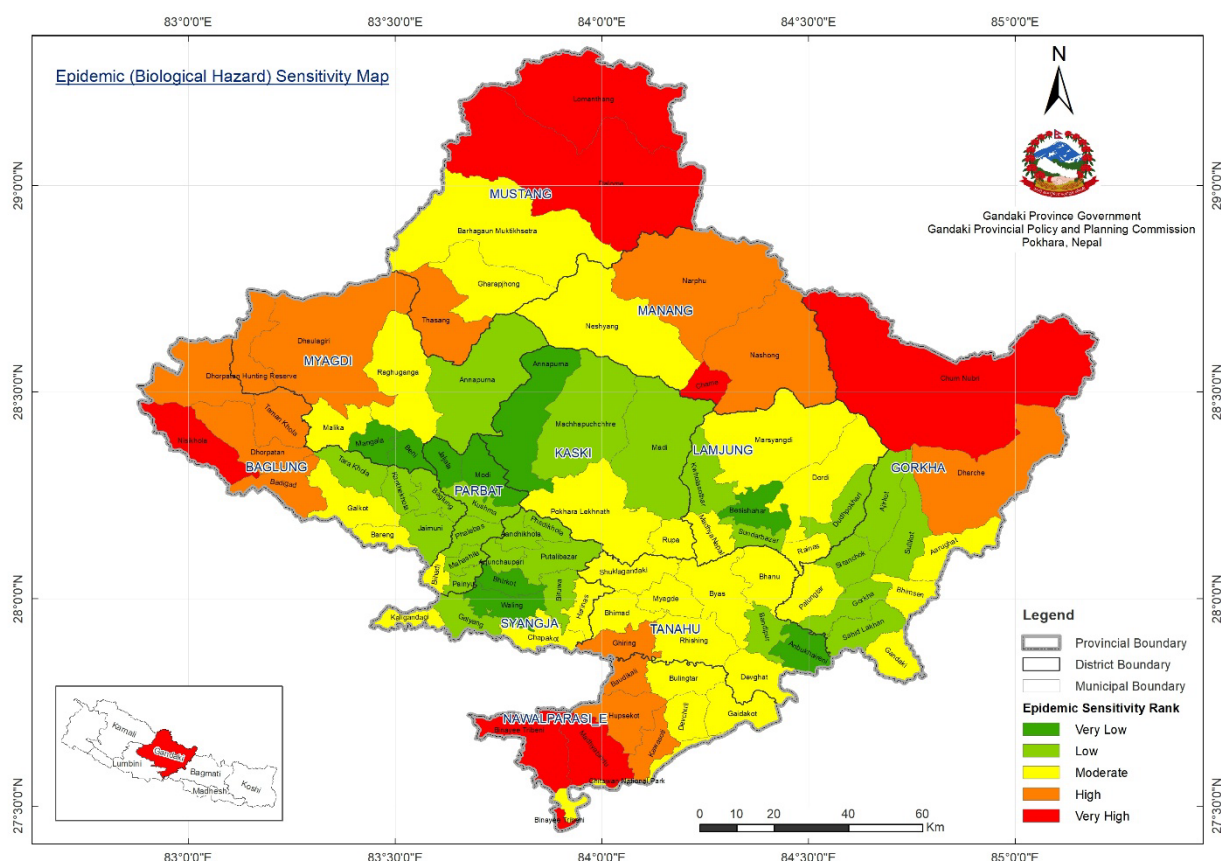


Figure 4.30: Health sensitivity map

Technological hazard sensitivity includes population density, age group population distribution (below 16, 16–60, and above 60 years), and built-up area distribution and density were used to assess the sensitivity. The technological hazard sensitivity analysis (detailed calculation shown in Annex 6) reveals that Pokhara Metropolitan City is very highly sensitive due to its dense population and high concentration of buildings, making it particularly vulnerable to technological hazards like infrastructure failures, industrial accidents, and urban fires. Additionally, Kawasoti and Gaidakot municipalities in Nawalparasi East district as presented in Figure 4.31, also exhibit high sensitivity, reflecting similar urban characteristics and demographic pressures. In contrast, the northern districts such as Mustang and Manang, characterized by low population density and sparse built-up distribution, show low sensitivity, indicating relatively lower potential impact from technological hazards.

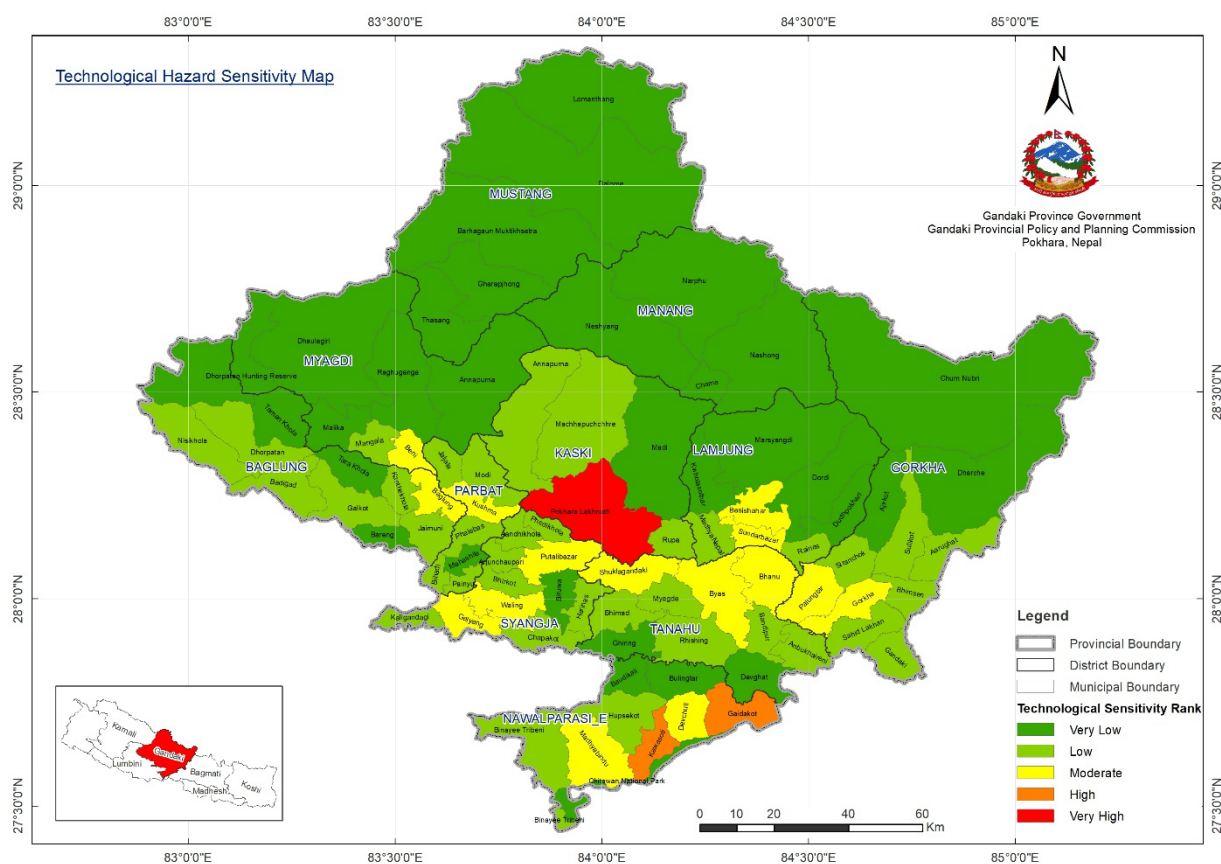


Figure 4.31: Technological hazard sensitivity map

4.8 Adaptive Capacity

Higher adaptive capacity implies a stronger ability to cope with hazards through institutional strength, physical infrastructure, and community preparedness. By identifying areas of low adaptive capacity, decision-makers can prioritize interventions, allocate resources effectively, and formulate targeted disaster risk reduction (DRR) strategies that enhance resilience and sustainability. It helps to inform planning, resource allocation, and disaster risk reduction (DRR) strategies. Incorporating adaptive capacity into VRAs ensures a comprehensive understanding of local coping mechanisms and highlights the gaps needing attention for sustainable resilience-building.

Adaptive capacity was measured using a variety of socio-economic, infrastructural, and institutional indicators. These include the presence and effectiveness of community awareness programs and DRR budgets allocated by municipalities to support preparedness. Wealth status and the share of economically active populations indicate financial stability and employment

resilience. Building types (e.g., reinforced or non-engineered structures) reflect the robustness of housing against hazards. Similarly, access to technology, such as mobile communication and early warning systems, boosts adaptive responses. Educational attainment enhances individuals' understanding of risks and appropriate action, while road infrastructure development facilitates mobility, emergency response, and service delivery during disasters.

Table 4.7: Structured framework of Adaptive capacity indicators

Component	Criteria	Weight	Sub-criteria	Weight
Flood Adaptive Capacity	Status of Road (m)	0.2	Paved	0.6
			Unpaved	0.4
	Building Type (Nos)	0.2	Mud bonded	0.25
			Cement/RCC bonded	0.6
			Wooden and others	0.15
	Community Awareness training	0.2		
	Wealth Status (%)	0.2	Poorest	0.1
			Poorer	0.15
			Middle	0.2
			Richer	0.25
			Richest	0.3
	Economically Active Population (Nos)	0.2	Employed	0.7
			Unemployed	0.3

Landslide Adaptive Capacity	Community Awareness training	0.2		
	DRR Budget (NRs)	0.3		
	Building Type	0.3	Mud bonded	0.25
			Cement/RCC bonded	0.6
			Wooden and others	0.15
	Technology Access (Household Nos)	0.2	Radio	0.1
			Television	0.15
			Land line telephone	0.05
			Mobile phone (ordinary)	0.1
			Mobile phone (smart)	0.2
			Computer/ Laptop	0.2
			Internet	0.2

Fire Adaptive Capacity	National Park and conservation Area (Sqm)	0.3		
	DRR Budget (NRs)	0.4		
	Community Awareness training (Nos)	0.3		
Health Adaptive Capacity	No. of health center (Nos)	0.3		
	DRR Budget (NRs)	0.3		
	Education Level (Nos)	0.4	School Level	0.2
			Graduate	0.35
			Postgraduate	0.45
Technological Adaptive Capacity	Length of Road (m)	0.2	Paved	0.7
			Unpaved	0.3
	Education Level (Nos)	0.2	School Level	0.2
			Graduate	0.35
			Postgraduate	0.45
	Health center distance (m)	0.2		
	Employed Population (Nos)	0.2		
	Community Awareness training (Nos)	0.2		

Flood-related adaptive capacity incorporates elements such as embankment and drainage infrastructure, early warning systems, emergency shelters, and flood-resilient building design. According to the Flood Adaptive Capacity Map (detailed calculation shown in Annex 2) as presented in Figure 4.32, northern municipalities in Mustang and Manang districts show very low capacity (red), likely due to limited infrastructure and sparse population distribution. In contrast, municipalities in Nawalparasi, Tanahu, and parts of Syangja exhibit high to very high adaptive capacity (light and dark green), signifying better preparedness, accessibility, and DRR investments. This geographic disparity underscores the need for targeted capacity-building interventions in remote and mountainous regions.

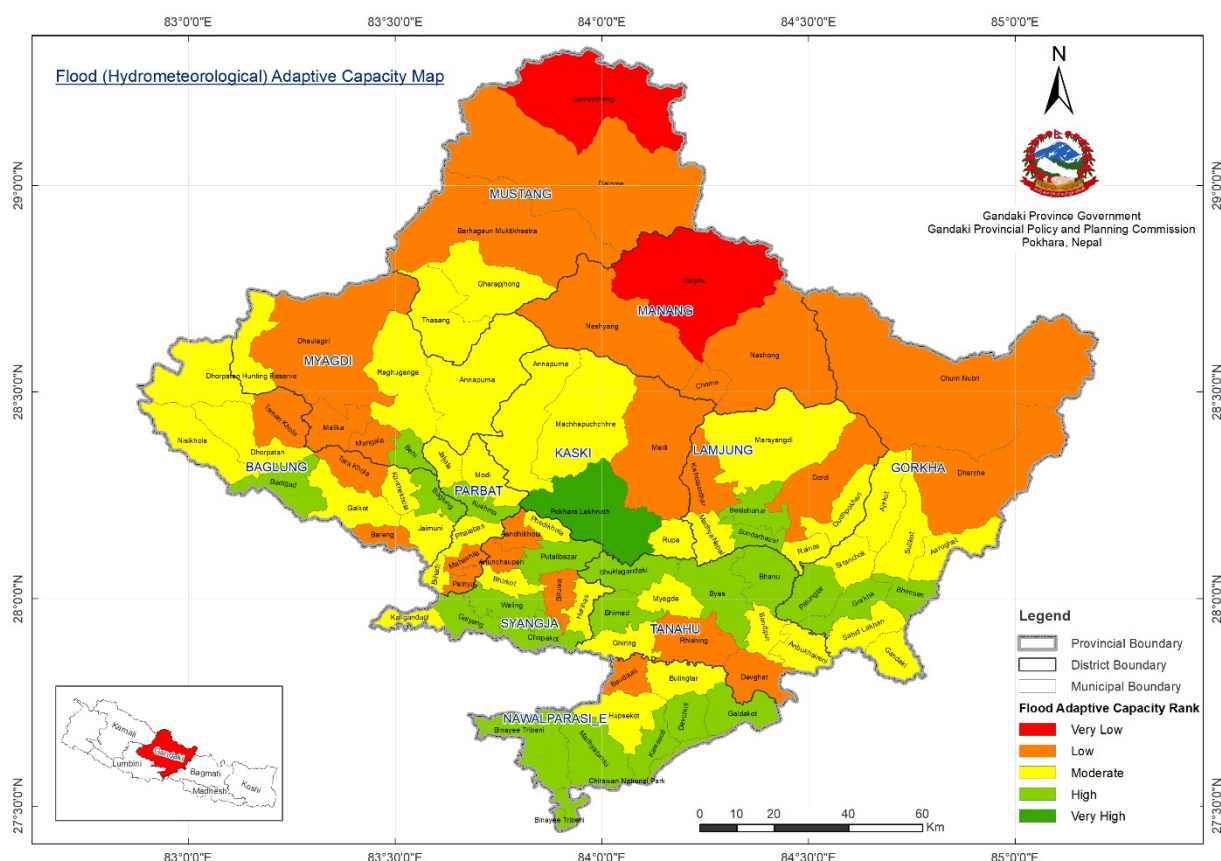


Figure 4.32: Flood hazard adaptive capacity map

Key adaptive capacity indicators for landslides include slope stabilization structures, community awareness training on landslide risks, relocation plans, and early warning mechanisms. The Landslide Adaptive Capacity Map (detailed calculation shown in Annex 3) as presented in Figure 4.33, indicates very low capacity in Manang, with low capacity in Myagdi, Baglung, and eastern Lamjung, reflecting rugged terrain, fragile infrastructure, and limited emergency access. Conversely, southern Parbat, Tanahu, and Nawalparasi districts show high to very high adaptive capacity, benefiting from road connectivity and stronger local governance. These variations suggest that mountainous areas with poor access and infrastructure remain the most at-risk, highlighting the need for proactive mitigation planning.

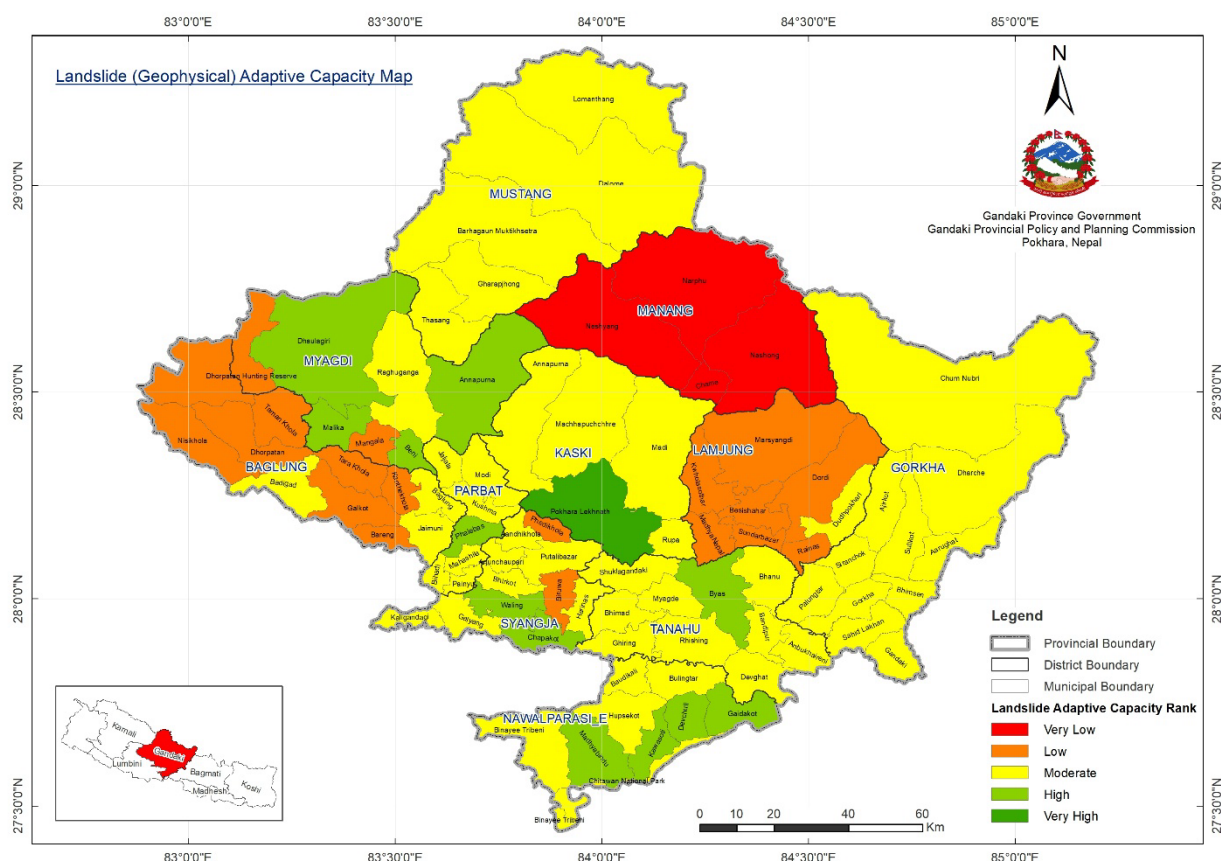


Figure 4.33: Landslide hazard adaptive capacity map

Fire-related adaptive capacity hinges on fire service availability, forest management, awareness programs on fire hazards, and household-level safety practices. The Fire Adaptive Capacity Map (detailed calculation shown in Annex 4) reveals as presented in Figure 4.34, very low capacity in several municipalities of Baglung, Lamjung, and Gorkha, where forest cover is dense, and emergency services are scarce. In contrast, Mustang, Kaski, and Nawalparasi show high to very high capacity, likely due to better access, forest fire surveillance systems, and more responsive institutional arrangements. This suggests a strong correlation between infrastructure and governance and the ability to prevent and respond to environmental fire hazards.

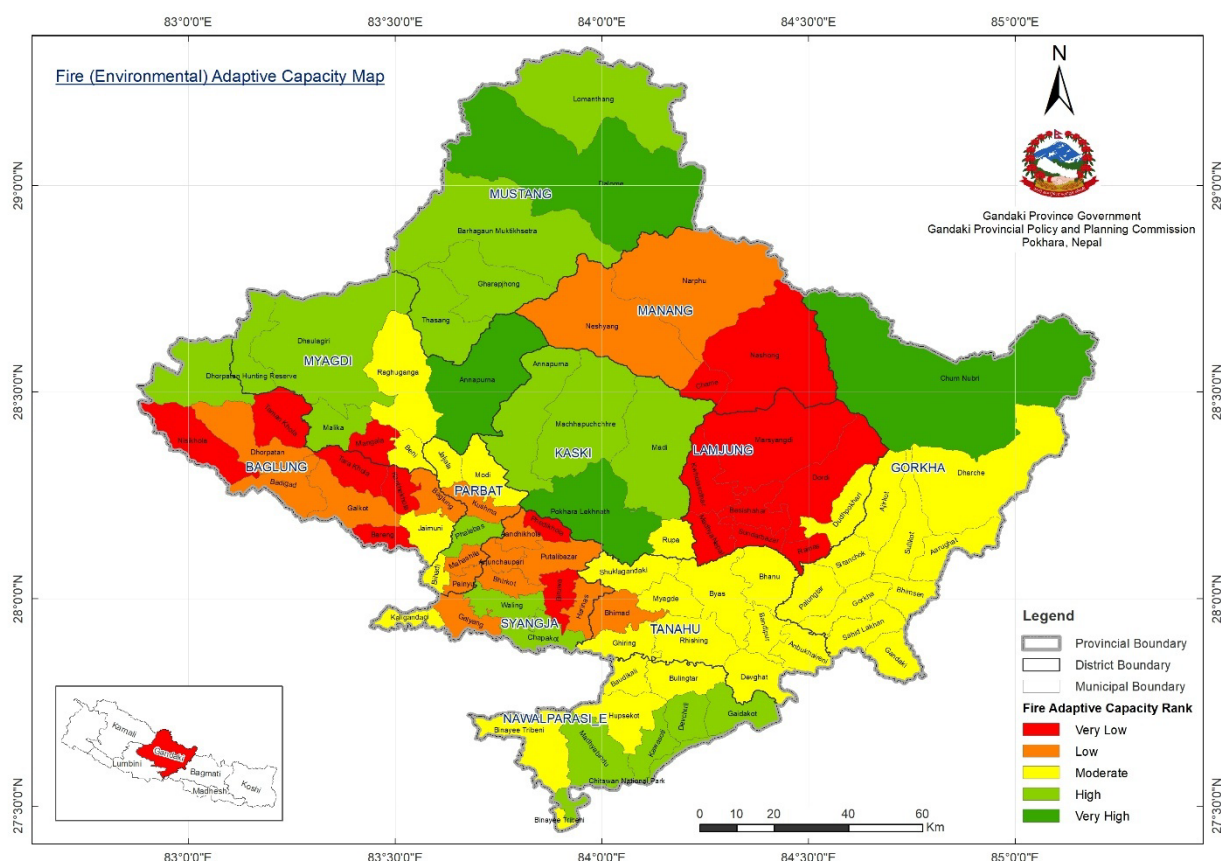


Figure 4.34: Fire hazard adaptive capacity map

In health contexts, adaptive capacity encompasses the availability and accessibility of health care services, hospital capacity, trained medical personnel, public health outreach, and disease surveillance systems. The Health Adaptive Capacity Map (detailed calculation shown in Annex 5) as presented in Figure 4.35, reveals areas like Kaski (especially Pokhara region) show higher capacity (green/yellow), due to better medical infrastructure and services. In contrast, remote districts such as Manang and Mustang are marked with low capacity (orange/red), reflecting challenges like sparse health facilities and difficult access. Such gaps affect the province's ability to respond to epidemics, heatwaves, or climate-sensitive diseases, emphasizing the importance of equitable health investment in disaster planning.

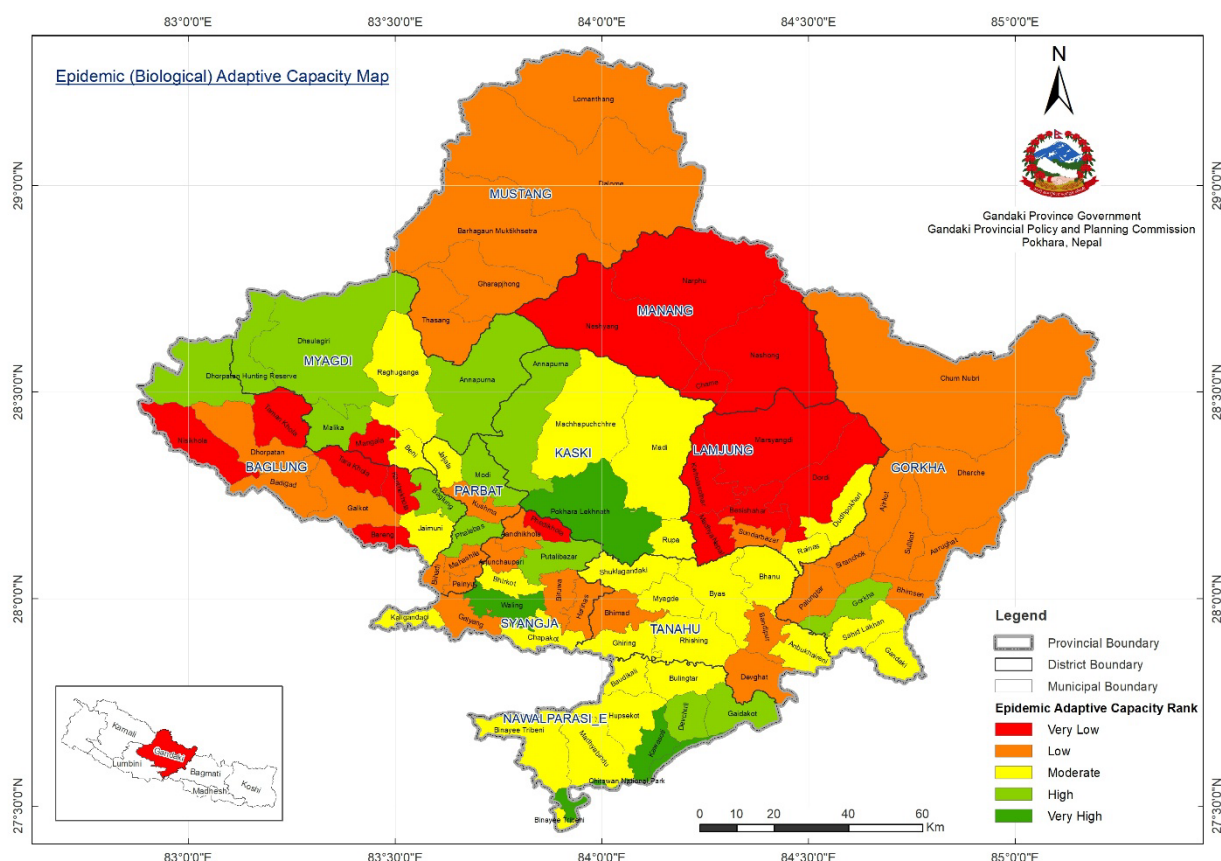


Figure 4.35: Health hazard adaptive capacity map

Technological hazard adaptive capacity indicators focus on emergency communication systems, industrial safety measures, hazardous material management, and the existence of technological disaster response plans. The technological hazard map (detailed calculation shown in Annex 6) as presented in Figure 4.36, illustrates that much of Gandaki Province, particularly rural and mountainous regions (orange/red), has low to very low adaptive capacity. Only select municipalities, such as parts of Kaski, exhibit high capacity (green), owing to better technological infrastructure and emergency management systems. The outcomes highlight a pressing need to extend technological hazard preparedness, strengthen industrial safety protocols, and enhance communication systems across the province to safeguard communities.

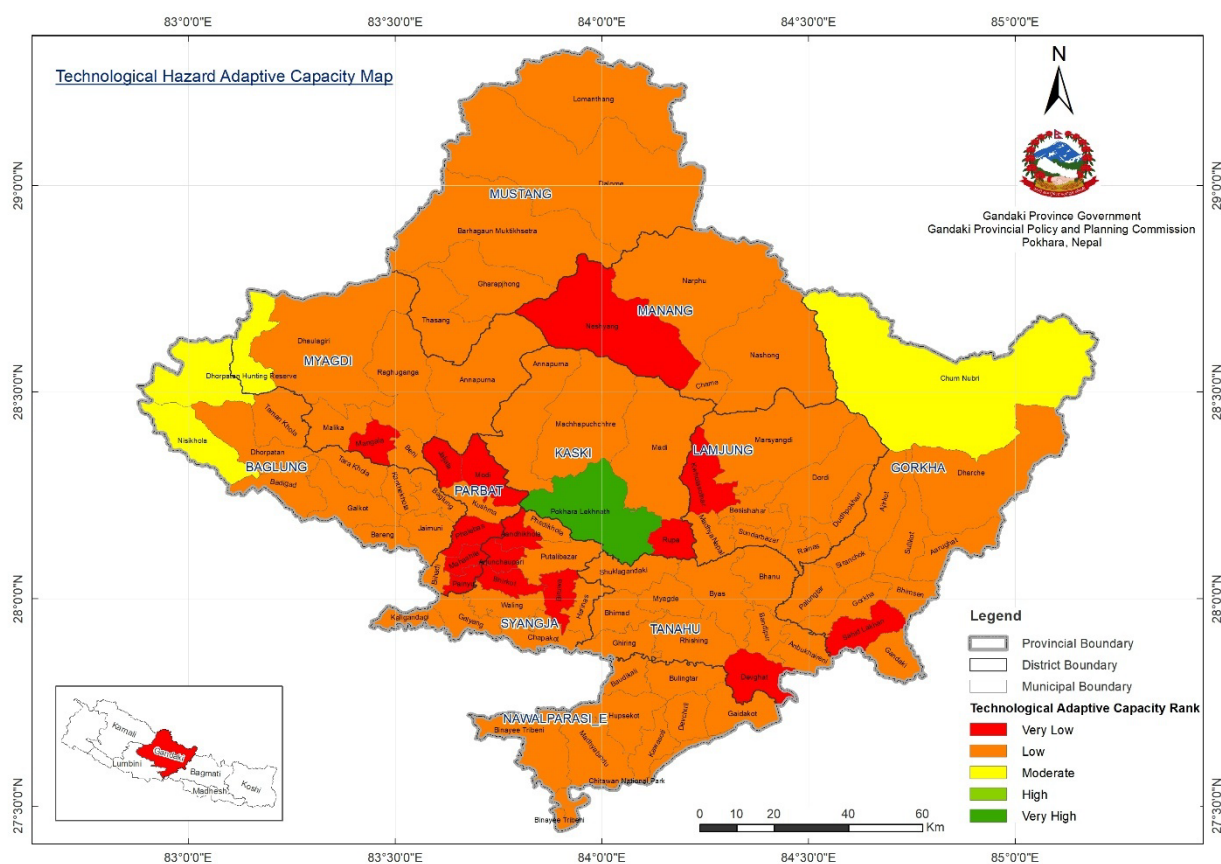


Figure 4.36: Technological hazard adaptive capacity map

4.9 Vulnerability

Vulnerability is influenced by two key components: sensitivity (S) and adaptive capacity (AC). Sensitivity denotes how exposed or susceptible a population or area is to harm, often determined by various factors as explained in above headings. Adaptive capacity, on the other hand, reflects the ability of individuals or systems to anticipate, cope with, and recover from hazard impacts. A higher sensitivity combined with a lower adaptive capacity results in higher vulnerability, while robust adaptive mechanisms can significantly reduce vulnerability even in high-risk environments.

In vulnerability risk assessments, analyzing vulnerability helps in pinpointing areas where the impacts of hazards - such as hydrometeorological, geophysical, environmental, biological and technological hazards-based disasters - are likely to be more severe. The significance of assessing vulnerability lies in its critical role in Vulnerability and Risk Assessments (VRA), which are essential tools for disaster risk reduction and resilience planning.

4.10 Risk

Individual hazard risk maps, such as those for floods, landslides, fires, health (biological hazards), and technological hazards help identify specific municipal-level vulnerabilities and exposures. These individual maps are developed based on key factors like hazard intensity, historical frequency, community exposure, and adaptive capacity. These individual maps are vital in isolating particular threats and their spatial patterns, which informs hazard-specific interventions. The integrated multi-hazard risk map combines these individual risks, offering a holistic perspective essential for planning comprehensive disaster risk reduction (DRR) strategies. This integrated view is particularly valuable in regions where multiple hazards interact or compound impacts, supporting well-rounded local policies, adaptation strategies, and resource allocation.

The flood risk map (detailed calculation shown in Annex 7) as presented in Figure 4.37, developed by the study team, indicates that Areas with very high flood risk include municipalities in Nawalparasi (East) like Madhya Bindu and Devchuli, and parts of Myagdi and Lamjung such as Annapurna Rural municipality and Madhya Nepal Municipality. Several municipalities in Kaski and Syangja fall into the high to moderate range, while urban/rural municipalities in Manang, Mustang, and northern Gorkha typically experience low to very low flood risks due to arid or high-altitude geography. Flood risk is primarily influenced by topography, river proximity, land use, and drainage infrastructure. For instance, municipalities along major river corridors such as the Kaligandaki and Narayani show higher susceptibility. These areas face recurrent monsoonal flooding, impacting agriculture, settlements, and transportation. Outcomes of mapping flood risk include the identification of municipalities requiring urgent flood control measures, embankment strengthening, and early warning systems. Furthermore, such mapping assists in land-use planning by restricting high-risk floodplain development.

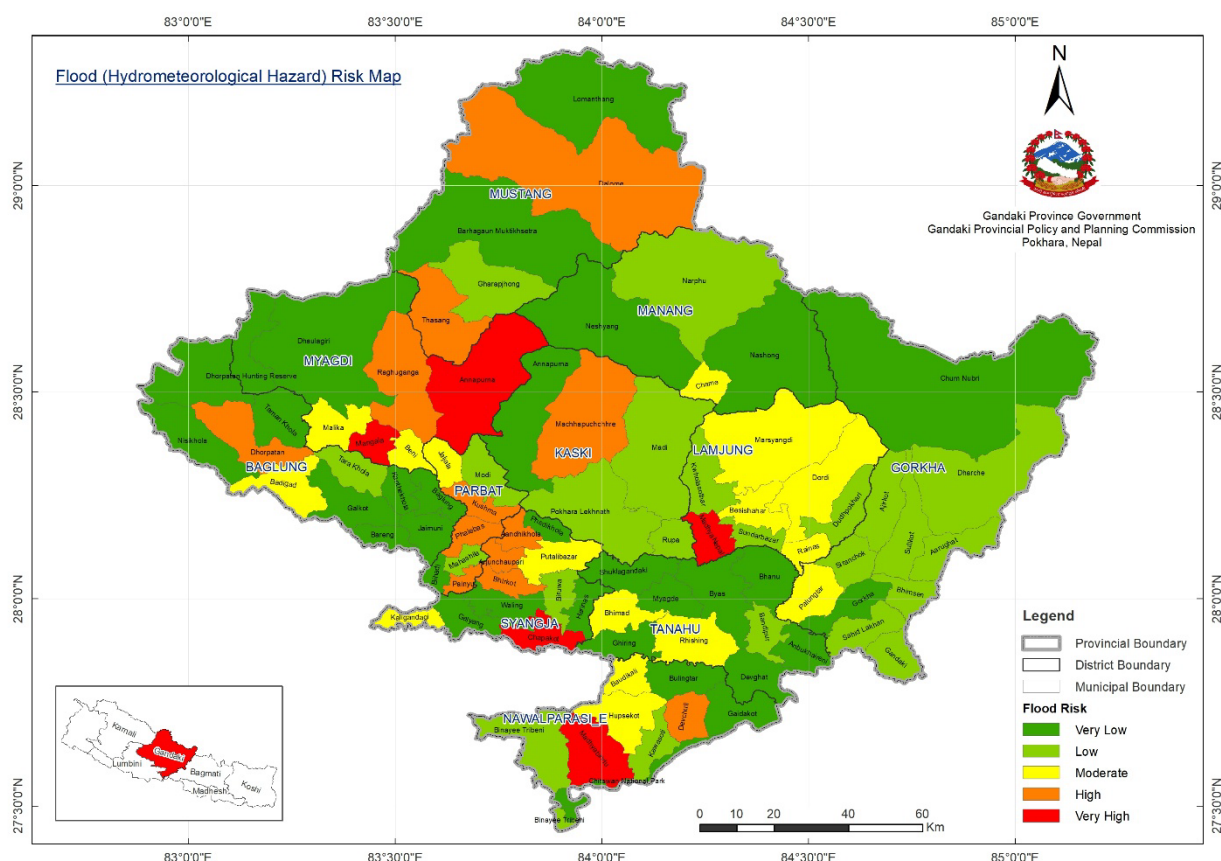


Figure 4.37: Flood risk map of Gandaki province

The landslide risk (detailed calculation shown in Annex 7) as presented in Figure 4.38, developed by the study team, a major geophysical hazard in Gandaki's hilly and mountainous terrain, is found with the very high category evident in Mangala Rural municipality and Raghuganga (Myagdi), Marshyangdi (Lamjung), and Dhorpatan (Baglung), which are in steep terrain with erosion-prone soils. Several rural/urban municipalities in Annapurna (Myagdi), Machhapuchchhre (Kaski), Dordi (Lamjung), Dharche (Gorkha), Kushma (Parbat) and Bhirkot (Syangja) lie in the high category. On the other hand, municipalities in Nawalparasi (East) and some parts of Gorkha and Tanahu fall under the low or very low landslide risk category. The steep slopes, unregulated development, and deforestation contribute to this high vulnerability. Landslides are frequent during the monsoon season and can cause devastating impacts including road blockages, destruction of homes, and loss of lives. The map suggests the need for slope stabilization, improved land-use planning, and forest conservation in high-risk zones. Targeted community awareness and infrastructure resilience measures are key outcomes for these areas.

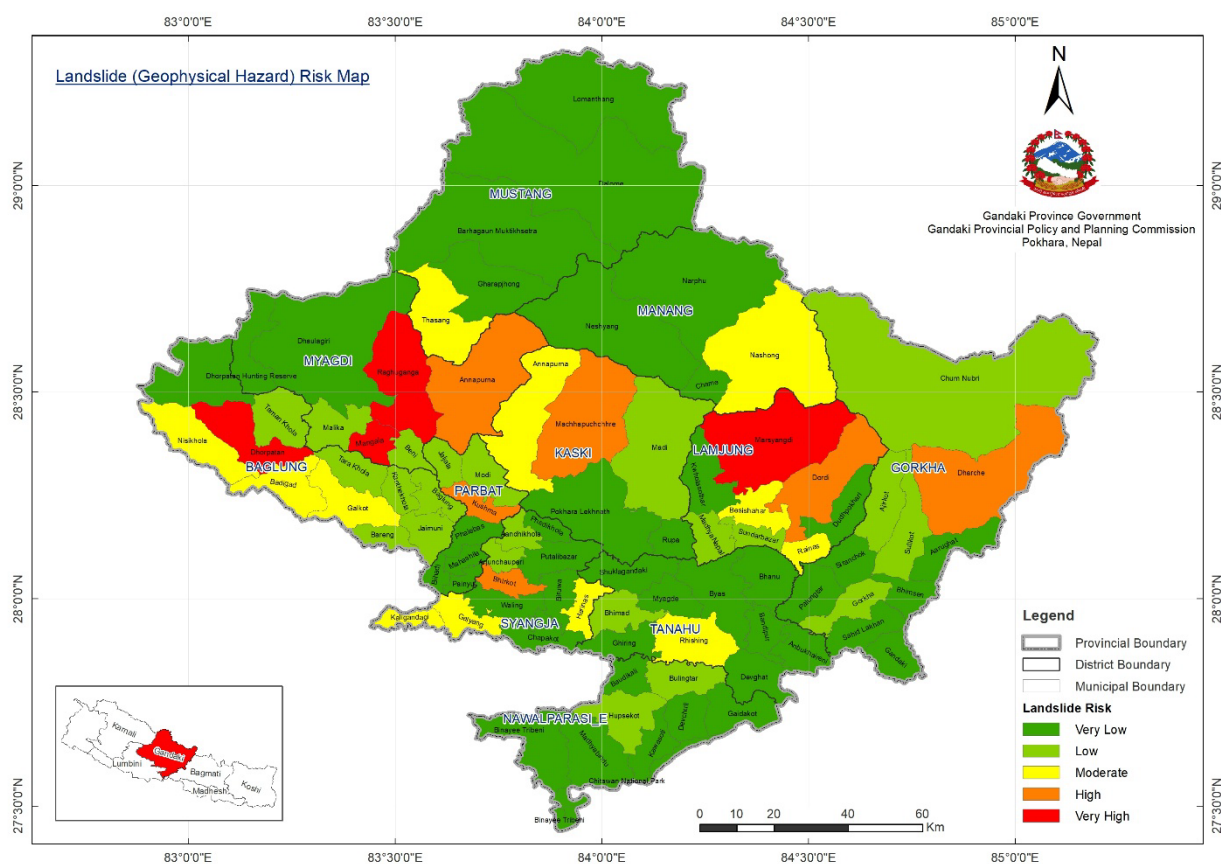


Figure 4.38: Landslide risk map of Gandaki province

The forest fire risk (detailed calculation shown in Annex 7) as presented in Figure 4.39, developed by the study team, particularly environmental fire hazards such as forest fires and accidental fires, with very high fire risk seen in municipalities like Badigad, Dhorpatan and Jaimuni in Baglung, Mangala in Myagdi, Kushma in Parbat and Bhirkot in Syangja. Rhishing (Tanahu), Pokhara Lekhnath (Kaski), Madhyabindu (Nawalparasi East) and Galyang (Syangja) fall under the high category. Rural/urban municipalities in higher altitudes or those with less forest cover, such as in Mustang and Manang, generally fall into the low to very low risk category. Some central hilly areas report moderate fire risk, often due to seasonal vegetation burning and forest degradation. The map highlights 'Very High' risk clusters in western and southern Gandaki, which may be linked to dry climatic conditions, combustible vegetation, and human activities. Forest fires are a seasonal threat, often peaking during dry winter and pre-monsoon periods. Factors contributing to this risk include settlement proximity to forests, vegetation condition, and lack of firefighting infrastructure. These risks threaten biodiversity, carbon stocks, and human settlements. The outcomes underline the importance of integrated fire management, community-based fire surveillance, and rapid response mechanisms.

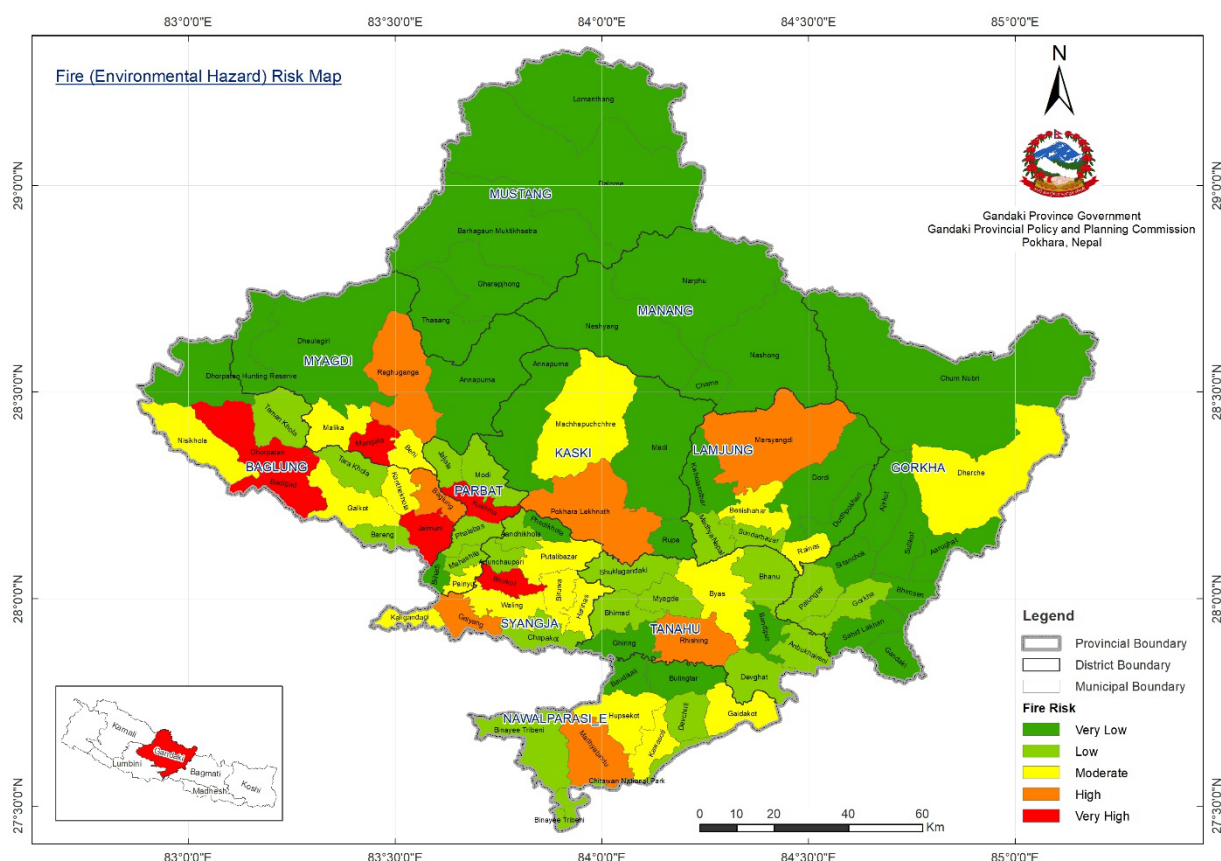


Figure 4.39: Fire risk map of Gandaki province

The health (biological hazard) risk map (detailed calculation shown in Annex 7) as presented in Figure 4.40, developed by the study team, shows distinct patterns across Gandaki Province. Health risk is very high in Tarakhola (Baglung), Madhya Nepal (Lamjung), Mangala (Myagdi), and several other municipalities in Baglung and Lamjung, indicating major public health vulnerabilities. These regions might face challenges such as limited healthcare access, high population density, or inadequate sanitation. Several urban/rural municipalities of Manang, Lamjung, Parbat and Baglung fall under the high category. The urban/rural municipalities with moderate risk include those in Gorkha, Syangja, and Tanahu. Urban centers such as Pokhara and Devchuli show low to very low risk, likely due to better healthcare infrastructure. Key outcomes include identifying health system gaps, strengthening primary care services, improving surveillance networks, and integrating health preparedness into disaster plans. The map helps policymaker's direct health infrastructure improvements, epidemic preparedness measures, and targeted health interventions to the most vulnerable communities.

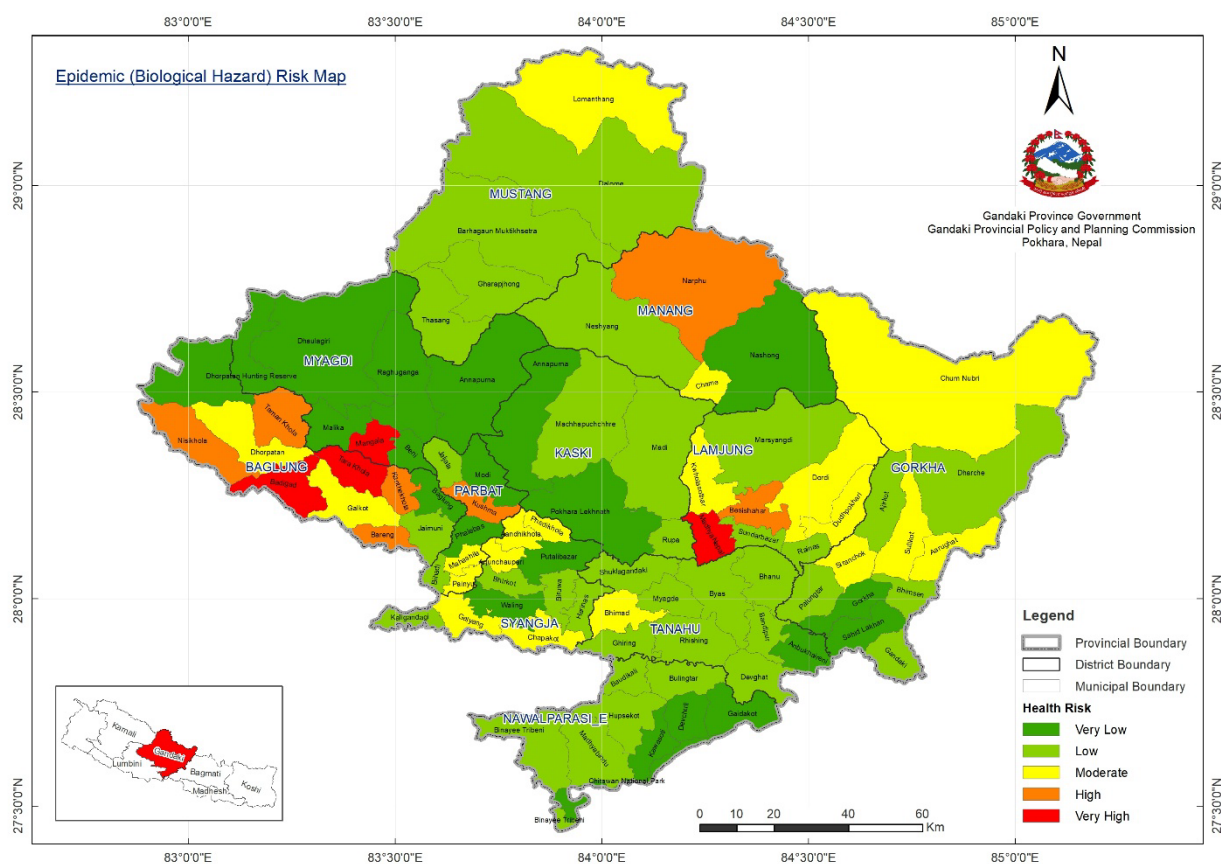


Figure 4.40: Health hazard risk map of Gandaki province

The technological hazard risk map (detailed calculation shown in Annex 7) as presented in Figure 4.41, developed by the study team, reveals that the technological risk is mostly in the low to moderate range for rural municipalities. However, very high risk is observed in Pokhara Metropolitan City (Kaski), while high risk is seen in Devchuli and Kawasoti (Nawalparasi East), indicating pressure on urban infrastructure and services. These zones likely correspond to industrial hubs, dense urban centers, or areas with significant transport and energy infrastructure, increasing exposure to accidents or technological failures. The majority of remote and rural areas, including rural municipalities in Mustang, Manang, and northern Gorkha, fall into the very low risk category due to limited exposure to technological hazards. The risk assessment outcomes stress the importance of hazard zoning, emergency response training, and compliance with safety standards in industrial and transport operations. Enhanced coordination between municipal disaster management committees and utility service providers is critical.

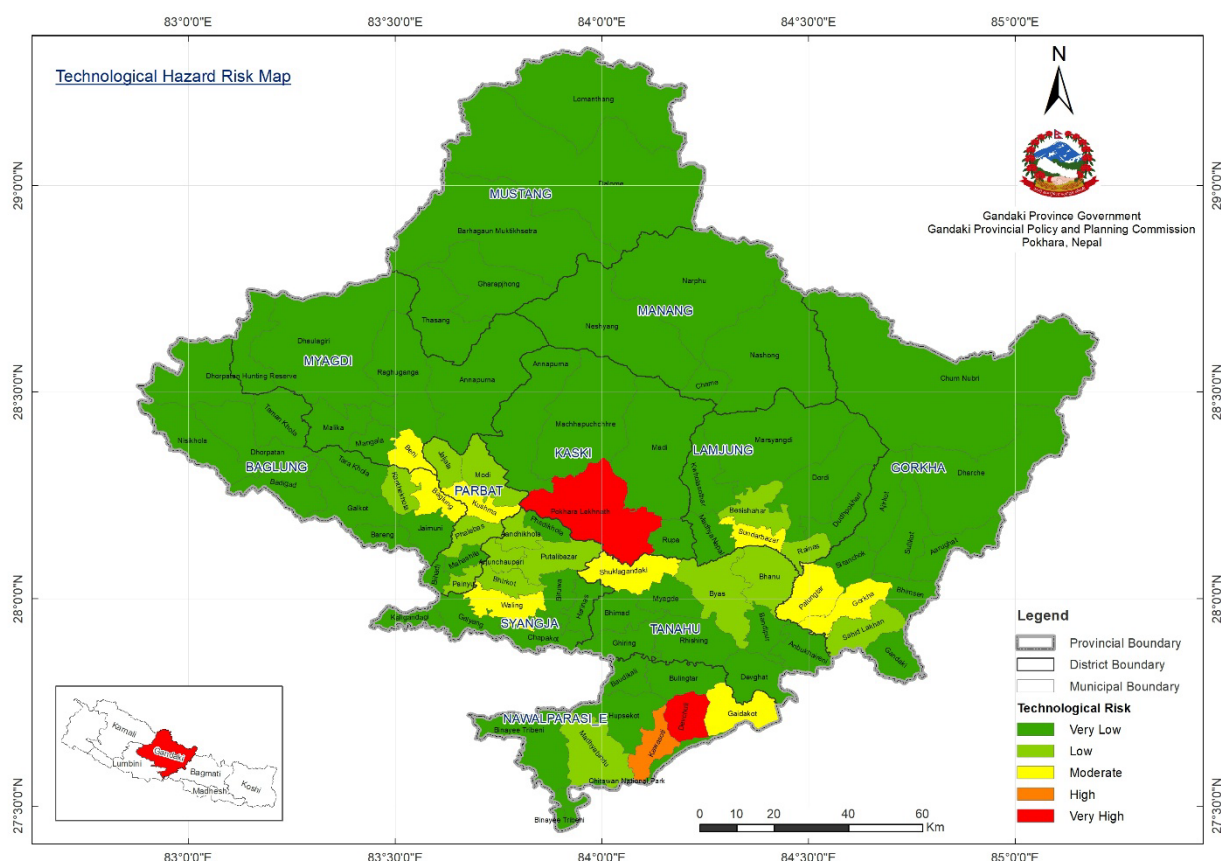


Figure 4.41: Technological hazard risk map of Gandaki province

Integrating all individual hazard risks into a multi-hazard risk index enables the identification of municipalities most at risk due to spatial overlapping vulnerabilities. The multi-hazard risk map (detailed calculation shown in Annex 7) as presented in Figure 4.42, developed by the study team, shows very high risk in municipalities like Pokhara (Kaski) and parts of Baglung, with several municipalities in Lamjung, Parbat, and Nawalparasi falling under moderate to high risk. This map is crucial because it illustrates areas where multiple hazards overlap, compounding community vulnerability. Such integrated mapping allows prioritization of high-risk zones for multi-sectoral intervention—spanning land use regulation, resilient infrastructure, emergency planning, and local capacity building. The outcomes of the integrated risk index support evidence-based policymaking and the development of Local Disaster and Climate Resilience Frameworks (LDCRFs), ensuring comprehensive disaster preparedness and climate resilience. Multi-hazard risk mapping thus forms the foundation for resilient development planning at the provincial and municipal levels.

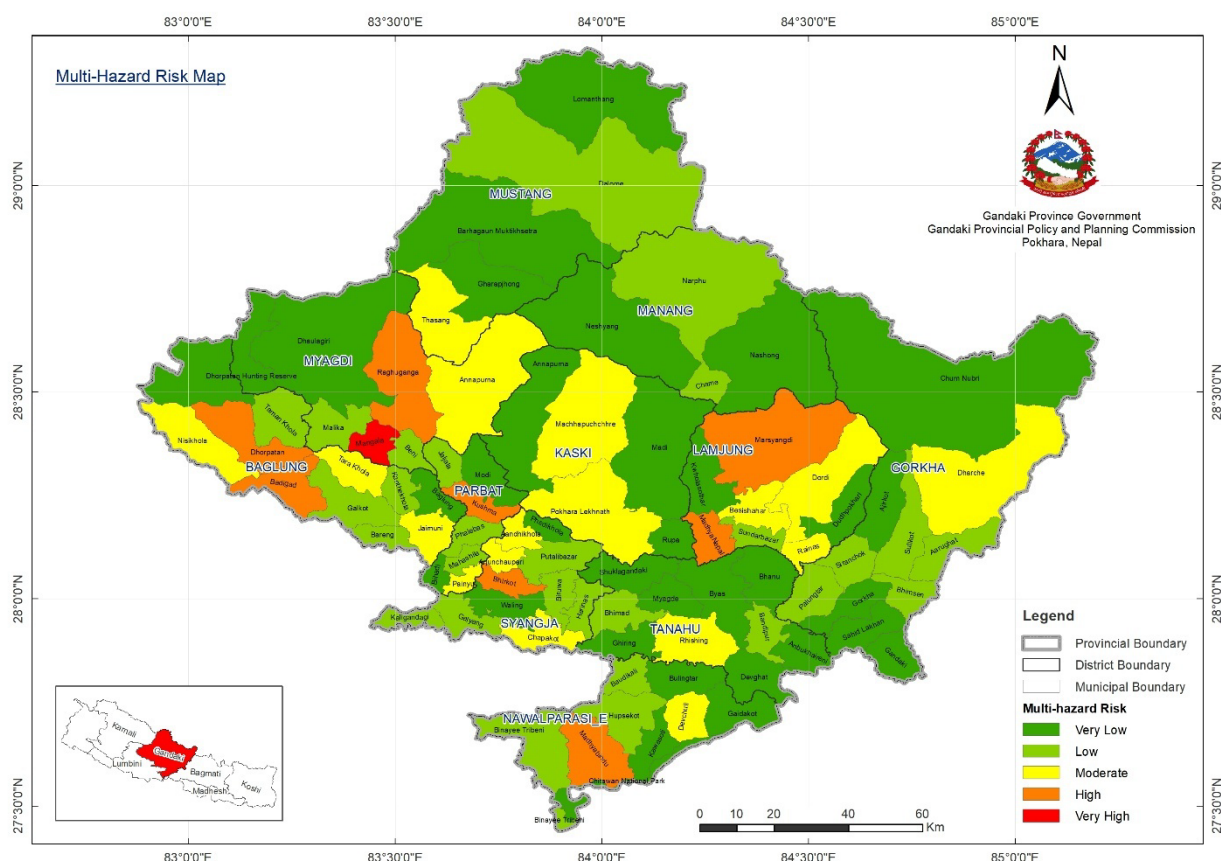


Figure 4.42: Multi-hazard risk map of Gandaki province

4.11 Quantitative Risk Matrix

The Quantitative Risk Matrix, derived from the individual risk indices of flood, landslide, forest fire, health hazard, and technological hazard across the 85 local levels of Gandaki Province, offers a visual and analytical representation of hazard-specific and cumulative risk. The vulnerability risk index itself doesn't have a specific unit of measurement like meters or kilograms. It was typically expressed as a dimensionless number, ranging from 0 to 100, and classified into categories such as "low," "medium," and "high." Each risk level is classified using a color-coded system based on the calculated risk index values: red indicates high risk, yellow denotes moderate risk, and green represents low risk. These colors reflect the severity of risk associated with each hazard in every municipality. Municipalities displaying high-intensity red across all five hazards signify areas with a high level of integrated or compound risk, warranting urgent attention and intervention. On the other hand, municipalities with predominantly green shades suggest relatively lower vulnerability. This matrix serves as a crucial decision-support tool, enabling policymakers and disaster management authorities to

identify risk hotspots and prioritize risk reduction strategies. The detailed breakdown of risk classification per local level is presented in Table 4.8.

Table 4.8: Quantitative Risk Matrix

SN	District	Local Level	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
1	Gorkha	Chumanubri Gaunpalika	3.805	5.394	0.992	18.216	1.017
2	Gorkha	Ajirkot Gaunpalika	13.916	5.710	2.850	9.540	1.036
3	Gorkha	Barpak Sulikot Gaunpalika	15.081	7.875	4.371	18.322	1.036
4	Gorkha	Dharche Gaunpalika	12.107	35.584	12.854	10.574	1.022
5	Gorkha	Aarughat Gaunpalika	15.070	4.592	4.828	29.783	1.033
6	Gorkha	Bhimsenthapa Gaunpalika	18.872	1.432	2.663	12.994	1.040
7	Gorkha	Siranchowk Gaunpalika	13.255	2.792	5.047	20.325	1.083
8	Gorkha	Palungtar Municipality	22.700	2.724	6.221	14.034	1.279
9	Gorkha	Gorkha Municipality	5.398	5.071	9.432	1.505	1.316
10	Gorkha	Shahid Lakhan Gaunpalika	12.551	2.690	3.700	6.750	1.160
11	Gorkha	Gandaki Gaunpalika	13.862	2.308	2.548	10.362	1.040
12	Manang	Narpa Bhumi Gaunpalika	10.296	3.834	1.445	52.652	1.021
13	Manang	Manang Ngisyang Gaunpalika	2.730	3.740	1.503	17.081	1.031
14	Manang	Chame Gaunpalika	20.438	3.959	2.194	31.545	1.035
15	Manang	Nason Gaunpalika	1.910	18.345	2.376	1.720	1.030
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	36.436	3.848	1.046	14.147	1.012
17	Mustang	Gharpajhong Gaunpalika	10.773	1.750	2.235	8.167	1.031
18	Mustang	Varagung Muktichhetra Gaunpalika	7.549	1.654	1.089	9.152	1.023
19	Mustang	Lomanthang Gaunpalika	1.170	1.237	1.234	25.172	1.000
20	Mustang	Thasang Gaunpalika	35.318	13.886	2.231	11.746	1.034
21	Myagdi	Annapurna Gaunpalika	64.029	22.723	1.091	1.813	1.040

SN	District	Local Level	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
22	Myagdi	Raghuganga Gaunpalika	52.352	54.535	23.015	6.033	1.038
23	Myagdi	Dhawalagiri Gaunpalika	5.754	3.111	2.287	1.028	1.029
24	Myagdi	Malika Gaunpalika	28.915	7.358	19.117	0.974	1.037
25	Myagdi	Mangala Gaunpalika	58.810	99.969	90.862	89.781	1.093
26	Myagdi	Beni Municipality	19.918	6.423	11.432	2.690	1.288
27	Kaski	Madi Gaunpalika	13.322	6.375	3.121	7.426	1.044
28	Kaski	Machhapuchchhre Gaunpalika	48.864	27.076	11.839	11.393	1.044
29	Kaski	Annapurna Gaunpalika	5.448	15.860	2.883	1.355	1.043
30	Kaski	Pokhara Metropolitan City	10.509	3.655	25.825	3.087	100.000
31	Kaski	Rupa Gaunpalika	14.303	1.448	3.972	10.175	1.050
32	Lamjung	Dordi Gaunpalika	25.855	20.792	4.896	28.725	1.039
33	Lamjung	Marshyangdi Gaunpalika	24.619	67.973	20.068	14.740	1.041
34	Lamjung	Kwhola Sothar Gaunpalika	11.239	2.069	5.519	20.016	1.046
35	Lamjung	Madhya Nepal Municipality	59.596	4.992	6.873	98.435	1.085
36	Lamjung	Bensishahar Municipality	22.138	15.240	13.887	51.697	1.187
37	Lamjung	Sundarbazar Municipality	13.518	6.528	8.467	10.585	1.299
38	Lamjung	Rainas Municipality	29.537	11.716	13.727	15.414	1.127
39	Lamjung	Dudhapokhari Gaunpalika	11.071	2.511	4.060	17.957	1.040
40	Tanahu	Bhanu Municipality	5.647	3.748	7.477	10.965	1.183
41	Tanahu	Byas Municipality	6.983	4.389	18.100	7.630	1.251
42	Tanahu	Myagde Gaunpalika	5.960	3.585	7.356	10.001	1.066
43	Tanahu	Shuklagandaki Municipality	4.593	3.182	8.207	7.937	1.338
44	Tanahu	Bhimad Municipality	21.440	6.528	8.673	23.735	1.049
45	Tanahu	Ghiring Gaunpalika	1.035	4.285	2.648	13.584	1.048
46	Tanahu	Rhishing Gaunpalika	20.828	16.688	40.658	12.370	1.048
47	Tanahu	Devghat Gaunpalika	5.988	2.566	7.944	13.658	1.048
48	Tanahu	Bandipur Gaunpalika	17.962	3.379	5.223	12.004	1.049

SN	District	Local Level	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
49	Tanahu	Aanbu Khaireni Gaunpalika	3.837	4.372	5.876	4.508	1.047
50	Nawalparasi (East)	Gaidakot Municipality	3.448	1.002	14.112	1.983	1.510
51	Nawalparasi (East)	Bulingtar Gaunpalika	5.249	4.724	3.363	8.200	1.049
52	Nawalparasi (East)	Baudikali Gaunpalika	28.883	3.486	3.067	10.276	1.047
53	Nawalparasi (East)	Hupsekot Gaunpalika	23.957	5.089	16.370	9.925	1.050
54	Nawalparasi (East)	Devchuli Municipality	45.799	1.926	10.797	2.193	63.639
55	Nawalparasi (East)	Kawasoti Municipality	10.933	0.995	14.663	1.478	2.010
56	Nawalparasi (East)	Madhya Bindu Municipality	98.648	1.001	28.032	12.956	1.173
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	14.766	1.497	9.937	14.782	1.052
58	Syangja	Putalibazar Municipality	27.506	3.034	13.439	1.542	1.153
59	Syangja	Phedikhola Gaunpalika	0.938	3.304	3.980	23.605	1.052
60	Syangja	Aandhikhola Gaunpalika	38.570	4.950	10.882	21.676	1.125
61	Syangja	Arjun Choupari Gaunpalika	37.030	8.755	10.197	33.039	1.155
62	Syangja	Bhirkot Municipality	47.368	20.196	60.593	12.151	1.245
63	Syangja	Biruwa Gaunpalika	13.331	4.310	11.723	14.235	1.049
64	Syangja	Harinas Gaunpalika	0.909	18.820	18.635	13.702	1.048
65	Syangja	Chapakot Municipality	62.972	2.567	7.536	22.077	1.049
66	Syangja	Walling Municipality	5.876	4.047	15.197	2.332	1.350
67	Syangja	Galyang Municipality	4.890	10.515	20.333	19.149	1.048
68	Syangja	Kaligandaki Gaunpalika	26.594	11.303	13.446	11.098	1.045
69	Parbat	Modi Gaunpalika	12.103	5.303	8.440	2.263	1.141
70	Parbat	Jaljala Gaunpalika	30.121	7.230	9.245	9.009	1.212
71	Parbat	Kushma Municipality	38.899	24.046	58.959	35.733	1.335
72	Parbat	Phalebas Municipality	36.671	2.324	6.158	4.033	1.152
73	Parbat	Mahashila Gaunpalika	15.491	2.753	6.998	20.735	1.046

SN	District	Local Level	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
74	Parbat	Bihadi Gaunpalika	1.153	1.790	5.204	11.670	1.044
75	Parbat	Paiyu Gaunpalika	36.624	4.380	11.927	26.630	1.150
76	Baglung	Baglung Municipality	7.139	7.926	20.325	2.313	1.522
77	Baglung	Kathekhola Gaunpalika	6.774	6.335	12.930	40.069	1.154
78	Baglung	Tarakhola Gaunpalika	16.436	6.268	5.874	99.777	1.040
79	Baglung	Tamankhola Gaunpalika	4.819	5.459	9.595	44.811	1.035
80	Baglung	Dhorpatan Municipality	42.144	63.240	71.991	21.954	1.036
81	Baglung	Nisikhola Gaunpalika	4.793	14.982	12.742	59.114	1.034
82	Baglung	Badigad Gaunpalika	32.645	12.103	99.966	90.956	1.038
83	Baglung	Galkot Municipality	4.446	12.070	14.375	26.984	1.040
84	Baglung	Bareng Gaunpalika	5.866	7.819	11.005	37.598	1.040
85	Baglung	Jaimuni Municipality	6.548	9.381	83.500	7.640	1.104

4.12 Discussion

The discussion section helps to validate findings by showing alignment or divergence with recognized data, adds depth to the results, and highlights the relevance of the study in the broader context. The comparison between observed flood risk outcomes from our study and those presented in the reference report reveals a strong alignment in identifying Nawalparasi (East) and Kaski as very high flood risk zones. Both sources emphasize the vulnerability of municipalities like Madhya Bindu and Devchuli in Nawalparasi (East) and several parts of Kaski due to their proximity to major river systems. Our mapping also highlights flood-prone areas in Myagdi and Lamjung, reinforcing the reference report's classification of these districts under moderate flood hazard. This consistency in findings supports the reliability of our methodology.

In the case of landslide hazards, our study findings resonate well with the reference report by highlighting Baglung and Kaski districts in the very high category and Lamjung, Myagdi, Syangja, Tanahu, and Gorkha in the high-risk category. Our detailed municipal-level mapping, such as identifying Mangala, Raghuganga, and Marshyangdi as very high-risk local units,

offers a more localized lens that complements the broader district-level hotspot identification from the reference. The similar classification suggests that both studies accurately reflect the physical terrain, land-use dynamics, and climatic triggers contributing to frequent landslides in Gandaki Province.

Regarding forest fire hazards, the study recognizes municipalities like Badigad, Dhorpatan, and Mangala as very high-risk zones, which is consistent with the reference report identifying Nawalparasi (East) and Gorkha as districts facing very high fire risk. While our municipal-level analysis provides granularity—highlighting seasonal, anthropogenic, and vegetative factors—the reference report’s district-wide approach supports this view with broader hazard rankings. Both perspectives validate the increased fire susceptibility in southern and western parts of Gandaki and affirm the importance of community-based fire surveillance and rapid response interventions.

The health risk (epidemic) patterns observed in our study are also well reflected in the reference ranking. Districts such as Gorkha, Tanahu, and Syangja are categorized as very high risk in the reference report, which aligns with our identification of several municipalities in these districts exhibiting elevated biological hazard vulnerabilities. Our mapping adds depth by linking these risks to specific factors such as healthcare access and sanitation infrastructure. This correlation reinforces the importance of prioritizing health system strengthening and epidemic preparedness in these high-risk areas, ensuring that localized vulnerabilities are addressed within broader public health planning.

Although the reference report does not have technological hazards, the outcomes from our study complement the broader context of urban vulnerability and disaster risk mentioned in the disaster hotspot classifications. For instance, our findings that Pokhara, Devchuli, and Kawasoti are at high to very high technological risk resonate with the report’s identification of Kaski and Nawalparasi East as climate-related disaster hotspots. The urban infrastructure pressure and exposure to industrial risks in these areas underscore the necessity of hazard zoning and safety compliance, particularly as urbanization intensifies. Together, these insights highlight the value of multi-hazard risk mapping for forward-looking urban disaster risk management.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The multi-hazard risk assessment for Gandaki Province highlights significant spatial variations in vulnerability across different hazards, including floods, landslides, fires, epidemics, and technological risks. The study reveals that densely populated urban areas like Pokhara Metropolitan City and southern municipalities such as Nawalparasi East face high flood and technological risks, while remote mountainous regions like Mustang and Manang exhibit heightened sensitivity to landslides and health hazards due to limited infrastructure and accessibility. The integrated multi-hazard risk map underscores overlapping vulnerabilities in several municipalities, emphasizing the need for targeted interventions to enhance resilience. Factors such as topography, population density, infrastructure quality, and adaptive capacity play crucial roles in shaping risk profiles, necessitating a holistic approach to disaster risk reduction (DRR) and climate adaptation planning.

Furthermore, the assessment demonstrates that socio-economic factors, including gender dynamics, education levels, and housing conditions, significantly influence vulnerability. Female-dominated households in rural areas, traditional housing structures in hilly regions, and limited access to healthcare in remote districts amplify risks, requiring gender-sensitive and inclusive DRR strategies. The findings also highlight the importance of localized risk mapping, as hazard exposure and adaptive capacity vary considerably even within districts. By integrating these insights into provincial and municipal planning, Gandaki Province can better prioritize resource allocation, strengthen early warning systems, and build community resilience against multi-hazard threats.

5.2 Recommendations

To address the identified risks and enhance disaster resilience in Gandaki Province, the following measures are recommended:

Strengthen Multi-Hazard Early Warning Systems (EWS):

- Expand real-time monitoring for floods, landslides, and forest fires using satellite data and community-based sensors.
- Improve dissemination channels (e.g., mobile alerts, sirens) to ensure timely warnings reach vulnerable populations, especially in remote areas.

Risk-Informed Infrastructure Design

- Utilize municipality-level multi-hazard risk maps to guide the design of roads, water supply, and irrigation systems, ensuring they are resilient to local hazard profiles.
- Designing with risk data from the outset minimizes future variation orders and construction delays due to unforeseen hazard impacts.

Enforce Resilient Infrastructure and Land-Use Policies:

- Implement building codes for disaster-resistant construction, particularly in high-risk zones like Pokhara and landslide-prone hilly areas.
- Restrict settlements and critical infrastructure in floodplains and steep slopes through zoning regulations.

Enhance Community Preparedness and Adaptive Capacity:

- Conduct regular DRR training and simulation drills for local governments and communities, focusing on gender-inclusive participation.
- Promote livelihood diversification and climate-smart agriculture to reduce dependency on hazard-prone sectors.

Improve Health and Technological Hazard Management:

- Upgrade healthcare facilities in high epidemic-risk zones (e.g., Baglung, Lamjung) and establish mobile clinics for remote areas.

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- Develop contingency plans for industrial and urban technological hazards, including fire safety audits in densely populated municipalities.

These recommendations should be integrated into provincial and local development plans, with coordinated efforts from government agencies, NGOs, and communities to ensure sustainable risk reduction and climate resilience.

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Annex 1: Exposure, sensitivity, and adaptive capacity indicators for hazards

Hazard	Exposure Indicator	Weight	Sensitivity Indicator	Weight	Adaptive Capacity Indicator	Weight
Hydrometeorological hazard (Flood) Exposure	Distance to River (m)	0.15	Below 15 Population	0.2	Status of Road	0.2
	Infrastructure exposure (km)	0.1	16 - 60 Population	0.05	Building Type	0.2
	Landcover	0.2	Above 60 Population	0.2	Community Awareness training	0.2
	Population	0.25	Wealth Quintile	0.35	Wealth Status	0.2
	No of infrastructure	0.1	Drinking Water Availability	0.2	Economically Active Population	0.2
	Slope	0.2				
Geophysical hazard (Landslide) Exposure	Slope	0.3	Slope	0.15	Community Awareness training	0.2
	Physiographic Region	0.2	Physiographic Region	0.15	DRR Budget	0.3
	Landcover	0.2	Below 15 Population	0.15	Building Type	0.3
	Population Density	0.15	16-60 Population	0.05	Technology Access	0.2
	No of infrastructure	0.15	Above 60 Population	0.15		
			Building on Slope	0.25		
			Community Awareness	0.1		
Environmental hazard (Fire) Exposure	Forest Type	0.2	Below 15 Population	0.15	National Park and conservation Area	0.3
	Max Temperature	0.1	16-60 Population	0.05	DRR Budget	0.4
	Min Temperature	0.1	Above 60 Population	0.15	Community Awareness training	0.3
	Total Annual Precipitation	0.2	Settlement distance to forest (m)	0.2		
	Building to forest distance	0.2	Air Quality Sensitivity	0.1		
	Fuel load density - biomass	0.2	Vegetation condition index	0.15		
			Infrastructure exposure from forest (m)	0.2		

Hazard	Exposure Indicator	Weight	Sensitivity Indicator	Weight	Adaptive Capacity Indicator	Weight
Biological hazard (Health) Exposure	Total Population	0.3	Below 15 Population	0.15	No. of health center	0.3
	Distance from Settlement	0.3	16-60 Population	0.05	DRR Budget	0.3
	Distance from River	0.2	Above 60 Population	0.15	Education Level	0.4
	Distance from Road	0.2	Health center distance (Km)	0.25		
			Building Type	0.2		
			Slope	0.2		
Technological hazard Exposure	Distance from Petrol Pump	0.4	Population Density	0.2	Length of Road	0.2
	Distance from Road (m)	0.2	Below 15 Population	0.2	Education Level	0.2
	Distance from Industry (m)	0.4	16 - 60 Population	0.1	Health center distance (Km)	0.2
			Above 60 Population	0.2	Employed Population	0.2
			Landcover (Builtup)	0.15	Community Awareness training	0.2
			Building Density	0.15		

Annex 2: Hazard, Exposure and Vulnerability of Flood hazard

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1	Gorkha	Chumanubri Gaunpalika	0.100	0.087	0.405	0.054	0.351
2	Gorkha	Ajirkot Gaunpalika	0.150	0.247	0.387	0.105	0.282
3	Gorkha	Barpak Sulikot Gaunpalika	0.150	0.286	0.389	0.126	0.264
4	Gorkha	Dharche Gaunpalika	0.200	0.137	0.405	0.073	0.333
5	Gorkha	Aarughat Gaunpalika	0.150	0.299	0.386	0.134	0.252
6	Gorkha	Bhimsenthapa Gaunpalika	0.150	0.396	0.390	0.153	0.237
7	Gorkha	Siranchowk Gaunpalika	0.100	0.384	0.391	0.131	0.260
8	Gorkha	Palungtar Municipality	0.150	0.493	0.381	0.152	0.228
9	Gorkha	Gorkha Municipality	0.050	0.499	0.365	0.196	0.169
10	Gorkha	Shahid Lakhan Gaunpalika	0.100	0.368	0.383	0.126	0.257
11	Gorkha	Gandaki Gaunpalika	0.100	0.383	0.385	0.113	0.272
12	Manang	Narpa Bhumi Gaunpalika	0.150	0.124	0.455	0.035	0.420
13	Manang	Manang Ngisyang Gaunpalika	0.050	0.133	0.411	0.071	0.341
14	Manang	Chame Gaunpalika	0.250	0.196	0.394	0.083	0.310
15	Manang	Nason Gaunpalika	0.050	0.109	0.395	0.091	0.304
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	0.450	0.165	0.421	0.059	0.362
17	Mustang	Gharapajhong Gaunpalika	0.150	0.202	0.376	0.107	0.269
18	Mustang	Varagung Muktichhetra Gaunpalika	0.100	0.189	0.393	0.086	0.307
19	Mustang	Lomanthang Gaunpalika	0.000	0.243	0.490	0.031	0.459
20	Mustang	Thasang Gaunpalika	0.500	0.198	0.390	0.126	0.264
21	Myagdi	Annapurna Gaunpalika	1.000	0.175	0.392	0.122	0.270
22	Myagdi	Raghuganga Gaunpalika	0.700	0.182	0.413	0.110	0.303
23	Myagdi	Dhawalagiri Gaunpalika	0.150	0.094	0.395	0.077	0.318
24	Myagdi	Malika Gaunpalika	0.250	0.282	0.391	0.087	0.305
25	Myagdi	Mangala Gaunpalika	0.500	0.286	0.394	0.091	0.303
26	Myagdi	Beni Municipality	0.150	0.461	0.368	0.153	0.215
27	Kaski	Madi Gaunpalika	0.150	0.225	0.392	0.095	0.297
28	Kaski	Machhapuchchhre Gaunpalika	0.800	0.177	0.372	0.117	0.255

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
29	Kaski	Annapurna Gaunpalika	0.100	0.188	0.376	0.150	0.226
30	Kaski	Pokhara Metropolitan City	1.000	0.796	0.324	0.888	0.010
31	Kaski	Rupa Gaunpalika	0.100	0.393	0.391	0.117	0.273
32	Lamjung	Dordi Gaunpalika	0.300	0.218	0.388	0.095	0.293
33	Lamjung	Marshyangdi Gaunpalika	0.400	0.179	0.374	0.119	0.255
34	Lamjung	Kwhola Sothar Gaunpalika	0.100	0.259	0.395	0.066	0.328
35	Lamjung	Madhya Nepal Municipality	0.450	0.424	0.363	0.133	0.230
36	Lamjung	Bensishahar Municipality	0.200	0.445	0.358	0.173	0.185
37	Lamjung	Sundarbazar Municipality	0.100	0.503	0.358	0.156	0.202
38	Lamjung	Rainas Municipality	0.200	0.483	0.373	0.146	0.227
39	Lamjung	Dudhapokhari Gaunpalika	0.100	0.288	0.395	0.104	0.291
40	Tanahu	Bhanu Municipality	0.050	0.444	0.379	0.181	0.198
41	Tanahu	Byas Municipality	0.100	0.473	0.347	0.233	0.114
42	Tanahu	Myagde Gaunpalika	0.050	0.408	0.366	0.140	0.227
43	Tanahu	Shuklagandaki Municipality	0.050	0.459	0.341	0.184	0.158
44	Tanahu	Bhimad Municipality	0.200	0.387	0.369	0.163	0.206
45	Tanahu	Ghiring Gaunpalika	0.000	0.351	0.394	0.105	0.289
46	Tanahu	Rhishing Gaunpalika	0.150	0.324	0.397	0.077	0.319
47	Tanahu	Devghat Gaunpalika	0.050	0.329	0.379	0.097	0.282
48	Tanahu	Bandipur Gaunpalika	0.150	0.380	0.369	0.134	0.236
49	Tanahu	Aanbu Khaireni Gaunpalika	0.050	0.308	0.339	0.139	0.200
50	Nawalparasi (East)	Gaidakot Municipality	0.050	0.538	0.321	0.218	0.104
51	Nawalparasi (East)	Bulingtar Gaunpalika	0.050	0.315	0.384	0.124	0.260
52	Nawalparasi (East)	Baudikali Gaunpalika	0.250	0.294	0.386	0.094	0.291
53	Nawalparasi (East)	Hupsekot Gaunpalika	0.250	0.326	0.363	0.144	0.218
54	Nawalparasi (East)	Devchuli Municipality	0.400	0.562	0.327	0.177	0.150
55	Nawalparasi (East)	Kawasoti Municipality	0.100	0.767	0.332	0.224	0.108
56	Nawalparasi (East)	Madhya Bindu Municipality	1.000	0.473	0.365	0.212	0.153
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	0.150	0.338	0.381	0.163	0.218
58	Syangja	Putalibazar Municipality	0.250	0.436	0.364	0.177	0.187

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
59	Syangja	Phedikhola Gaunpalika	0.000	0.407	0.373	0.141	0.232
60	Syangja	Aandhikhola Gaunpalika	0.250	0.390	0.390	0.097	0.293
61	Syangja	Arjun Choupari Gaunpalika	0.250	0.379	0.385	0.096	0.289
62	Syangja	Bhirkot Municipality	0.350	0.393	0.380	0.126	0.254
63	Syangja	Biruwa Gaunpalika	0.100	0.330	0.393	0.089	0.304
64	Syangja	Harinas Gaunpalika	0.000	0.332	0.397	0.118	0.279
65	Syangja	Chapakot Municipality	0.550	0.399	0.383	0.171	0.211
66	Syangja	Walling Municipality	0.050	0.503	0.361	0.180	0.181
67	Syangja	Galyang Municipality	0.050	0.368	0.375	0.166	0.209
68	Syangja	Kaligandaki Gaunpalika	0.200	0.392	0.386	0.134	0.252
69	Parbat	Modi Gaunpalika	0.100	0.337	0.374	0.103	0.271
70	Parbat	Jaljala Gaunpalika	0.250	0.345	0.372	0.113	0.259
71	Parbat	Kushma Municipality	0.300	0.454	0.367	0.155	0.211
72	Parbat	Phalebas Municipality	0.250	0.391	0.387	0.110	0.278
73	Parbat	Mahashila Gaunpalika	0.100	0.347	0.391	0.056	0.335
74	Parbat	Bihadi Gaunpalika	0.000	0.397	0.386	0.108	0.278
75	Parbat	Paiyu Gaunpalika	0.250	0.379	0.379	0.093	0.286
76	Baglung	Baglung Municipality	0.050	0.588	0.365	0.178	0.187
77	Baglung	Kathekhola Gaunpalika	0.050	0.382	0.390	0.116	0.274
78	Baglung	Tarakhola Gaunpalika	0.150	0.265	0.382	0.073	0.309
79	Baglung	Tamankhola Gaunpalika	0.050	0.232	0.395	0.068	0.327
80	Baglung	Dhorpatan Municipality	0.450	0.263	0.384	0.121	0.263
81	Baglung	Nisikhola Gaunpalika	0.050	0.259	0.401	0.111	0.291
82	Baglung	Badigad Gaunpalika	0.350	0.309	0.383	0.159	0.223
83	Baglung	Galkot Municipality	0.050	0.288	0.383	0.139	0.244
84	Baglung	Bareng Gaunpalika	0.050	0.287	0.390	0.072	0.317
85	Baglung	Jaimuni Municipality	0.050	0.347	0.400	0.108	0.291

Annex 3: Hazard, Exposure and Vulnerability of Landslide hazard

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1	Gorkha	Chumanubri Gaunpalika	0.067	0.389	0.529	0.194	0.335
2	Gorkha	Ajirkot Gaunpalika	0.100	0.344	0.471	0.200	0.271
3	Gorkha	Barpak Sulikot Gaunpalika	0.150	0.344	0.478	0.215	0.263
4	Gorkha	Dharche Gaunpalika	0.500	0.401	0.541	0.202	0.339
5	Gorkha	Aarughat Gaunpalika	0.083	0.349	0.467	0.222	0.245
6	Gorkha	Bhimsenthapa Gaunpalika	0.017	0.264	0.412	0.206	0.206
7	Gorkha	Siranchowk Gaunpalika	0.050	0.301	0.440	0.202	0.238
8	Gorkha	Palungtar Municipality	0.083	0.262	0.385	0.227	0.158
9	Gorkha	Gorkha Municipality	0.133	0.344	0.411	0.236	0.176
10	Gorkha	Shahid Lakhan Gaunpalika	0.050	0.304	0.436	0.213	0.222
11	Gorkha	Gandaki Gaunpalika	0.033	0.327	0.449	0.208	0.241
12	Manang	Narpa Bhumi Gaunpalika	0.033	0.327	0.517	0.000	0.517
13	Manang	Manang Ngisyang Gaunpalika	0.033	0.342	0.485	0.008	0.477
14	Manang	Chame Gaunpalika	0.033	0.362	0.494	0.008	0.486
15	Manang	Nason Gaunpalika	0.150	0.376	0.616	0.011	0.604
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	0.083	0.263	0.448	0.190	0.257
17	Mustang	Gharpajhong Gaunpalika	0.017	0.347	0.459	0.194	0.265
18	Mustang	Varagung Muktichhetra Gaunpalika	0.017	0.305	0.456	0.192	0.264
19	Mustang	Lomanthang Gaunpalika	0.000	0.237	0.405	0.182	0.222
20	Mustang	Thasang Gaunpalika	0.267	0.360	0.479	0.214	0.264
21	Myagdi	Annapurna Gaunpalika	0.500	0.418	0.539	0.334	0.205
22	Myagdi	Raghuganga Gaunpalika	1.000	0.370	0.523	0.238	0.284
23	Myagdi	Dhawalagiri Gaunpalika	0.050	0.385	0.526	0.307	0.219
24	Myagdi	Malika Gaunpalika	0.133	0.369	0.519	0.264	0.255
25	Myagdi	Mangala Gaunpalika	1.000	0.378	0.569	0.055	0.514
26	Myagdi	Beni Municipality	0.100	0.466	0.493	0.263	0.230
27	Kaski	Madi Gaunpalika	0.117	0.375	0.477	0.234	0.243

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
28	Kaski	Machhapuchchhre Gaunpalika	0.550	0.378	0.479	0.233	0.247
29	Kaski	Annapurna Gaunpalika	0.267	0.419	0.504	0.243	0.261
30	Kaski	Pokhara Metropolitan City	1.000	0.527	0.273	0.869	0.010
31	Kaski	Rupa Gaunpalika	0.017	0.285	0.427	0.229	0.198
32	Lamjung	Dordi Gaunpalika	0.250	0.382	0.506	0.099	0.407
33	Lamjung	Marshyangdi Gaunpalika	0.867	0.369	0.495	0.083	0.412
34	Lamjung	Kwhola Sothar Gaunpalika	0.017	0.326	0.469	0.072	0.397
35	Lamjung	Madhya Nepal Municipality	0.083	0.309	0.419	0.112	0.307
36	Lamjung	Bensishahar Municipality	0.233	0.390	0.430	0.122	0.308
37	Lamjung	Sundarbazar Municipality	0.100	0.347	0.414	0.100	0.314
38	Lamjung	Rainas Municipality	0.183	0.339	0.403	0.064	0.340
39	Lamjung	Dudhapokhari Gaunpalika	0.033	0.314	0.473	0.184	0.289
40	Tanahu	Bhanu Municipality	0.133	0.254	0.395	0.234	0.161
41	Tanahu	Byas Municipality	0.150	0.318	0.402	0.262	0.141
42	Tanahu	Myagde Gaunpalika	0.083	0.287	0.409	0.194	0.215
43	Tanahu	Shuklagandaki Municipality	0.083	0.302	0.402	0.229	0.173
44	Tanahu	Bhimad Municipality	0.167	0.289	0.414	0.188	0.226
45	Tanahu	Ghiring Gaunpalika	0.117	0.252	0.411	0.190	0.222
46	Tanahu	Rhishing Gaunpalika	0.417	0.291	0.449	0.194	0.255
47	Tanahu	Devghat Gaunpalika	0.033	0.340	0.466	0.190	0.276
48	Tanahu	Bandipur Gaunpalika	0.067	0.300	0.429	0.192	0.236
49	Tanahu	Aanbu Khaireni Gaunpalika	0.067	0.365	0.466	0.192	0.274
50	Nawalparasi (East)	Gaidakot Municipality	0.017	0.299	0.341	0.328	0.013
51	Nawalparasi (East)	Bulingtar Gaunpalika	0.117	0.306	0.424	0.217	0.207
52	Nawalparasi (East)	Baudikali Gaunpalika	0.083	0.297	0.423	0.223	0.200
53	Nawalparasi (East)	Hupsekot Gaunpalika	0.217	0.250	0.388	0.238	0.149
54	Nawalparasi (East)	Devchuli Municipality	0.100	0.325	0.356	0.298	0.058
55	Nawalparasi (East)	Kawasoti Municipality	0.017	0.304	0.291	0.346	0.010
56	Nawalparasi (East)	Madhya Bindu Municipality	0.033	0.189	0.316	0.343	0.010
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	0.050	0.212	0.349	0.252	0.098

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
58	Syangja	Putalibazar Municipality	0.050	0.350	0.439	0.207	0.231
59	Syangja	Phedikhola Gaunpalika	0.050	0.276	0.412	0.080	0.332
60	Syangja	Aandhikhola Gaunpalika	0.083	0.320	0.449	0.156	0.293
61	Syangja	Arjun Choupari Gaunpalika	0.167	0.313	0.453	0.160	0.293
62	Syangja	Bhirkot Municipality	0.383	0.323	0.465	0.161	0.305
63	Syangja	Biruwa Gaunpalika	0.067	0.299	0.447	0.118	0.329
64	Syangja	Harinas Gaunpalika	0.500	0.276	0.427	0.173	0.254
65	Syangja	Chapakot Municipality	0.117	0.280	0.408	0.312	0.096
66	Syangja	Walling Municipality	0.117	0.453	0.447	0.332	0.114
67	Syangja	Galyang Municipality	0.200	0.340	0.461	0.185	0.276
68	Syangja	Kaligandaki Gaunpalika	0.250	0.355	0.453	0.224	0.229
69	Parbat	Modi Gaunpalika	0.100	0.316	0.456	0.187	0.269
70	Parbat	Jaljala Gaunpalika	0.133	0.373	0.498	0.251	0.247
71	Parbat	Kushma Municipality	0.617	0.335	0.432	0.212	0.220
72	Parbat	Phalebas Municipality	0.083	0.313	0.445	0.343	0.102
73	Parbat	Mahashila Gaunpalika	0.033	0.326	0.486	0.163	0.322
74	Parbat	Bihadi Gaunpalika	0.017	0.340	0.461	0.176	0.284
75	Parbat	Paiyu Gaunpalika	0.067	0.340	0.469	0.174	0.296
76	Baglung	Baglung Municipality	0.100	0.520	0.447	0.184	0.263
77	Baglung	Kathekhola Gaunpalika	0.083	0.332	0.477	0.096	0.381
78	Baglung	Tarakhola Gaunpalika	0.067	0.344	0.527	0.073	0.454
79	Baglung	Tamankhola Gaunpalika	0.050	0.373	0.547	0.075	0.472
80	Baglung	Dhorpatan Municipality	0.783	0.391	0.544	0.145	0.399
81	Baglung	Nisikhola Gaunpalika	0.150	0.384	0.571	0.092	0.478
82	Baglung	Badigad Gaunpalika	0.150	0.432	0.528	0.190	0.338
83	Baglung	Galkot Municipality	0.167	0.370	0.500	0.147	0.353
84	Baglung	Bareng Gaunpalika	0.100	0.331	0.483	0.077	0.406
85	Baglung	Jaimuni Municipality	0.183	0.338	0.494	0.227	0.266

Annex 4: Hazard, Exposure and Vulnerability of Forest Fire hazard

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1	Gorkha	Chumanubri Gaunpalika	0.020	0.393	0.530	0.545	0.010
2	Gorkha	Ajirkot Gaunpalika	0.027	0.509	0.667	0.245	0.422
3	Gorkha	Barpak Sulikot Gaunpalika	0.040	0.593	0.688	0.252	0.436
4	Gorkha	Dharche Gaunpalika	0.400	0.456	0.449	0.251	0.198
5	Gorkha	Aarughat Gaunpalika	0.047	0.595	0.688	0.265	0.423
6	Gorkha	Bhimsenthapa Gaunpalika	0.020	0.574	0.694	0.245	0.449
7	Gorkha	Siranchowk Gaunpalika	0.047	0.598	0.682	0.238	0.444
8	Gorkha	Palungtar Municipality	0.060	0.589	0.696	0.245	0.451
9	Gorkha	Gorkha Municipality	0.093	0.616	0.692	0.245	0.447
10	Gorkha	Shahid Lakhan Gaunpalika	0.033	0.654	0.626	0.245	0.381
11	Gorkha	Gandaki Gaunpalika	0.020	0.662	0.608	0.245	0.363
12	Manang	Narpa Bhumi Gaunpalika	0.020	0.234	0.466	0.155	0.311
13	Manang	Manang Ngisyang Gaunpalika	0.007	0.381	0.566	0.137	0.428
14	Manang	Chame Gaunpalika	0.020	0.349	0.555	0.022	0.534
15	Manang	Nason Gaunpalika	0.033	0.335	0.437	0.053	0.384
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	0.060	0.403	0.454	0.503	0.010
17	Mustang	Gharapajhong Gaunpalika	0.047	0.506	0.474	0.311	0.163
18	Mustang	Varagung Muktichhetra Gaunpalika	0.007	0.481	0.494	0.417	0.078
19	Mustang	Lomanthang Gaunpalika	0.000	0.498	0.539	0.376	0.163
20	Mustang	Thasang Gaunpalika	0.047	0.478	0.508	0.335	0.172
21	Myagdi	Annapurna Gaunpalika	0.087	0.437	0.475	0.497	0.010
22	Myagdi	Raghuganga Gaunpalika	0.567	0.475	0.534	0.285	0.249
23	Myagdi	Dhawalagiri Gaunpalika	0.100	0.412	0.502	0.404	0.097
24	Myagdi	Malika Gaunpalika	0.300	0.617	0.615	0.317	0.298
25	Myagdi	Mangala Gaunpalika	0.800	0.637	0.579	0.043	0.536
26	Myagdi	Beni Municipality	0.167	0.629	0.595	0.292	0.303
27	Kaski	Madi Gaunpalika	0.073	0.448	0.576	0.377	0.199
28	Kaski	Machhapuchchhre Gaunpalika	0.507	0.395	0.536	0.371	0.165

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
29	Kaski	Annapurna Gaunpalika	0.060	0.432	0.581	0.356	0.225
30	Kaski	Pokhara Metropolitan City	1.000	0.508	0.723	0.575	0.149
31	Kaski	Rupa Gaunpalika	0.040	0.561	0.689	0.282	0.407
32	Lamjung	Dordi Gaunpalika	0.060	0.420	0.574	0.101	0.474
33	Lamjung	Marshyangdi Gaunpalika	0.327	0.428	0.541	0.126	0.415
34	Lamjung	Kwhola Sothar Gaunpalika	0.047	0.550	0.643	0.105	0.538
35	Lamjung	Madhya Nepal Municipality	0.060	0.528	0.673	0.107	0.566
36	Lamjung	Bensishahar Municipality	0.120	0.543	0.702	0.099	0.603
37	Lamjung	Sundarbazar Municipality	0.073	0.540	0.667	0.092	0.575
38	Lamjung	Rainas Municipality	0.113	0.557	0.671	0.056	0.614
39	Lamjung	Dudhapokhari Gaunpalika	0.040	0.530	0.675	0.231	0.444
40	Tanahu	Bhanu Municipality	0.080	0.562	0.671	0.231	0.440
41	Tanahu	Byas Municipality	0.187	0.606	0.691	0.231	0.460
42	Tanahu	Myagde Gaunpalika	0.073	0.637	0.640	0.224	0.416
43	Tanahu	Shuklagandaki Municipality	0.087	0.558	0.686	0.231	0.455
44	Tanahu	Bhimad Municipality	0.087	0.628	0.630	0.200	0.430
45	Tanahu	Ghiring Gaunpalika	0.020	0.634	0.627	0.224	0.403
46	Tanahu	Rhishing Gaunpalika	0.440	0.657	0.642	0.224	0.417
47	Tanahu	Devghat Gaunpalika	0.060	0.715	0.718	0.224	0.494
48	Tanahu	Bandipur Gaunpalika	0.040	0.682	0.698	0.224	0.474
49	Tanahu	Aanbu Khaireni Gaunpalika	0.047	0.679	0.695	0.224	0.470
50	Nawalparasi (East)	Gaidakot Municipality	0.173	0.733	0.653	0.339	0.314
51	Nawalparasi (East)	Bulingtar Gaunpalika	0.033	0.634	0.609	0.264	0.344
52	Nawalparasi (East)	Baudikali Gaunpalika	0.033	0.624	0.585	0.278	0.307
53	Nawalparasi (East)	Hupsekot Gaunpalika	0.233	0.638	0.585	0.271	0.314
54	Nawalparasi (East)	Devchuli Municipality	0.147	0.677	0.627	0.326	0.301
55	Nawalparasi (East)	Kawasoti Municipality	0.213	0.604	0.669	0.346	0.323
56	Nawalparasi (East)	Madhya Bindu Municipality	0.493	0.624	0.613	0.346	0.267
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	0.113	0.697	0.615	0.270	0.345
58	Syangja	Putalibazar Municipality	0.140	0.520	0.722	0.202	0.521

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
59	Syangja	Phedikhola Gaunpalika	0.027	0.526	0.744	0.092	0.652
60	Syangja	Aandhikhola Gaunpalika	0.093	0.582	0.734	0.179	0.555
61	Syangja	Arjun Choupari Gaunpalika	0.087	0.594	0.731	0.186	0.545
62	Syangja	Bhirkot Municipality	0.540	0.592	0.740	0.173	0.567
63	Syangja	Biruwa Gaunpalika	0.093	0.596	0.715	0.128	0.588
64	Syangja	Harinas Gaunpalika	0.180	0.624	0.688	0.209	0.478
65	Syangja	Chapakot Municipality	0.093	0.632	0.716	0.377	0.338
66	Syangja	Walling Municipality	0.200	0.593	0.728	0.364	0.365
67	Syangja	Galyang Municipality	0.173	0.637	0.726	0.193	0.533
68	Syangja	Kaligandaki Gaunpalika	0.127	0.654	0.724	0.266	0.458
69	Parbat	Modi Gaunpalika	0.080	0.565	0.719	0.217	0.502
70	Parbat	Jaljala Gaunpalika	0.107	0.612	0.678	0.293	0.385
71	Parbat	Kushma Municipality	0.587	0.576	0.731	0.209	0.521
72	Parbat	Phalebas Municipality	0.087	0.601	0.717	0.414	0.303
73	Parbat	Mahashila Gaunpalika	0.053	0.652	0.730	0.203	0.527
74	Parbat	Bihadi Gaunpalika	0.040	0.641	0.719	0.216	0.502
75	Parbat	Paiyu Gaunpalika	0.100	0.635	0.734	0.209	0.524
76	Baglung	Baglung Municipality	0.193	0.604	0.644	0.140	0.504
77	Baglung	Kathekhola Gaunpalika	0.120	0.612	0.575	0.080	0.495
78	Baglung	Tarakhola Gaunpalika	0.053	0.589	0.555	0.080	0.474
79	Baglung	Tamankhola Gaunpalika	0.093	0.540	0.601	0.080	0.520
80	Baglung	Dhorpatan Municipality	0.773	0.585	0.617	0.140	0.477
81	Baglung	Nisikhola Gaunpalika	0.120	0.569	0.605	0.080	0.524
82	Baglung	Badigad Gaunpalika	1.000	0.613	0.697	0.206	0.491
83	Baglung	Galkot Municipality	0.140	0.610	0.617	0.140	0.477
84	Baglung	Bareng Gaunpalika	0.100	0.567	0.618	0.080	0.538
85	Baglung	Jaimuni Municipality	1.000	0.598	0.669	0.249	0.419

Annex 5: Hazard, Exposure and Vulnerability of Health hazard

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1	Gorkha	Chumanubri Gaunpalika	0.167	0.434	0.495	0.174	0.320
2	Gorkha	Ajirkot Gaunpalika	0.167	0.523	0.313	0.179	0.134
3	Gorkha	Barpak Sulikot Gaunpalika	0.333	0.545	0.309	0.181	0.129
4	Gorkha	Dharche Gaunpalika	0.167	0.360	0.394	0.177	0.217
5	Gorkha	Aarughat Gaunpalika	0.500	0.528	0.326	0.180	0.146
6	Gorkha	Bhimsenthapa Gaunpalika	0.167	0.572	0.351	0.180	0.170
7	Gorkha	Siranchowk Gaunpalika	0.333	0.604	0.310	0.181	0.129
8	Gorkha	Palungtar Municipality	0.167	0.617	0.360	0.188	0.172
9	Gorkha	Gorkha Municipality	0.167	0.581	0.320	0.418	0.010
10	Gorkha	Shahid Lakhan Gaunpalika	0.167	0.600	0.304	0.225	0.079
11	Gorkha	Gandaki Gaunpalika	0.167	0.648	0.343	0.225	0.118
12	Manang	Narpa Bhumi Gaunpalika	0.333	0.462	0.448	0.000	0.448
13	Manang	Manang Ngisyang Gaunpalika	0.167	0.435	0.342	0.043	0.299
14	Manang	Chame Gaunpalika	0.167	0.542	0.454	0.001	0.453
15	Manang	Nason Gaunpalika	0.000	0.286	0.439	0.001	0.438
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	0.167	0.356	0.484	0.184	0.300
17	Mustang	Gharapajhong Gaunpalika	0.167	0.408	0.330	0.186	0.145
18	Mustang	Varagung Muktichhetra Gaunpalika	0.167	0.355	0.372	0.184	0.188
19	Mustang	Lomanthang Gaunpalika	0.167	0.478	0.588	0.180	0.408
20	Mustang	Thasang Gaunpalika	0.167	0.427	0.393	0.189	0.205
21	Myagdi	Annapurna Gaunpalika	0.333	0.413	0.306	0.300	0.010
22	Myagdi	Raghuganga Gaunpalika	0.167	0.471	0.345	0.256	0.089
23	Myagdi	Dhawalagiri Gaunpalika	0.000	0.421	0.396	0.317	0.079
24	Myagdi	Malika Gaunpalika	0.000	0.606	0.329	0.286	0.043
25	Myagdi	Mangala Gaunpalika	0.833	0.590	0.278	0.038	0.241
26	Myagdi	Beni Municipality	0.167	0.561	0.297	0.270	0.027
27	Kaski	Madi Gaunpalika	0.167	0.514	0.312	0.209	0.103
28	Kaski	Machhapuchchhre Gaunpalika	0.333	0.472	0.301	0.211	0.090

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
29	Kaski	Annapurna Gaunpalika	0.167	0.461	0.288	0.382	0.010
30	Kaski	Pokhara Metropolitan City	0.500	0.615	0.332	0.901	0.010
31	Kaski	Rupa Gaunpalika	0.167	0.618	0.330	0.209	0.121
32	Lamjung	Dordi Gaunpalika	0.333	0.515	0.330	0.114	0.217
33	Lamjung	Marshyangdi Gaunpalika	0.167	0.468	0.336	0.097	0.238
34	Lamjung	Kwhola Sothar Gaunpalika	0.167	0.577	0.317	0.051	0.266
35	Lamjung	Madhya Nepal Municipality	0.833	0.618	0.333	0.081	0.252
36	Lamjung	Bensishahar Municipality	0.500	0.602	0.295	0.070	0.225
37	Lamjung	Sundarbazar Municipality	0.167	0.623	0.319	0.193	0.126
38	Lamjung	Rainas Municipality	0.333	0.626	0.326	0.233	0.093
39	Lamjung	Dudhapokhari Gaunpalika	0.333	0.594	0.324	0.208	0.115
40	Tanahu	Bhanu Municipality	0.167	0.607	0.358	0.224	0.134
41	Tanahu	Byas Municipality	0.167	0.610	0.338	0.249	0.090
42	Tanahu	Myagde Gaunpalika	0.167	0.605	0.338	0.216	0.122
43	Tanahu	Shuklagandaki Municipality	0.167	0.619	0.326	0.234	0.092
44	Tanahu	Bhimad Municipality	0.333	0.583	0.351	0.193	0.157
45	Tanahu	Ghiring Gaunpalika	0.167	0.570	0.390	0.211	0.179
46	Tanahu	Rhishing Gaunpalika	0.167	0.622	0.360	0.212	0.149
47	Tanahu	Devghat Gaunpalika	0.167	0.610	0.337	0.168	0.169
48	Tanahu	Bandipur Gaunpalika	0.167	0.597	0.321	0.171	0.150
49	Tanahu	Aanbu Khaireni Gaunpalika	0.167	0.587	0.268	0.217	0.051
50	Nawalparasi (East)	Gaidakot Municipality	0.167	0.545	0.351	0.334	0.018
51	Nawalparasi (East)	Bulingtar Gaunpalika	0.167	0.579	0.343	0.240	0.102
52	Nawalparasi (East)	Baudikali Gaunpalika	0.167	0.547	0.378	0.240	0.138
53	Nawalparasi (East)	Hupsekot Gaunpalika	0.167	0.516	0.386	0.245	0.142
54	Nawalparasi (East)	Devchuli Municipality	0.333	0.565	0.346	0.358	0.010
55	Nawalparasi (East)	Kawasoti Municipality	0.167	0.559	0.419	0.502	0.010
56	Nawalparasi (East)	Madhya Bindu Municipality	0.167	0.508	0.458	0.267	0.191
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	0.167	0.467	0.490	0.251	0.239
58	Syangja	Putalibazar Municipality	0.167	0.610	0.314	0.390	0.010

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
59	Syangja	Phedikhola Gaunpalika	0.167	0.636	0.325	0.039	0.287
60	Syangja	Aandhikhola Gaunpalika	0.333	0.625	0.312	0.178	0.134
61	Syangja	Arjun Choupari Gaunpalika	0.500	0.612	0.319	0.178	0.140
62	Syangja	Bhirkot Municipality	0.333	0.611	0.300	0.226	0.074
63	Syangja	Biruwa Gaunpalika	0.167	0.597	0.324	0.144	0.180
64	Syangja	Harinas Gaunpalika	0.167	0.577	0.353	0.174	0.179
65	Syangja	Chapakot Municipality	0.667	0.592	0.339	0.267	0.072
66	Syangja	Walling Municipality	0.333	0.620	0.285	0.501	0.010
67	Syangja	Galyang Municipality	0.333	0.599	0.310	0.188	0.122
68	Syangja	Kaligandaki Gaunpalika	0.167	0.596	0.374	0.236	0.138
69	Parbat	Modi Gaunpalika	0.333	0.593	0.299	0.326	0.010
70	Parbat	Jaljala Gaunpalika	0.333	0.579	0.281	0.224	0.057
71	Parbat	Kushma Municipality	0.500	0.616	0.319	0.168	0.151
72	Parbat	Phalebas Municipality	0.500	0.622	0.323	0.310	0.014
73	Parbat	Mahashila Gaunpalika	0.333	0.635	0.318	0.193	0.125
74	Parbat	Bihadi Gaunpalika	0.167	0.637	0.331	0.195	0.137
75	Parbat	Paiyu Gaunpalika	0.500	0.624	0.306	0.196	0.110
76	Baglung	Baglung Municipality	0.333	0.613	0.304	0.295	0.010
77	Baglung	Kathekhola Gaunpalika	0.333	0.610	0.317	0.060	0.257
78	Baglung	Tarakhola Gaunpalika	1.000	0.581	0.323	0.097	0.227
79	Baglung	Tamankhola Gaunpalika	0.333	0.591	0.393	0.096	0.297
80	Baglung	Dhorpatan Municipality	0.167	0.590	0.429	0.142	0.287
81	Baglung	Nisikhola Gaunpalika	0.333	0.583	0.498	0.099	0.399
82	Baglung	Badigad Gaunpalika	0.833	0.585	0.391	0.145	0.246
83	Baglung	Galkot Municipality	0.333	0.581	0.327	0.147	0.180
84	Baglung	Bareng Gaunpalika	0.333	0.609	0.338	0.097	0.241
85	Baglung	Jaimuni Municipality	0.167	0.648	0.309	0.225	0.084

Annex 6: Hazard, Exposure and Vulnerability of Technological hazard

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
1	Gorkha	Chumanubri Gaunpalika	0.000	0.307	0.012	0.212	0.010
2	Gorkha	Ajirkot Gaunpalika	0.000	0.657	0.041	0.067	0.010
3	Gorkha	Barpak Sulikot Gaunpalika	0.000	0.665	0.068	0.071	0.010
4	Gorkha	Dharche Gaunpalika	0.000	0.413	0.029	0.145	0.010
5	Gorkha	Aarughat Gaunpalika	0.000	0.602	0.068	0.092	0.010
6	Gorkha	Bhimsenthapa Gaunpalika	0.000	0.744	0.069	0.090	0.010
7	Gorkha	Siranchowk Gaunpalika	0.000	0.768	0.075	0.055	0.020
8	Gorkha	Palungtar Municipality	0.000	0.827	0.123	0.060	0.062
9	Gorkha	Gorkha Municipality	0.000	0.825	0.171	0.100	0.071
10	Gorkha	Shahid Lakhan Gaunpalika	0.000	0.814	0.080	0.043	0.036
11	Gorkha	Gandaki Gaunpalika	0.000	0.738	0.068	0.075	0.010
12	Manang	Narpa Bhumi Gaunpalika	0.000	0.391	0.000	0.101	0.010
13	Manang	Manang Ngisyang Gaunpalika	0.000	0.567	0.005	0.046	0.010
14	Manang	Chame Gaunpalika	0.000	0.649	0.005	0.107	0.010
15	Manang	Nason Gaunpalika	0.000	0.552	0.003	0.155	0.010
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	0.000	0.222	0.001	0.131	0.010
17	Mustang	Gharapajhong Gaunpalika	0.000	0.570	0.008	0.086	0.010
18	Mustang	Varagung Mukti chhetra Gaunpalika	0.000	0.428	0.003	0.094	0.010
19	Mustang	Lomanthang Gaunpalika	0.000	0.000	0.003	0.195	0.010
20	Mustang	Thasang Gaunpalika	0.000	0.630	0.010	0.164	0.010
21	Myagdi	Annapurna Gaunpalika	0.000	0.733	0.030	0.105	0.010
22	Myagdi	Raghuganga Gaunpalika	0.000	0.711	0.040	0.103	0.010
23	Myagdi	Dhawalagiri Gaunpalika	0.000	0.528	0.024	0.150	0.010
24	Myagdi	Malika Gaunpalika	0.000	0.692	0.048	0.072	0.010
25	Myagdi	Mangala Gaunpalika	0.000	0.763	0.055	0.032	0.023
26	Myagdi	Beni Municipality	0.000	0.829	0.135	0.071	0.064
27	Kaski	Madi Gaunpalika	0.000	0.821	0.037	0.063	0.010
28	Kaski	Machhapuchhre Gaunpalika	0.000	0.811	0.061	0.070	0.010

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
29	Kaski	Annapurna Gaunpalika	0.000	0.787	0.058	0.099	0.010
30	Kaski	Pokhara Metropolitan City	1.000	0.983	1.000	0.814	0.186
31	Kaski	Rupa Gaunpalika	0.000	0.933	0.052	0.050	0.010
32	Lamjung	Dordi Gaunpalika	0.000	0.715	0.038	0.086	0.010
33	Lamjung	Marshyangdi Gaunpalika	0.000	0.755	0.037	0.114	0.010
34	Lamjung	Kwhola Sothar Gaunpalika	0.000	0.855	0.023	0.045	0.010
35	Lamjung	Madhya Nepal Municipality	0.000	0.901	0.072	0.054	0.018
36	Lamjung	Bensishahar Municipality	0.000	0.874	0.118	0.079	0.040
37	Lamjung	Sundarbazar Municipality	0.000	0.871	0.118	0.055	0.063
38	Lamjung	Rainas Municipality	0.000	0.825	0.081	0.052	0.029
39	Lamjung	Dudhapokhari Gaunpalika	0.000	0.741	0.030	0.058	0.010
40	Tanahu	Bhanu Municipality	0.000	0.854	0.125	0.086	0.040
41	Tanahu	Byas Municipality	0.000	0.893	0.188	0.136	0.052
42	Tanahu	Myagde Gaunpalika	0.000	0.916	0.082	0.069	0.013
43	Tanahu	Shuklagandaki Municipality	0.000	0.944	0.156	0.089	0.066
44	Tanahu	Bhimad Municipality	0.000	0.907	0.093	0.102	0.010
45	Tanahu	Ghiring Gaunpalika	0.000	0.883	0.047	0.083	0.010
46	Tanahu	Rhishing Gaunpalika	0.000	0.884	0.051	0.059	0.010
47	Tanahu	Devghat Gaunpalika	0.000	0.891	0.045	0.042	0.010
48	Tanahu	Bandipur Gaunpalika	0.000	0.889	0.069	0.058	0.010
49	Tanahu	Aanbu Khaireni Gaunpalika	0.000	0.870	0.068	0.060	0.010
50	Nawalparasi (East)	Gaidakot Municipality	0.000	0.960	0.217	0.118	0.098
51	Nawalparasi (East)	Bulingtar Gaunpalika	0.000	0.911	0.043	0.116	0.010
52	Nawalparasi (East)	Baudikali Gaunpalika	0.000	0.877	0.043	0.089	0.010
53	Nawalparasi (East)	Hupsekot Gaunpalika	0.000	0.929	0.070	0.075	0.010
54	Nawalparasi (East)	Devchuli Municipality	1.000	0.981	0.193	0.075	0.118
55	Nawalparasi (East)	Kawasoti Municipality	0.000	0.977	0.294	0.103	0.191
56	Nawalparasi (East)	Madhya Bindu Municipality	0.000	0.957	0.143	0.110	0.034
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	0.000	0.963	0.076	0.136	0.010
58	Syangja	Putalibazar Municipality	0.000	0.950	0.117	0.088	0.030

SN	District	Local Level	Hazard	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
59	Syangja	Phedikhola Gaunpalika	0.000	0.953	0.057	0.059	0.010
60	Syangja	Aandhikhola Gaunpalika	0.000	0.919	0.057	0.032	0.025
61	Syangja	Arjun Choupari Gaunpalika	0.000	0.896	0.068	0.036	0.032
62	Syangja	Bhirkot Municipality	0.000	0.902	0.087	0.037	0.050
63	Syangja	Biruwa Gaunpalika	0.000	0.899	0.048	0.043	0.010
64	Syangja	Harinas Gaunpalika	0.000	0.889	0.051	0.081	0.010
65	Syangja	Chapakot Municipality	0.000	0.907	0.075	0.092	0.010
66	Syangja	Walling Municipality	0.000	0.886	0.148	0.075	0.073
67	Syangja	Galyang Municipality	0.000	0.881	0.102	0.097	0.010
68	Syangja	Kaligandaki Gaunpalika	0.000	0.842	0.085	0.114	0.010
69	Parbat	Modi Gaunpalika	0.000	0.885	0.064	0.034	0.029
70	Parbat	Jaljala Gaunpalika	0.000	0.854	0.083	0.037	0.046
71	Parbat	Kushma Municipality	0.000	0.902	0.137	0.068	0.069
72	Parbat	Phalebas Municipality	0.000	0.875	0.081	0.048	0.032
73	Parbat	Mahashila Gaunpalika	0.000	0.843	0.044	0.036	0.010
74	Parbat	Bihadi Gaunpalika	0.000	0.822	0.063	0.079	0.010
75	Parbat	Paiyu Gaunpalika	0.000	0.848	0.076	0.043	0.033
76	Baglung	Baglung Municipality	0.000	0.859	0.190	0.078	0.112
77	Baglung	Kathekhola Gaunpalika	0.000	0.807	0.091	0.056	0.035
78	Baglung	Tarakhola Gaunpalika	0.000	0.738	0.029	0.063	0.010
79	Baglung	Tamankhola Gaunpalika	0.000	0.649	0.024	0.122	0.010
80	Baglung	Dhorpatan Municipality	0.000	0.663	0.066	0.182	0.010
81	Baglung	Nisikhola Gaunpalika	0.000	0.629	0.053	0.250	0.010
82	Baglung	Badigad Gaunpalika	0.000	0.709	0.072	0.199	0.010
83	Baglung	Galkot Municipality	0.000	0.744	0.074	0.113	0.010
84	Baglung	Bareng Gaunpalika	0.000	0.735	0.043	0.061	0.010
85	Baglung	Jaimuni Municipality	0.000	0.810	0.077	0.054	0.024

Annex 7: Individual and Multi-Hazard Risk Index

SN	District	Local Level	Multi-hazard Risk	Flood Risk	Landslide Risk	Foremost Fire Risk	Health Risk	Technological Risk
1	Gorkha	Chumanubri Gaunpalika	6.384	3.805	5.394	0.992	18.216	1.017
2	Gorkha	Ajirkot Gaunpalika	8.041	13.916	5.710	2.850	9.540	1.036
3	Gorkha	Barpak Sulikot Gaunpalika	10.917	15.081	7.875	4.371	18.322	1.036
4	Gorkha	Dharche Gaunpalika	16.673	12.107	35.584	12.854	10.574	1.022
5	Gorkha	Aarughat Gaunpalika	12.453	15.070	4.592	4.828	29.783	1.033
6	Gorkha	Bhimsenthapa Gaunpalika	9.122	18.872	1.432	2.663	12.994	1.040
7	Gorkha	Siranchowk Gaunpalika	9.605	13.255	2.792	5.047	20.325	1.083
8	Gorkha	Palungtar Municipality	11.359	22.700	2.724	6.221	14.034	1.279
9	Gorkha	Gorkha Municipality	4.735	5.398	5.071	9.432	1.505	1.316
10	Gorkha	Shahid Lakhani Gaunpalika	6.459	12.551	2.690	3.700	6.750	1.160
11	Gorkha	Gandaki Gaunpalika	7.294	13.862	2.308	2.548	10.362	1.040
12	Manang	Narpa Bhumi Gaunpalika	14.896	10.296	3.834	1.445	52.652	1.021
13	Manang	Manang Ngisyang Gaunpalika	5.499	2.730	3.740	1.503	17.081	1.031
14	Manang	Chame Gaunpalika	13.863	20.438	3.959	2.194	31.545	1.035
15	Manang	Nason Gaunpalika	5.962	1.910	18.345	2.376	1.720	1.030
16	Mustang	Lo Ghekar Damodarkunda Gaunpalika	14.981	36.436	3.848	1.046	14.147	1.012
17	Mustang	Gharapajhong Gaunpalika	5.741	10.773	1.750	2.235	8.167	1.031
18	Mustang	Varagung Muktichhetra Gaunpalika	4.775	7.549	1.654	1.089	9.152	1.023
19	Mustang	Lomanthang Gaunpalika	5.980	1.170	1.237	1.234	25.172	1.000
20	Mustang	Thasang Gaunpalika	16.854	35.318	13.886	2.231	11.746	1.034
21	Myagdi	Annapurna Gaunpalika	25.520	64.029	22.723	1.091	1.813	1.040
22	Myagdi	Raghuganga Gaunpalika	34.102	52.352	54.535	23.015	6.033	1.038
23	Myagdi	Dhawalagiri Gaunpalika	3.156	5.754	3.111	2.287	1.028	1.029
24	Myagdi	Malika Gaunpalika	13.680	28.915	7.358	19.117	0.974	1.037

SN	District	Local Level	Multi-hazard Risk	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
25	Myagdi	Mangala Gaunpalika	74.330	58.810	99.969	90.862	89.781	1.093
26	Myagdi	Beni Municipality	9.963	19.918	6.423	11.432	2.690	1.288
27	Kaski	Madi Gaunpalika	7.648	13.322	6.375	3.121	7.426	1.044
28	Kaski	Machhapuchhre Gaunpalika	25.587	48.864	27.076	11.839	11.393	1.044
29	Kaski	Annapurna Gaunpalika	6.407	5.448	15.860	2.883	1.355	1.043
30	Kaski	Pokhara Metropolitan City	18.558	10.509	3.655	25.825	3.087	100.000
31	Kaski	Rupa Gaunpalika	7.389	14.303	1.448	3.972	10.175	1.050
32	Lamjung	Dordi Gaunpalika	19.538	25.855	20.792	4.896	28.725	1.039
33	Lamjung	Marshyangdi Gaunpalika	30.441	24.619	67.973	20.068	14.740	1.041
34	Lamjung	Kwhola Sothar Gaunpalika	8.824	11.239	2.069	5.519	20.016	1.046
35	Lamjung	Madhya Nepal Municipality	39.953	59.596	4.992	6.873	98.435	1.085
36	Lamjung	Bensishahar Municipality	22.993	22.138	15.240	13.887	51.697	1.187
37	Lamjung	Sundarbazar Municipality	9.204	13.518	6.528	8.467	10.585	1.299
38	Lamjung	Rainas Municipality	17.045	29.537	11.716	13.727	15.414	1.127
39	Lamjung	Dudhapokhari Gaunpalika	8.253	11.071	2.511	4.060	17.957	1.040
40	Tanahu	Bhanu Municipality	6.064	5.647	3.748	7.477	10.965	1.183
41	Tanahu	Byas Municipality	7.558	6.983	4.389	18.100	7.630	1.251
42	Tanahu	Myagde Gaunpalika	5.894	5.960	3.585	7.356	10.001	1.066
43	Tanahu	Shuklagandaki Municipality	5.126	4.593	3.182	8.207	7.937	1.338
44	Tanahu	Bhimad Municipality	14.217	21.440	6.528	8.673	23.735	1.049
45	Tanahu	Ghiring Gaunpalika	4.601	1.035	4.285	2.648	13.584	1.048
46	Tanahu	Rhishing Gaunpalika	19.098	20.828	16.688	40.658	12.370	1.048
47	Tanahu	Devghat Gaunpalika	6.466	5.988	2.566	7.944	13.658	1.048
48	Tanahu	Bandipur Gaunpalika	9.522	17.962	3.379	5.223	12.004	1.049
49	Tanahu	Aanbu Khairani Gaunpalika	4.132	3.837	4.372	5.876	4.508	1.047
50	Nawalparasi (East)	Gaidakot Municipality	3.949	3.448	1.002	14.112	1.983	1.510

SN	District	Local Level	Multi-hazard Risk	Flood Risk	Landslide Risk	Foremost Fire Risk	Health Risk	Technological Risk
51	Nawalparasi (East)	Bulingtar Gaunpalika	5.005	5.249	4.724	3.363	8.200	1.049
52	Nawalparasi (East)	Baudikali Gaunpalika	12.156	28.883	3.486	3.067	10.276	1.047
53	Nawalparasi (East)	Hupsekot Gaunpalika	13.005	23.957	5.089	16.370	9.925	1.050
54	Nawalparasi (East)	Devchuli Municipality	22.643	45.799	1.926	10.797	2.193	63.639
55	Nawalparasi (East)	Kawasoti Municipality	6.225	10.933	0.995	14.663	1.478	2.010
56	Nawalparasi (East)	Madhya Bindu Municipality	36.758	98.648	1.001	28.032	12.956	1.173
57	Nawalparasi (East)	Binayi Tribeni Gaunpalika	9.356	14.766	1.497	9.937	14.782	1.052
58	Syangja	Putalibazar Municipality	11.450	27.506	3.034	13.439	1.542	1.153
59	Syangja	Phedikholga Gaunpalika	6.530	0.938	3.304	3.980	23.605	1.052
60	Syangja	Aandhikhola Gaunpalika	18.889	38.570	4.950	10.882	21.676	1.125
61	Syangja	Arjun Choupari Gaunpalika	21.550	37.030	8.755	10.197	33.039	1.155
62	Syangja	Bhirkot Municipality	30.903	47.368	20.196	60.593	12.151	1.245
63	Syangja	Biruwa Gaunpalika	9.787	13.331	4.310	11.723	14.235	1.049
64	Syangja	Harinas Gaunpalika	10.618	0.909	18.820	18.635	13.702	1.048
65	Syangja	Chapakot Municipality	25.184	62.972	2.567	7.536	22.077	1.049
66	Syangja	Walling Municipality	5.656	5.876	4.047	15.197	2.332	1.350
67	Syangja	Galyang Municipality	11.080	4.890	10.515	20.333	19.149	1.048
68	Syangja	Kaligandaki Gaunpalika	15.145	26.594	11.303	13.446	11.098	1.045
69	Parbat	Modi Gaunpalika	6.790	12.103	5.303	8.440	2.263	1.141
70	Parbat	Jaljala Gaunpalika	14.154	30.121	7.230	9.245	9.009	1.212
71	Parbat	Kushma Municipality	33.805	38.899	24.046	58.959	35.733	1.335
72	Parbat	Phalebas Municipality	13.428	36.671	2.324	6.158	4.033	1.152
73	Parbat	Mahashila Gaunpalika	10.637	15.491	2.753	6.998	20.735	1.046
74	Parbat	Bihadi Gaunpalika	4.012	1.153	1.790	5.204	11.670	1.044
75	Parbat	Paiyu Gaunpalika	19.312	36.624	4.380	11.927	26.630	1.150
76	Baglung	Baglung Municipality	7.787	7.139	7.926	20.325	2.313	1.522
77	Baglung	Kathekhola Gaunpalika	13.685	6.774	6.335	12.930	40.069	1.154

SN	District	Local Level	Multi-hazard Risk	Flood Risk	Landslide Risk	Forest Fire Risk	Health Risk	Technological Risk
78	Baglung	Tarakhola Gaunpalika	27.438	16.436	6.268	5.874	99.777	1.040
79	Baglung	Tamankhola Gaunpalika	13.316	4.819	5.459	9.595	44.811	1.035
80	Baglung	Dhorpatan Municipality	43.746	42.144	63.240	71.991	21.954	1.036
81	Baglung	Nisikhola Gaunpalika	19.021	4.793	14.982	12.742	59.114	1.034
82	Baglung	Badigad Gaunpalika	46.109	32.645	12.103	99.966	90.956	1.038
83	Baglung	Galkot Municipality	12.008	4.446	12.070	14.375	26.984	1.040
84	Baglung	Bareng Gaunpalika	12.989	5.866	7.819	11.005	37.598	1.040
85	Baglung	Jaimuni Municipality	18.473	6.548	9.381	83.500	7.640	1.104