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

STATE OF ENVIRONMENT REPORT

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FOREWORD

It gives me great pleasure to present the *State of Environment Report of Gandaki Province*, prepared under the leadership of the Gandaki Province Policy and Planning Commission and with technical support from UNDP Nepal.

Gandaki Province is blessed with extraordinary natural diversity—from the high Himalayas, glaciers, and snow-fed rivers to forests, wetlands, lakes, fertile valleys, and culturally rich settlements. These natural assets form the foundation of our agriculture, tourism, hydropower, livelihoods, and identity. At the same time, these resources are increasingly vulnerable to the impacts of climate change, unplanned urbanization, infrastructure expansion, waste generation, land-use change, and the growing demand for water and energy resources.

The State of Environment Report provides a critical evidence base for Gandaki Province as we work to align development with environmental sustainability, climate resilience, and the needs of the local communities. This report has been prepared through careful review of available data, field consultations, expert analysis, observations, and case studies. The expert team worked with great dedication and regularly shared the progress of the report with concerned institutions and stakeholders at different stages. I sincerely appreciate their hard work, professionalism, and commitment throughout this process.

The Gandaki Province Policy and Planning Commission has endorsed this document as an important reference for evidence-based planning and policymaking. Hence, it should not remain merely as a technical document; rather, as a practical guide for provincial and local governments in shaping policies, annual programmes, budgeting, project screening, climate action, and environmental monitoring.,

On behalf of the Government of Gandaki Province, I extend my sincere thanks to the United Nations Development Programme (UNDP) for partnering with us in producing this important document. I also extend my deep appreciation to the Gandaki Province Policy and Planning Commission, sectoral ministries, local governments, UNDP Nepal, the expert team, and all stakeholders who contributed to this important work. I am confident that this report will support our shared efforts towards building a cleaner, safer, more resilient, and more inclusive Gandaki Province for the present and future generations.

HON'BLE MR. SURENDRA RAJ PANDEY
Chief Minister of Gandaki Province

FOREWORD

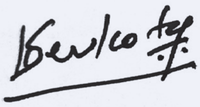
The preparation of the *State of Environment Report of Gandaki Province* marks an important institutional milestone for the Gandaki Province Policy and Planning Commission. Prepared with technical support from UNDP Nepal, this report reflects our commitment to strengthening environmental governance and ensuring that development planning is guided by reliable evidence, sustainability principles, and long-term resilience.

This report is the outcome of dedicated technical work, comprehensive review of available data, field consultations, observations, case studies, and continuous engagement with concerned stakeholders at different stages. It brings together scientific evidence and policy analysis to provide a comprehensive overview of environmental trends, challenges, risks, and emerging opportunities in Gandaki Province.

I extend my deep appreciation to the United Nations Development Programme (UNDP) in Nepal for providing us the financial and technical support to produce this report. I am also thankful to the expert team, provincial ministries, local governments, and all contributors for their valuable support and cooperation in the preparation of this report.

As the report has been endorsed by the Gandaki Province Policy and Planning Commission, I believe it will serve as a practical planning tool for integrating environmental priorities into periodic plans, annual programmes, the Medium-Term Expenditure Framework, and evidence-based policy decisions across all levels of the Government. It is also expected to contribute to cross-sector learning and collaboration on governance, climate resilience, sustainable urban systems, green jobs, and circular economy approaches across provincial and local institutions.

I am confident that this report will contribute significantly to informed policymaking, strengthening environmental governance, and a more resilient, prosperous and sustainable future for Gandaki Province.



HON'BLE DR. KRISHNA CHANDRA DEVKOTA
Vice Chairman
Gandaki Province Policy and Planning Commission

FOREWORD

It is a pleasure to contribute this foreword to the State of Environment (SoE) Report of Gandaki Province, prepared under the leadership of the Province Policy and Planning Commission, with technical support from UNDP Nepal.

This report comes at an important time, as Gandaki Province seeks to advance sustainable, climate-resilient and inclusive development while safeguarding its rich natural assets. The SoE provides a comprehensive assessment of current condition, trends and challenges of the natural environment along key environment indicators and serves as a foundation tool for sustainable provincial development planning by providing evidence-based insights that align environmental protection with economic and social goals.

UNDP Nepal is pleased to have supported this important initiative, consistent with its commitment to sustainable development, innovation and inclusion in Nepal.

I commend the Government of Gandaki Province, the Provincial Policy and Planning Commission (PPPC), provincial ministries, local governments, experts and all other stakeholders for their dedication throughout the preparation, consultation and validation process.

I am confident that this report will serve as a practical tool for integrating environmental priorities into policies, plans, budgets, and investments.

UNDP Nepal remains committed to continued collaboration with provincial and local partners to advance sustainable, inclusive, and risk-informed development in Gandaki Province.

KYOKO YOKOSUKA
Resident Representative
United Nations Development Programme Nepal

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Acronyms and Abbreviations

A. Institutional and Governance Actors

ADB : Asian Development Bank
AEPC : Alternative Energy Promotion Centre
CBS : Central Bureau of Statistics
CTEVT : Council for Technical Education and Vocational Training
DCCs : District Coordination Committees
DHM : Department of Hydrology and Meteorology
DMG : Department of Mines and Geology
DNPWC : Department of National Parks and Wildlife Conservation
DOAD : Department of Agriculture Development
DOE / DoEnv : Department of Environment
DOED : Department of Electricity Development
DOLMA : Department of Land Management and Archive
DWSS : Department of Water Supply and Sewerage
FAO : Food and Agriculture Organization of United Nations
FRTC : Forest Research and Training Centre
IFC : International Finance Corporation
IOM : International Organization for Migration
IPPAN : Independent Power Producers' Association, Nepal
ICIMOD : International Centre for Integrated Mountain Development
IUCN : International Union for Conservation of Nature
LCDA : Lake Cluster Development Authority
LIBIRD : Local Initiatives for Biodiversity, Research and Development
MoCTCA : Ministry of Culture, Tourism and Civil Aviation
MoEA : Ministry of Economic Affairs
MOALD / MOAD: Ministry of Agriculture and Livestock Development
MoEST : Ministry of Education, Science and Technology
MoEWRI : Ministry of Energy, Water Resources and Irrigation
MoEWRWS : Ministry of Energy, Water Resources and Water Supply (Provincial)
MoFAGA : Ministry of Federal Affairs and General Administration
MoFE : Ministry of Forests and Environment
MoHP : Ministry of Health and Population
MoIAL : Ministry of Internal Affairs and Law
MoIT : Ministry of Industry and Tourism
MoPID : Ministry of Physical Infrastructure Development
MoPIT : Ministry of Physical Infrastructure and Transport
MoYSD : Ministry of Youth and Social Development
NDRRMA : National Disaster Risk Reduction and Management Authority
NEA : Nepal Electricity Authority
NOC : Nepal Oil Corporation
NPC : National Planning Commission
NSO : National Statistics Office
OCMCM : Office of the Chief Minister and Council of Ministers
PPPC / PPC : Provincial Policy and Planning Commission
TAAN : Trekking Agencies' Association of Nepal
UGC : University Grant Commission

UNDP : United Nations Development Programme
UNEP : United Nations Environment Programme
UNICEF : United Nations International Children's Emergency Fund
WECS : Water and Energy Commission Secretariat
WHO : World Health Organization
WWF : World Wildlife Fund

B) Environmental and Climate Terms

BC : Black Carbon
CCA : Climate Change Adaptation
CDD : Consecutive Dry Days
CIDs : Climate-Induced Disasters
CMIP6 : Coupled Model Intercomparison Project Phase 6
CO : Carbon Monoxide
CWD : Consecutive Wet Days
DPSIR : Driving force, Pressure, State, Impact, and Response
DTR : Diurnal Temperature Range
EE : Environment Education
EIA : Environmental Impact Assessment
EP : Environment Protection (often referring to EP Act/Rules)
ESI : Environment and Social Impact Assessment
ESMP : Environment and Social Management Plan
GLOFs : Glacial Lake Outburst Floods
IEA : Integrated Environmental Assessment
IEE : Initial Environmental Examination
LULC : Land Use and Land Cover
MCT : Main Central Thrust (Geological Fault)
MHRA : Multi-Hazard Risk Assessment
MSW : Municipal Solid Waste
NAAQS : National Ambient Air Quality Standards
NLCMS : National Land Cover Monitoring System
NO_2 : Nitrogen Dioxide
NO_x : Nitrogen Oxides
O_3 : Ozone
OWL : Other Wooded Land
Pb : Lead
PCCSAP : Provincial Climate Change Strategy and Action Plan
PES : Payment for Ecosystem Services
$PM_{2.5}$: Fine Particulate Matter (< 2.5 µm)
PM_{10} : Particulate Matter (< 10 µm)
REDD+ : Reducing Emissions from Deforestation and forest Degradation
SO_2 : Sulphur Dioxide
SOM : Soil Organic Matter
SSP245 / SSP585: Shared Socioeconomic Pathways (Climate Scenarios)
Tmax / Tmin : Maximum and Minimum Temperature
TSP : Total Suspended Particulates
VOCs : Volatile Organic Compounds
CETP : Common Effluent Treatment Plant

C) Socio-Economic and General Terms

ADPs	: Annual Development Plans
BHS	: Basic Health Services
CAGR	: Compound Annual Growth Rate
CF / LF / CoF	: Community Forests / Leasehold Forests / Collaborative Forest
CFUGs	: Community Forest User Groups
CNP	: Chitwan National Park
COVID-19	: Coronavirus Disease 2019
EPI	: Expanded Programme on Immunization
FCHVs	: Female Community Health Volunteers
FY	: Fiscal Year
GDP	: Gross Domestic Product
GESI	: Gender Equality, Disability, and Social Inclusion
GNI	: Gross National Income
GRB	: Gender-Responsive Budgeting
GIS	: Geographic Information System
HDI	: Human Development Index
HMIS	: Health Management Information System
HQ	: Headquarters
I/NGOs	: International/Non-Governmental Organizations
IMR	: Infant Mortality Rate
KIIs	: Key Informant Interviews
LISA	: Local Government Institutional Capacity Self-Assessment
LPG	: Liquefied Petroleum Gas
MCSMEs	: Micro, Cottage, Small and Medium Enterprises
MR	: Mortality Rate
MRFs	: Material Recovery Facilities
MTEF	: Medium-Term Expenditure Framework
NLFS	: Nepal Labour Force Survey
NMR	: Neonatal Mortality Rate
NPHC	: National Population and Housing Census
NSIC	: Nepal Standard Industrial Classification
PHCCs	: Primary Health Care Centers
PHC-ORCs	: Primary Health Care Out-Reach Clinics
PPA	: Power Purchase Agreement
RM	: Rural Municipality
SDGs	: Sustainable Development Goals
TECS	: Technical Education in Community Schools
ToR	: Terms of Reference
TVET	: Technical Education and Vocational Training
USD	: United States Dollar
WASH	: Water, Sanitation, and Hygiene
ICT	: Information and Communication Technology

D) Technical Units, Chemicals, and Energy

ATF	: Aviation Turbine Fuel
CV	: Coefficient of Variation (Rainfall variability)
EV	: Electric Vehicle

GWh	: Gigawatt-hour
HEP	: Hydro-electric Project
kL	: Kilolitre
kWh	: Kilowatt-hour
MS	: Motor Spirit (Petrol)
MW	: Megawatt
Mt / MT	: Metric Tonne
N, P, K	: Nitrogen, Phosphorus, and Potassium
PJ	: Petajoule (10^{15} Joules)
PV	: Photovoltaic
pH	: Potential of Hydrogen
pp	: Percentage points
RETs	: Renewable Energy Technologies
SKO	: Superior Kerosene Oil
std dev	: Standard Deviation
TJ	: Terajoule
Wp	: Watt-peak
ICS	: Improved Cookstoves

Chapter 1. Introduction

1.1 Background

At the national level, environmental sustainability has been recognized as a cornerstone of Nepal's federal governance structure. The country's Constitution and policies, including the Environment Protection Act (2019) and National Environment Policy (2019), mandate the integration of environment and climate considerations into all spheres of development. However, Nepal as a whole faces mounting environmental challenges - from the impacts of climate change and biodiversity loss to pollution, climate-induced disasters (CIDs), and land degradation - which demand evidence-based assessment and responsive policy action.

Within this broader national context, Gandaki Province stands out as one of Nepal's most ecologically diverse and economically significant regions. Encompassing snow-fed rivers, fertile valleys, forest ecosystems, and globally renowned tourist destinations, the province contributes substantially to the country's tourism, hydropower, and agriculture-based economy. Yet, this natural wealth is increasingly under threat from a combination of climate change, unplanned development, and excessive exploitation of natural resources. Together, these drivers are eroding the province's environmental resilience, undermining socio-economic stability, and putting the livelihoods of its people at risk.

The impacts of climate change are already becoming visible across Gandaki's landscapes. Erratic rainfall patterns, prolonged droughts, rising temperatures, and frequent landslides are directly disrupting agriculture - the backbone of rural livelihoods. Glacial retreat in the high Himalayas threatens water availability for irrigation and hydropower generation, while the risk of glacial lake outburst floods (GLOFs) poses catastrophic dangers to downstream settlements and infrastructure. CIDs such as floods, avalanches, and droughts disproportionately affect marginalized communities, aggravating poverty and social vulnerability. The province's tourism industry, highly dependent on snow-capped peaks and stable trekking routes, also faces uncertainty as weather extremes disrupt travel and diminish the natural appeal of its landscapes.

Meanwhile, rapid urbanization, particularly in Pokhara and other growing municipalities, has intensified pressures on land, water, and air. Much of this growth has occurred without adequate environmental planning, resulting in the encroachment of fertile agricultural land, unmanaged solid waste, untreated wastewater discharge, and haphazard construction. Infrastructure expansion - including roads, housing, and hydropower projects - often lacks proper safeguards, fragmenting habitats, destabilizing fragile slopes, and elevating disaster risks. The absence of integrated land-use planning has led to uncontrolled settlement sprawl, traffic congestion, and urban air pollution, all of which degrade environmental quality and human well-being.

The over exploitation of forests, rivers, and soils further compounds the province's environmental vulnerabilities. While community forestry remains a success story, demand for timber, fuel wood, and non-timber forest products continues to put pressure on ecosystems. Unsustainable agricultural practices, such as slope cultivation and excessive use of agrochemicals, are accelerating soil erosion and reducing productivity. Rivers and lakes are being degraded by sand mining, hydropower diversion, and unregulated tourism, leading to declining water quality and aquatic biodiversity. Such unchecked extraction is undermining ecosystem services - including clean water, fertile soils, and carbon sequestration - that are critical for sustaining livelihoods.

Against this backdrop, the Provincial Policy and Planning Commission (PPPC), with technical support from the Ministry of Forests and Environment (MoFE) of Gandaki Province and UNDP, has initiated the preparation of a State of Environment (SoE) Report for the Gandaki Province. The SoE will serve as a comprehensive and systematic evaluation of environmental conditions and trends, covering key themes such as air, water, land, biodiversity, forests, and climate. It will examine not only the status of these resources but also the pressures placed upon them by human activities such as urbanization, infrastructure development, industrialization, agriculture, and energy use. By consolidating scientific data, environmental indicators, and monitoring results, the SoE will provide a structured and evidence-based overview of Gandaki's environment. Most importantly, it will act as a decision-support tool to guide policymakers at local, provincial, and national levels in advancing sustainable development and resilience building.

1.2 Rationale

The rationale for preparing a SoE report is firmly rooted in the need for informed and evidence-based decision-making. Policymakers, planners, and development agencies require accurate and timely information on environmental conditions to make sound choices about land use, infrastructure development, resource management, conservation priorities, and climate adaptation strategies. Without a reliable knowledge base, development risks being environmentally unsustainable, exacerbating vulnerabilities rather than addressing them. SoE reports provide this critical foundation by offering systematic assessments of environmental trends - both positive and negative - over time. They highlight not only the current status of natural resources but also identify emerging challenges, vulnerable ecosystems, and unsustainable practices that may require corrective action through policy reform, planning adjustments, or regulatory interventions.

Another key importance of SoE reporting lies in its role in promoting transparency, accountability, and public awareness ensuring compliance with the provision in the Constitution of Nepal that guarantees every citizen the right to live in a clean environment. By making environmental data accessible and understandable to citizens, SoE reports help communities become more informed about local, provincial, and national environmental issues. This accessibility encourages public engagement and fosters a culture of shared responsibility, where citizens, civil society, and private sector stakeholders actively participate in environmental stewardship. In this way, SoE reporting contributes not only to improved governance but also to a stronger social contract for sustainable development.

At the same time, SoE reports are vital tools for linking local and national efforts with global environmental goals and commitments. They are often designed to align with international environmental agreements, such as the Sustainable Development Goals (SDGs), the United Nations Framework Convention on Climate Change (UNFCCC), and the Convention on Biological Diversity (CBD). By tracking and presenting relevant environmental indicators, SoE report supports Nepal and Gandaki Province specifically in meeting their international reporting obligations while situating local actions within the global sustainability agenda. In addition, the SoE supports designing evidence-based planning and development activities at the provincial level.

The SoE is beyond being a descriptive document; it serves as a strategic policy-support tool. It provides a comprehensive and evidence-based assessment of the province's environmental conditions, trends, and emerging challenges. The information and data will guide policymakers in mainstreaming environment and climate change considerations into the Medium-Term Expenditure Framework (MTEF) and Annual Development Plans (ADPs). Moreover, in line with UNEP's Integrated Environmental Assessment (IEA) approach, the SoE presents the state of the environment but also analyzes the underlying drivers of change, the pressures exerted on ecosystems, the resulting impacts on people and livelihoods, and the effectiveness of current policy responses. Such an integrated perspective ensures that the SoE is not simply a technical report, but a decision-making instrument capable of steering the province toward a more sustainable, resilient, and inclusive development pathway.

1.3 Objectives and Scope

1.3.1 Objectives

The main objective of this assignment is to support the Provincial Policy and Planning Commission (PPPC) of the Gandaki Province in preparing the SoE Report for the Province to guide the province level periodic planning and decision-making process to prioritize environment and climate change considerations into annual plans and budgets of the province, to make the development sustainable and environment friendly and maintain the healthy natural environment and ecosystems resilient. Besides, there are a few specific objectives outlined below:

- Identify key priority environmental issues and their parameters related to air, water, land, soil, and biodiversity; and natural ecosystems to address the issues timely to achieve sustainable development in the province.
- Assess and analyze priority environment and climate issues of three decades with driving force, pressure, state, impact and response (DPSIR) analytical framework to formulate future projections under business-as-usual approach and recommend strategic response mechanisms and actions to reverse the environmental degradation trend to be incorporated in the provincial development plans and its implementation.
- Identify key environmental challenges and emerging issues together with the root causes, and opportunities for climate change adaptation, disaster risk reduction, augmenting ecosystem health, sustainable resource management and biodiversity conservation.
- Provide evidence-based recommendations to create policy incentives and formulation, implementation guidelines and monitoring mechanisms to ensure risk informed climate responsive and environmentally friendly inclusive development.
- Support to integrate key environmental indicators into the Province's MTEF and ADP processes.
- Enhance the understanding of sub-national/local governments and stakeholders about state and trend of environment and build their capacities on using this as a tool to make development inclusive, climate responsive, environmentally friendly.

1.3.2 Scope of Work

The preparation of the SoE Report for Gandaki Province was undertaken as a comprehensive and evidence-based assessment of the province's environmental condition, trends, pressures, and governance responses. The scope of work, as defined in the Terms of Reference (ToR), was intentionally broad to ensure that the SoE captures not only environmental parameters, but also the socio-economic drivers, institutional frameworks, and cross-sectoral dynamics that shape environmental change in the province.

The assignment covered the full process of SoE development from inception and methodological design to data analysis, stakeholder consultation, drafting, validation, and finalization. The Provincial Policy and Planning Commission (PPC) was identified as the key coordinating institution, working in close collaboration with the Ministry of Forests and Environment (MoFE) and the Provincial Climate Change Coordination Committee (PC4). Inter-ministerial coordination and structured stakeholder engagement were integral components of the work.

1. Inception and Preparatory Work

The first component of the assignment focused on establishing a clear methodological and institutional foundation for the SoE. This included conducting an inception meeting with MoFE, PPC, UNDP Nepal, and relevant stakeholders to agree on the analytical framework, reporting structure, thematic coverage, and data-sharing mechanisms. A detailed work plan, stakeholder engagement strategy, and data collection framework were developed to guide implementation.

The preparatory phase also included a rapid yet systematic review of relevant literature and policy documents, including national SoE reports, provincial environmental profiles, sectoral strategies, and existing datasets. This step ensured that the SoE would build upon prior knowledge while addressing identified gaps.

2. Stocktaking and Policy Review

A core part of the scope involved comprehensive stocktaking and policy analysis. This included critical review of provincial plans, policies, acts, rules, and strategies related to environment, climate change, disaster risk reduction, land use, agriculture, forestry, biodiversity, tourism, energy, industry, urban development, and waste management.

Key documents reviewed included the First and Second Provincial Five-Year Plans, the Provincial Status Paper (2018), Gandaki Province Environmental Conservation Act (2076), Provincial Environment Protection Rules (2079), draft Environment and Climate Change Policy, draft Provincial Climate Change Strategy and Action Plan (PCCSAP), the National Greenhouse Gas Inventory, and other relevant federal and provincial instruments. The objective of this review was not only descriptive, but analytical to assess coherence, overlaps, implementation gaps, and alignment with national and international environmental commitments.

3. Data Collection, Analysis and Thematic Assessment

The SoE preparation required extensive data collection from both secondary and primary sources. Secondary data were gathered from federal, provincial and local government agencies, national statistical systems, research publications, sectoral reports, and verified databases. Primary inputs were collected through consultations, key informant interviews (KIIs), and stakeholder workshops.

The analytical structure of the SoE was guided by the DPSIR framework (Drivers–Pressures–State–Impact–Response), ensuring systematic linkage between socio-economic drivers, environmental pressures, observed conditions, impacts on ecosystems and human well-being, and policy or institutional responses. The thematic coverage included major environmental sectors such as air quality, water resources, land use, forests and biodiversity, climate change, energy and industry, waste management, and urban environment. The analysis also identified emerging environmental issues, degradation hotspots, and climate- and disaster-related vulnerabilities across Gandaki's diverse physiographic zones (High Mountain, Mountain, Hill, and Terai).

4. Stakeholder Engagement and Participatory Validation

Stakeholder engagement was embedded throughout the assignment. Multi-stakeholder consultations were organized with provincial ministries, district coordination committees, municipalities, academic institutions, civil society organizations, private sector actors, and community representatives.

These consultations served multiple purposes: validating data and findings, identifying priority issues and emerging risks, documenting local best practices, and capturing perceptions of environmental change. The participatory approach strengthened the credibility and ownership of the SoE findings.

5. Report Preparation and Knowledge Products

The assignment included preparation of a comprehensive SoE report structured around thematic analyses supported by data tables, maps, charts, and case studies. The report integrates:

- Situation analysis by sector,
- DPSIR-based synthesis,
- Policy and institutional gap analysis,
- Identification of priority risks and trends,
- Strategic recommendations for improved environmental governance and integrated planning.

The final deliverables include the full SoE report in English and Nepali (formatted as per MoFE/UNDP standards), a validation-ready draft, a print-ready final version, a summary brief for policy audiences, and a presentation deck for dissemination.

6. Validation and Finalization

A validation workshop was conducted with key stakeholders to review the draft SoE, ensure technical accuracy, and incorporate institutional perspectives. Feedback received was systematically integrated into the final report. The final output was submitted in both digital and print-ready formats to facilitate policy use, public dissemination, and future updates.

In summary, the scope of work encompassed the end-to-end preparation of a scientifically robust, policy-relevant, participatory, and forward-looking State of Environment Report for Gandaki Province. It combined data-driven environmental assessment, institutional and policy analysis, stakeholder engagement, and strategic recommendations, with the objective of supporting informed decision-making, improved environmental governance, and sustainable development planning in the province.

1.4 Methodological Limitations and Future Improvement

This SoE report provides a broad and evidence-based assessment of environmental conditions in Gandaki Province. However, a few limitations should be noted while interpreting the findings. First, data availability and quality were not uniform across all themes. Some sectors had relatively strong datasets, while others lacked regular, up-to-date, and province-specific information. As a result, not all chapters could present the same level of depth and trend analysis.

Second, the report relied largely on secondary data collected from different institutions. In many cases, datasets were prepared in different years, scales, and formats, which created challenges for consistency and comparison. Similarly, local-level and disaggregated data were limited for some indicators, requiring the use of proxy information and analytical interpretation.

Third, although stakeholder consultations and selected observations were carried out, it was not possible to undertake detailed primary field verification for all sectors and all areas of the province. Finally, the DPSIR framework helped organize the analysis in a systematic way, but some environmental issues remain interlinked and cannot always be separated neatly into distinct categories.

These limitations also highlight the need for stronger provincial monitoring systems, regular data updating, and better inter-agency coordination in future SoE preparation.

Chapter 2. General Overview

2.1 Nepal by Province

Nepal is a landlocked federal democratic republic in South Asia with an estimated population of 29.2 million based on 2021 census and a total land area of 147,181 square kilometers (NPHC, 2021). Its population is diverse, comprising diverse ethnic groups spanning from the plains in the south to the high mountains in the north. Nepal is divided into seven provinces, 77 districts, and 753 municipalities for administrative purpose.

Among its provinces, Karnali is the largest, covering 28.0 thousand square kilometers (19.0%). Sudurpashchim follows with 19.5 thousand square kilometers (13.25%), and Lumbini covers 22.3 thousand square kilometers (15.15%). Gandaki, Bagmati, and Koshi cover 21.7, 20.3, and 25.9 thousand square kilometers, accounting for 14.74%, 13.79%, and 17.60%, respectively (**Table 2-1**). Madhesh is the smallest, with 9.7 thousand square kilometers (6.52%).

Table 2-1: Area Distribution of Nepal by Province

Province	Total area ('000 sq.km)	% of Area
Nepal	**147.181**	**100.0**
Koshi	25.9	17.60
Madhesh	9.6	6.52
Bagmati	20.3	13.79
Gandaki	**21.7**	**14.74**
Lumbini	22.3	15.15
Karnali	27.9	19.96
Sudurpashchim	19.5	13.25`

Source: NSO, 2025

2.2 Gandaki Province

Gandaki Province (~21,773km^2) occupies a central place in Nepal's physical, social, and economic landscape, shaped by its exceptional geographic diversity and rich cultural heritage. Extending from the high Himalayan ranges along the northern frontier to the fertile Terai plains in the south, the province encompasses some of the country's most dramatic mountain environments, major river systems, and densely settled urban centres. It is home to globally significant natural assets including snow-fed rivers, lakes, forests, and biodiversity-rich ecosystems as well as historically important settlements, religious sites, and tourism destinations. At the same time, Gandaki is experiencing rapid social and economic change, marked by urban growth around Pokhara, shifting livelihoods, labour migration, and evolving demographic patterns. These dynamics place the province at a critical intersection where human development aspirations, environmental sustainability, and disaster risk are closely intertwined. Understanding the provincial context is therefore essential for interpreting the state of the environment in Gandaki and for framing pathways toward resilient and inclusive development.

Spans from southern low-land (Terai/Siwalik), subtropical valleys to some of the Himalaya's tallest peaks, including the Annapurna and Dhaulagiri ranges (Figure 2-1). The province is culturally diverse and economically anchored by tourism, agriculture, and hydropower, with Pokhara serving as its gateway and capital city. Dense river networks and iconic lakes shape its settlements, livelihoods, and transport corridors, while protected areas and trekking routes make it a national hub for nature-based tourism and mountain adventure. This blend of dramatic geography, rich cultures, and water-driven economies frames Gandaki's development opportunities and risks.

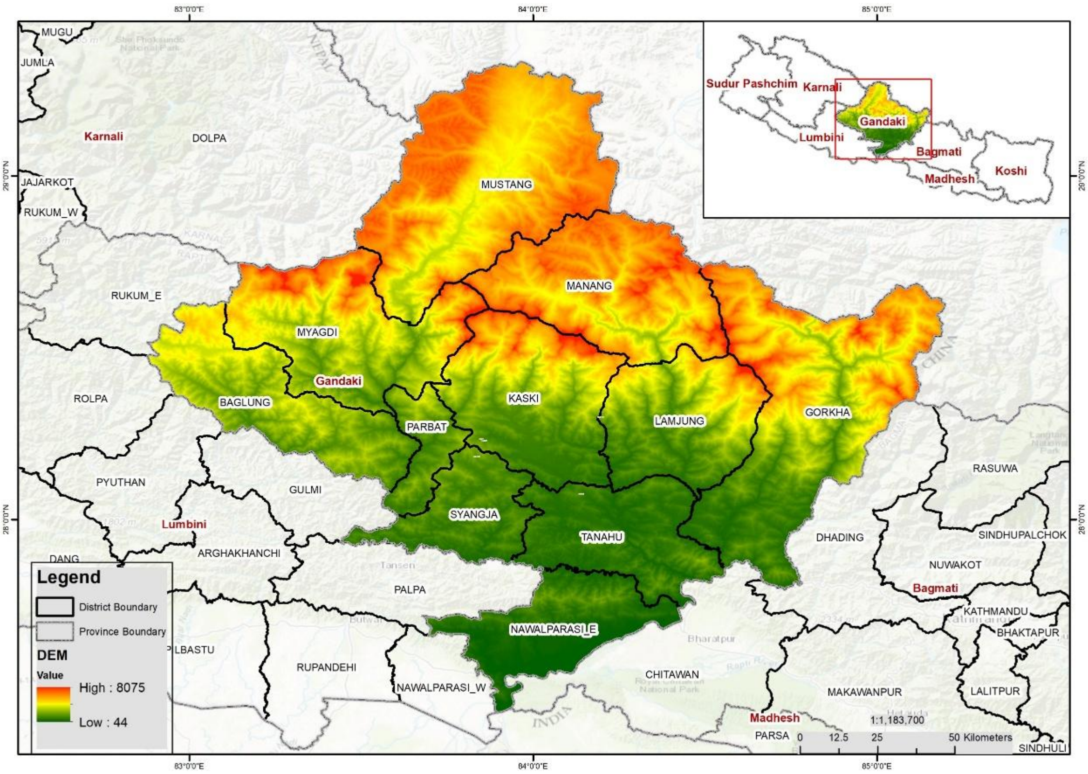


Figure 2-1. Location and Elevation Model of Gandaki Province

2.2.1 Geography and Demography

Geography:

Gandaki Province lies in central Nepal and forms a striking north–south transect from the high Himalaya to the Terai lowlands. It is bordered by Bagmati Province to the east, and by Lumbini and Karnali Provinces to the west; to the north it shares an international border with China, while its southern edge connects toward Lumbini Province and the adjoining Indian plains. The province covers about 21.5 thousand km² (around 14.7% of Nepal's total area), making it one of the larger provinces in the country.

Administratively, Gandaki consists of 11 districts Gorkha, Lamjung, Tanahun, Kaski, Manang, Mustang, Parbat, Syangja, Myagdi, Baglung, and Nawalparasi (Bardaghat Susta East) and is divided into 85 local levels (1 metropolitan city, 26 municipalities, and 58 rural municipalities). The province is physiographically diverse: two districts lie predominantly in the mountain region (Manang and Mustang), eight in the hills, and one in the Terai (Nawalparasi East) a gradient that strongly influences climate, settlement patterns, ecosystem types, and exposure to hazards. This terrain diversity is mirrored in Gandaki's water and biodiversity assets. The provincial plan documents more than 290 lakes and ponds (including Tilicho, Phewa, Begnas, Rupa, Damodar and Birendra), extensive wetlands, and glaciers covering about 17,300 ha in the Gandaki River Basin, underlining the province's role in water regulation and ecosystem services.

The second Five Year Plan (PPPC, 2080 (2024)) also notes that Gandaki contains major river basins and sub-watersheds, with the Gandaki system comprising numerous Himalayan-fed rivers such as Trishuli, Budhigandaki, Marsyangdi, Seti, Madi, Modi, Myagdi and Kaligandaki and highlights the province's steep and fragile topography that contributes to recurring erosion, landslides and flood risks. These geographic features are not only ecological strengths but also key "drivers" and "state conditions" shaping environmental pressures and disaster vulnerability across the province.

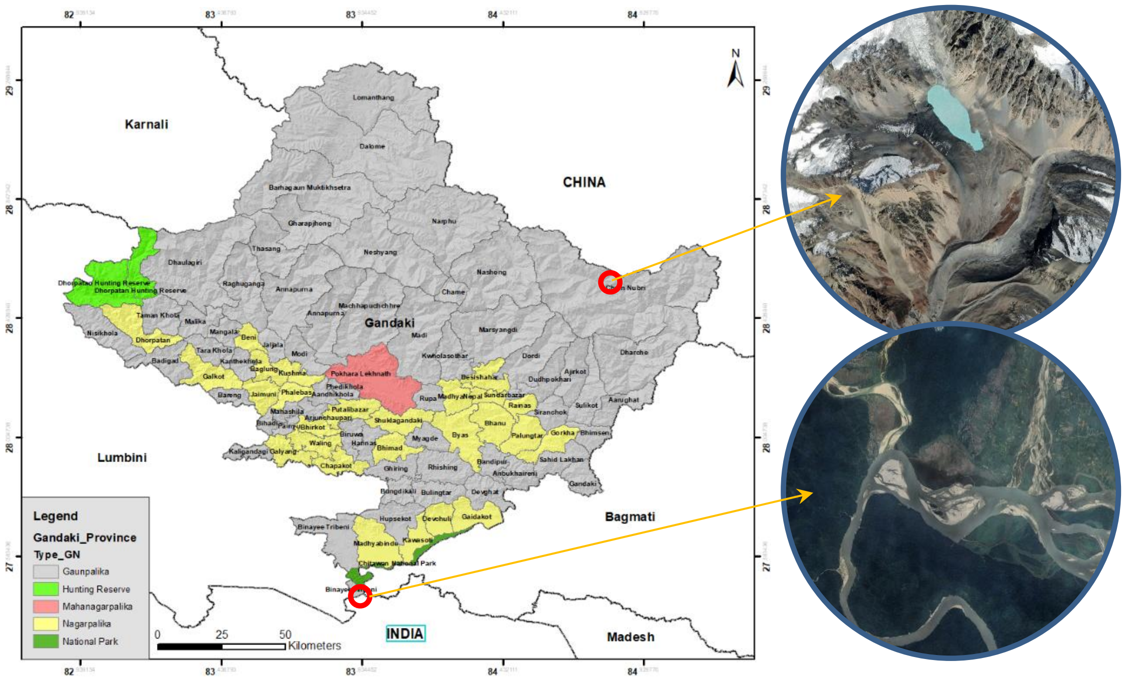


Figure 2-2. Distribution of Rural and Urban Municipalities in Gandaki Province

Demography:

Gandaki Province has a relatively moderate population size, but distinct demographic characteristics shaped by migration, urban concentration, and changing household structure. As of the National Population and Housing Census 2021 (CBS, 2021a), the province's total population was 2,466,427, comprising 1,170,833 males (47.47%) and 1,295,594 females (52.53%), with a sex ratio of 90.37 males per 100 females. Over the last decade, the province recorded a low annual average population growth rate of 0.25% (2011–2021) below the national rate reflecting a combination of declining fertility and outward labour migration.

Population distribution varies sharply by geography. The census reports an overall population density of 115 persons/km² in 2021 (up slightly from 2011), but with major district contrasts: Kaski has the highest density (297) while Manang has the lowest (3). In absolute numbers, Kaski is the most populous district (600,051 persons) and Manang the least (5,658 persons). This uneven settlement pattern is closely linked to accessibility, service concentration (especially around Pokhara), and livelihood opportunities, which in turn affect land-use change, demand for water and energy, and pressure on urban infrastructure.

The province is also becoming increasingly urban in demographic terms: by 2021, 65.8% of the population lived in urban municipalities and 34.2% in rural municipalities. Household structure is changing alongside this transition. The number of households rose to 662,480 in 2021 (from 578,219 in 2011), while average household size declined to 3.72 persons per household (from 4.16 in 2011), indicating smaller family units and shifting living arrangements. Gandaki's age structure suggests a strong working-age base: 62.8% of the population is aged 15–59, while 23.9% are aged 0–14 and 13.3% are aged over 60. Together, these geographic and demographic realities provide the foundation for the SoE narrative: Gandaki's steep mountain–hill–Terai gradient, dense river and lake systems, and expanding urban population create a setting where development gains and environmental pressures are tightly interlinked particularly around water security, watershed stability, waste management, and climate- and disaster-related risks.

2.2.2 Geology and Geo-morphology

Gandaki Province lies in the central Himalayan region of Nepal and showcases some of the most diverse and complex geological and geomorphological formations in the country. The province stretches from the subtropical plains of the Siwalik Hills to the arid landscapes of the Trans-Himalayas, covering a wide *elevation gradient and crossing several major tectonic and geological zones of the Himalayas. This spatial variation results in diverse landforms, rock types, and geohazards that define the province's natural landscape and environmental dynamics (Figure 2-3)*

Figure ***2-3***).

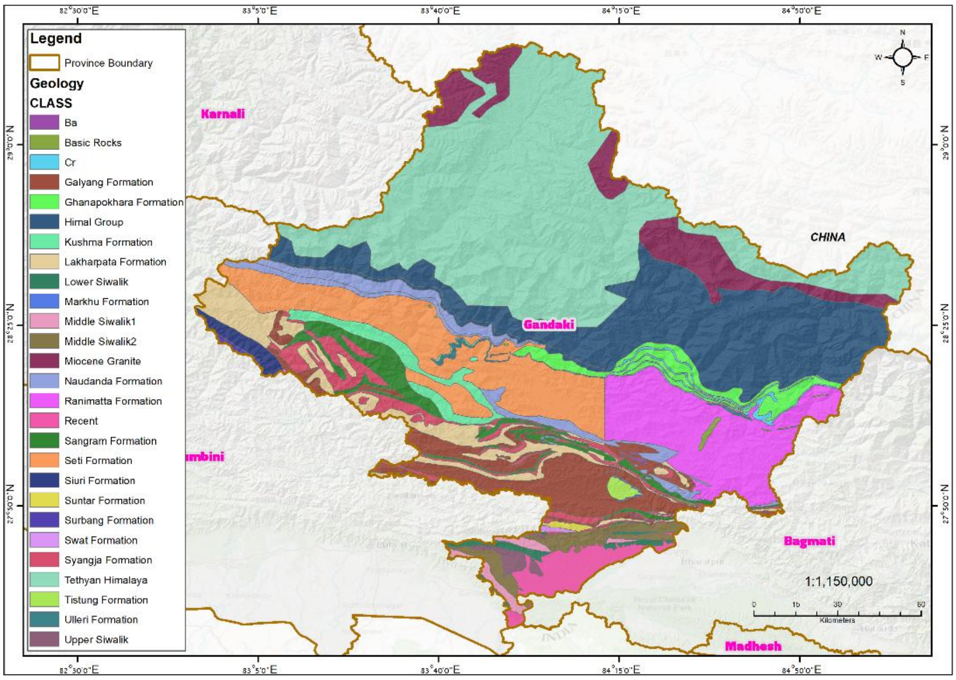


Figure 2-3. Regional Geological Map of Gandaki Province

Geologically, the province is traversed by five major tectonic zones, each running roughly east-west and stacked from south to north due to the ongoing collision of the Indian and Eurasian plates. These zones include the Siwalik Zone**,** Lesser Himalaya**,** Main Central Thrust (MCT) zone, Higher Himalaya, and the Tethys Himalaya or Trans-Himalayan region. The southern Siwalik hills are composed mainly of sedimentary rocks such as sandstone, mudstone, and conglomerates formed from the erosion of the rising Himalayas. Moving northward into the Lesser Himalaya, metamorphic rocks such as phyllite, schist, and quartzite dominate, reflecting intense tectonic pressure and uplift. The MCT forms a significant geological boundary between the Lesser and Higher Himalayas and is associated with steep terrain and frequent landslides. The Higher Himalayas, composed of gneiss, granite, and high-grade metamorphic rocks, include some of the tallest peaks and deeply incised valleys. Finally, in the far north, the districts of Mustang and parts of Manang fall into the Tethys Himalaya, where fossil-rich sedimentary rocks such as limestone, dolomite, and shale reveal the province's ancient marine history.

From a geomorphological perspective, the province contains a range of landscapes formed by tectonic uplift, fluvial erosion, glaciation, and sedimentation. In the north, the trans-Himalayan region is characterized by arid plateaus**,** rocky cliffs**,** and ancient glacial landforms, shaped under cold desert conditions. The central mid-hills, which include districts such as Kaski, Syangja, and Lamjung, feature steep slopes**,** deep river gorges**,** alluvial terraces**,** and colluvial fans, making them particularly vulnerable to erosion, landslides, and debris flows. In contrast, the southern fringes of the province, part of the Siwalik Hills, consist of undulating hills**,** river floodplains, and alluvial deposits, more conducive to agriculture and human settlements. The Province can also be broadly classified into four major physiographic regions. These include:

1. Terain-Siwalik Region (Churia Range)

Gandaki Province contains small portion of Terai (~0.01%) while Siwalik region consist of about 4.61%. The total of Terai and Siwalik is about 4.62% (~1015km^2). The Siwalik zone is the youngest and southernmost mountain range in Gandaki Province. Geologically, it is made up of poorly consolidated sedimentary rocks such as sandstones, mudstones, and conglomerates, dating from the Miocene to Pleistocene epochs. These rocks were uplifted as a result of Himalayan tectonic activity and are structurally fragile. From a geomorphological perspective, the Siwalik consists of low-elevation hills (generally 600–1,500 meters) with steep slopes and narrow valleys. Due to weak rock strength and intense monsoonal rain, the area is prone to landslides, debris flows, and severe erosion. This region forms a transition zone between the flat Terai and the more elevated mountain zones to the north.

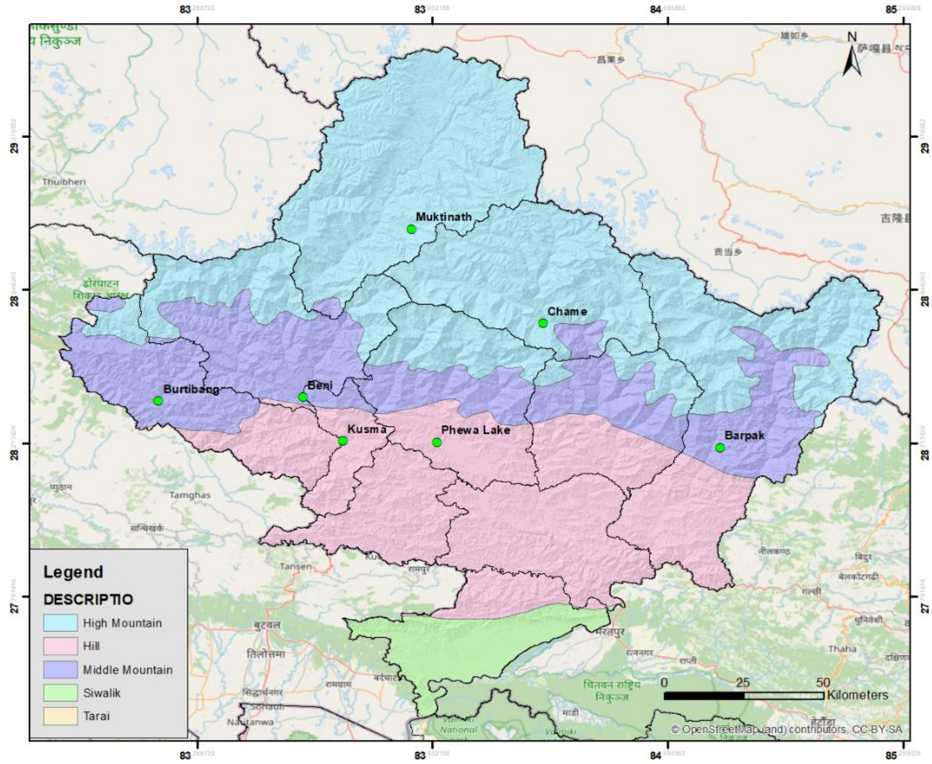


Figure 2-4. Physiography of Gandaki Province (Sources DMG, 2000)

2. Middle Hill Region

The Middle Mountains (~ 29.46%) lie directly north of the Siwaliks and are geologically older and more stable. This zone is composed largely of metamorphic rocks such as phyllites, schists, quartzites, and slates, often associated with the Lesser Himalayan formations. These rocks are harder and more consolidated than those of the Siwaliks but still structurally complex, with thrust zones such as the Main Central Thrust (MCT) forming prominent features. Geo-morphologically, the Middle Mountains have moderate elevations (ranging from 1,500 to 2,700 meters), and include broad valleys, rolling hills, and river-cut terraces. The zone is densely populated and intensively farmed, but it remains vulnerable to slope instability and erosion.

3. Mountain Region (High Hill Zone)

The Mountain Region (~21.95%) is often considered a transitional zone between the Middle Mountains and the High Himalayas - consists of higher ridges and steep terrain, typically between 2,700 and 4,000 meters. Geologically, it comprises crystalline metamorphic rocks such as gneisses and migmatites, with increasing uplift and deformation moving northward. This zone includes important ecological corridors and is home to forests, grazing lands, and scattered settlements. Geomorphologically, it features steep escarpments, narrow gorges, and high-relief terrain. The region is highly dynamic, with active landslide zones and signs of glacial shaping in upper reaches. Due to its elevation, agriculture is limited, but it plays a key role in hydrology and biodiversity conservation.

4. High Mountain Region (Greater Himalaya)

The High Mountain Region (~43.97%) encompasses the northernmost reaches of Gandaki Province, including some of Nepal's highest peaks such as Annapurna and Manaslu. Geologically, this region contains ancient, high-grade metamorphic and igneous rocks - primarily gneiss, schist, and granite - part of the Higher Himalayan Crystalline series. This zone is shaped by glacial and periglacial processes, with permanent snow cover, glaciers, cirques, and glacial lakes dominating the landscape. Elevations here exceed 4,000 meters, and in many cases go well above 6,000 meters. The geomorphology is extremely rugged, with sharp peaks, deep U-shaped valleys, and moraines. Though sparsely populated, the High Mountain region is critical for water resources, climate regulation, and ecotourism, and is also susceptible to hazards such as GLOFs (glacial lake outburst floods) and avalanches.

The landscape of Gandaki is one of the most topographically and climatically varied in Nepal ***(Figure 2-5)***. The northern districts, including Manang and Mustang, fall within the trans-Himalayan arid zone, marked by rugged mountains, sparse vegetation, and limited rainfall. In contrast, the central mid-hills and southern valleys, such as those in Lamjung, Kaski, Syangja, and Tanahun, offer fertile agricultural land, dense forests, and diverse ecosystems. Gandaki is also home to several major rivers - most notably the Gandaki River system, which includes the Kali Gandaki, Seti, Trisuli, Marshyangdi, Budigandaki, Chepe, Daraudi and Madi rivers. A large portion of the Annapurna Conservation Area, Nepal's largest protected area, also lies within the province.

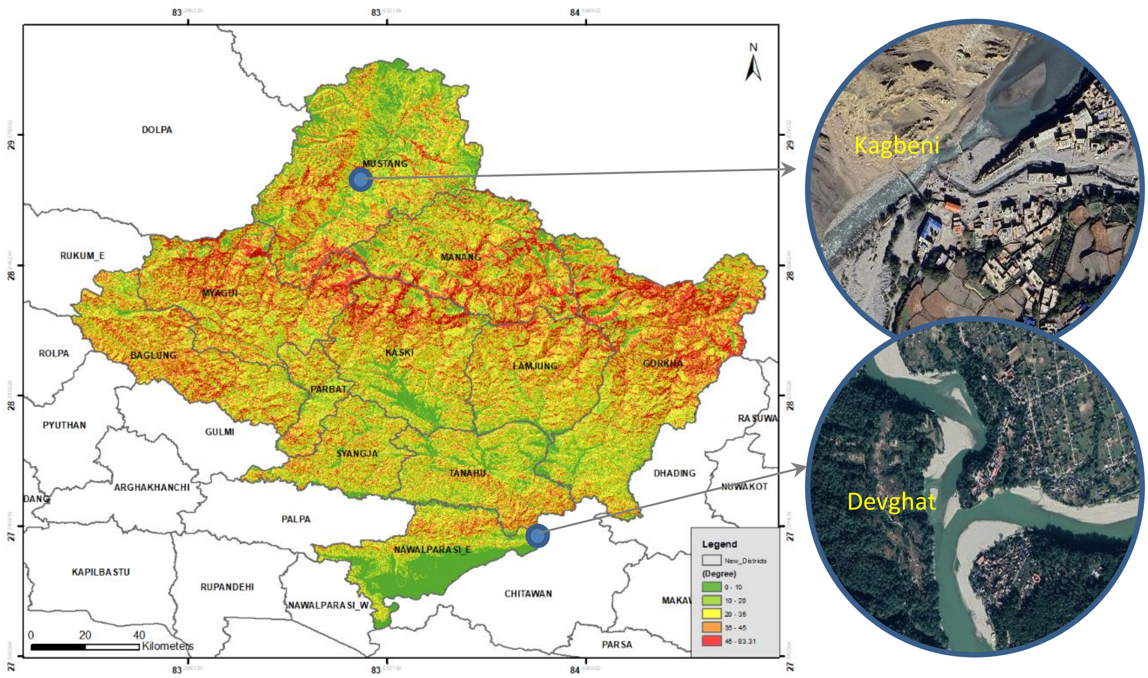


Figure 2-5. Landscape Slope of Gandaki Province

These physiographic and geological variations have profound implications for land use, settlement patterns, disaster risk, and environmental management in Gandaki Province. The active tectonics, fragile rock formations, and steep topography contribute to frequent geo-hazards such as landslides, slope failures, and river erosion, particularly during the monsoon season. The geomorphic complexity also means that climate change impacts - like altered precipitation, glacial retreat, and extreme weather events - manifest differently across regions, requiring location-specific adaptation strategies.

2.2.3 Society and Economy

Society

Gandaki Province represents a socially vibrant and geographically diverse society shaped by its Himalayan mountains, mid-hill settlements, and Terai plains. The province hosts more than a hundred caste and ethnic groups and a wide range of languages and religions, reflecting deep historical settlement patterns along trade routes, river valleys, and mountain corridors. This diversity has enriched cultural identity and social capital, but it also produces differentiated access to land, services, and economic opportunities across districts. Demographically, Gandaki is undergoing a notable transition. The province recorded a very low annual population growth rate (0.25% between 2011–2021), significantly below the national average (CBS, 2021b). At the same time, nearly two-thirds of the population now reside in urban municipalities, with Pokhara emerging as a major urban growth pole. Rural hill and mountain districts, in contrast, are experiencing out-migration particularly of working-age males resulting in a lower sex ratio and changing household structures. The average household size has declined to around 3.7 persons, indicating a shift toward smaller and more nuclear family units.

These demographic shifts directly influence the Urban Environment. Rapid urban concentration in Pokhara, Lekhnath, Kawasoti, Waling, Palungtar and other municipalities increases demand for housing, drinking water, sewerage systems, solid waste management, transportation, and energy. Smaller households and lifestyle transitions are also associated with increased per capita resource consumption, packaging waste, and wastewater generation. Urban expansion, if poorly managed, places pressure on wetlands, lakes (such as Phewa and Begnas), agricultural land and river corridors. Thus, social transformation is not only a demographic phenomenon; it is a key driver of environmental pressure in the province.

In terms of human development, Gandaki performs relatively well. Literacy rates are high (above 80 percent), sanitation coverage is strong, and health outcomes such as neonatal and under-five mortality are among the best in Nepal. These gains are reflected in comparatively high provincial HDI value. However, district-level disparities remain visible. Remote mountain areas face constraints in access to specialized health care, higher education, and stable employment. Households with persons with disabilities represent a significant share of the population and require targeted service inclusion. These inequalities matter from an environmental perspective: communities with limited access to services often rely more heavily on local forests, springs, and informal resource use systems, increasing ecological vulnerability.

Gandaki's society is marked by demographic stabilization, urban concentration, and improving human development outcomes. Yet these social gains also reshape consumption patterns, infrastructure needs, and environmental risk exposure making integrated planning across social and environmental sectors essential.

Economy

The economy of Gandaki Province is in structural transition, increasingly service-oriented while still anchored in agriculture and natural resources. Agriculture remains a primary livelihood in rural and hill districts, though its contribution to provincial Gross Domestic Product (GDP) has gradually declined relative to services (PPPC, 2080 (2024)). Farming in Gandaki is strongly influenced by terrain, irrigation availability, and climate variability. Hill-slope cultivation, terrace farming, and river basin agriculture depend on fragile ecosystems, making the sector sensitive to landslides, erratic rainfall, and changing temperature patterns.

The service sector dominates the provincial economy, with tourism as a strategic pillar (PPPC, 2080 (2024)). Gandaki hosts globally renowned destinations, including Annapurna, Manaslu, Mustang, Tilicho Lake, Phewa Lake, and major pilgrimage sites such as Muktinath and Manakamana. The hospitality sector hotels, homestays, restaurants and trekking services have expanded significantly in recent years. Tourism generates employment, foreign exchange and local entrepreneurship, but it also intensifies environmental pressures. Increased visitor numbers contribute to solid waste accumulation, wastewater discharge, trail erosion, forest fuelwood demand in high-altitude areas, and strain on urban infrastructure in Pokhara and trekking gateways.

Hydropower development is another major economic driver. Gandaki's river systems including Marsyangdi, Seti, Budhigandaki and Kaligandaki have enabled substantial electricity generation, contributing to high electrification rates in the province. However, hydropower infrastructure also alters river ecology, sediment transport, aquatic biodiversity and downstream water regimes. Balancing renewable energy expansion with watershed conservation and environmental flow maintenance is therefore a key policy challenge.

Remittances from foreign employment also play a major role in Gandaki's economy. Migration income supports household consumption, education, housing construction and small businesses. Yet it can also accelerate land-use change, urban sprawl, and increased material consumption linking economic growth to rising waste generation and construction pressure in peri-urban areas. Provincial GDP per capita is relatively higher (~1,596 USD) compared to several other provinces, reflecting tourism strength and service sector growth. Nevertheless, economic vulnerability persists. The province remains sensitive to external shocks such as earthquakes, pandemics (as seen during COVID-19 tourism collapse), and climate-induced disasters. Sustainable economic transformation therefore requires integrating tourism management, clean energy transition, climate resilience, and environmentally sound urban planning.

The economy of the province is deeply intertwined with its environmental base. Agriculture depends on soil and water systems; tourism depends on pristine landscapes; hydropower depends on healthy river basins; urban growth depends on sustainable infrastructure. Future prosperity will depend not only on economic expansion but on how effectively the province manages the environmental systems that sustain that growth.

2.2.4 Landuse and Livelihood

Land Use

Land use in Gandaki is shaped by its dramatic altitudinal gradients, climatic diversity, and varied topography ranging from high Himalayan plateaus through rolling hills to the limited Terai plains. A large portion of the province continues to be covered by forests, and agricultural land remains the primary use type for rural livelihoods. According to provincial forest planning documents (MoFE, 2024), about 35.85 % of Gandaki's total area is covered by forests, and an additional 5.4 % consists of shrubs or "butiyan" (secondary vegetation or shrub lands) across the province's districts. This forest and shrub complex forms a fundamental ecological backbone, regulating watershed function, supporting biodiversity, and providing raw materials such as fuelwood, timber and non-timber forest products for local communities.

Remote-sensing–based national land-cover monitoring data show that forests remain the dominant land cover class at the national scale, and comparable patterns are evident in hill and mountain regions like Gandaki (FRTC, 2024). While provincial-level satellite classification data specific to every land-cover type are still evolving, broader national datasets reflect that forest cover has increased or stabilized in many mid-hill areas with community forestry interventions.

In terms of agriculture, about 24 % of Gandaki's land area is considered cultivable, based on provincial agricultural planning studies. Of this cultivable land, roughly 24 % was reported as fallow (about 117,076 ha), indicating underuse due to challenges such as labour shortages, lack of irrigation, or migration-linked labour shifts (Neupane et al., 2021). This translates into a cropland area on the order of several tens of thousands of hectares, with additional cultivation occurring in smaller plots and terraced systems across the hills and valleys.

National agricultural census data (MoALD, 2025) also suggest that crop land under permanent crops (such as orchards or long-term plantations) exists in substantial area in Gandaki, with figures in the tens of thousands of hectares e.g., over 145,000 ha of permanent cropland recorded under one provincial dataset (NSO, 2024b). The spatial patterns of land use reveal clear physiographic influences:

- Forest and shrub lands dominate mountain and mid-hill districts, where steep slopes and limited flat land constrain intensive agriculture.
- Cultivable and cropland areas concentrate in river valleys and the small Terai belt, where soils and topography are more suited to cereals, vegetables, and other crops.
- Urban and built-up land has been expanding around municipal centres such as Pokhara, contributing to conversion of agricultural land and open spaces.

Together, these land-use patterns help explain the interplay between ecological function and human activity in Gandaki Province: forests and shrubs maintain natural capital and ecosystem services; cropland supports rural economies and food systems; and emerging urban land uses highlight pressures on productive landscapes. Understanding this mosaic of land use is essential for analyzing environmental change, resource demand, disaster risk, and sustainable development pathways in the province.

Livelihood

Gandaki's livelihood have undergone significant transformation over the past two decades, shaped by declining dependence on subsistence agriculture, expanding service-sector opportunities, and large-scale labour migration. While agriculture, forestry and fisheries still engage over half of the economically active population, their role as the primary source of household income has weakened. Small and fragmented landholdings, limited irrigation, labour shortages, and increasing climate variability have reduced the viability of farming as a standalone livelihood, particularly in hill and mountain districts.

One of the most defining livelihood features of the Province is labour migration. Census 2021 and recent migration profiling (IOM, 2023) indicate that around 11–12% of the provincial population was living abroad, a share higher than in several other provinces. Migration is especially pronounced among working-age males, resulting in a lower sex ratio and reshaped household labour dynamics. Districts such as Kaski, Syangja, Tanahun, Gorkha and Nawalparasi East show particularly high levels of out-migration. As a result, a substantial proportion of households often around one-third or more have at least one absent member working outside the country (CBS, 2021b).

Migration has made remittances a central pillar of livelihoods. Although provincial-level remittance totals are not officially disaggregated, national and provincial studies consistently show that Gandaki receives relatively high remittance inflows per receiving household, compared to many other provinces. Remittances are primarily used for daily consumption, education, health care, housing construction, debt repayment and savings, and in some cases for small business investment. For many rural households, remittance income exceeds earnings from agriculture, fundamentally altering livelihood strategies and reducing direct dependence on land-based production.

At the same time, the province has seen diversification into non-farm and service-based livelihoods**,** particularly in urban and peri-urban areas. Employment in construction, trade, transport, education, health services, hospitality and tourism has expanded, especially around Pokhara and major trekking gateways. Tourism-related livelihoods such as guiding, pottering, hotel and restaurant services, homestays, and transport provide important income opportunities in districts like Kaski, Manang, Mustang, Myagdi and Gorkha. However, these livelihoods are often seasonal and shock-sensitive, as demonstrated by the sharp income losses during the COVID-19 pandemic, highlighting their vulnerability to external disruptions.

Forest-based livelihoods remain important, particularly in rural and remote areas. Community forestry has strengthened local access to timber, fuelwood and non-timber forest products, while also supporting institutional participation and social cohesion. Nevertheless, continued reliance on firewood for cooking by nearly half of households indicates that biomass energy remains a key livelihood-environment interface, with implications for forest pressure, women's labour burden, and household health.

Overall, livelihoods in Gandaki Province are increasingly multi-sourced and migration-linked, combining agriculture, remittances, services, tourism and forest resources. While this diversification has improved income security and reduced poverty for many households, it has also created new challenges: labour shortages in agriculture, land abandonment, uneven urban growth, and rising consumption-related environmental pressures. Strengthening sustainable livelihoods in Gandaki will therefore require policies that link productive employment, skills development, clean energy access, climate-resilient agriculture, and environmentally responsible tourism ensuring that livelihood security does not come at the cost of environmental degradation.

2.2.5 Physical Infrastructures and Services

Infrastructure and basic services shape how people live, move, and access opportunities in Gandaki Province and they also strongly influence environmental pressures (e.g., land conversion, slope instability, river-bed extraction demand, energy use, waste generation) and the province's capacity to manage climate and disaster risks. Because Gandaki spans high mountains, mid-hills, river valleys and the southern lowland belt, service delivery is uneven by geography: urban corridors (especially the Pokhara Valley and highway-linked market centers) generally enjoy better access, while remote hill–mountain settlements face higher costs, seasonal disruption, and greater exposure to road- and climate-related hazards.

1) Road Network and Accessibility

Road connectivity is the backbone of access to markets, schools, health services, tourism destinations, and emergency response. Gandaki Province has a rapidly expanding road network, reflecting strong investment in connectivity across national, provincial, and local levels. As of FY 2020/21, (MoEA, 2025) the national strategic road network within the province totaled about 1,300 km, of which roughly 41% is blacktopped, while the remainder consists largely of earthen and gravel roads. At the same time, the provincial and local road network, according to the MoEA (2025) has expanded substantially, reaching approximately 11,728 km by FY 2079/80, dominated by earthen roads (over 80%). While the strategic road network (SNR) in the province is estimated to be 1675km (**Figure 2-6**). This mix indicates that, while key corridors are improving, a substantial share of the network remains vulnerable to monsoon disruption, landslides, and maintenance backlogs, especially on earthen and gravel sections and on steep hill alignments.

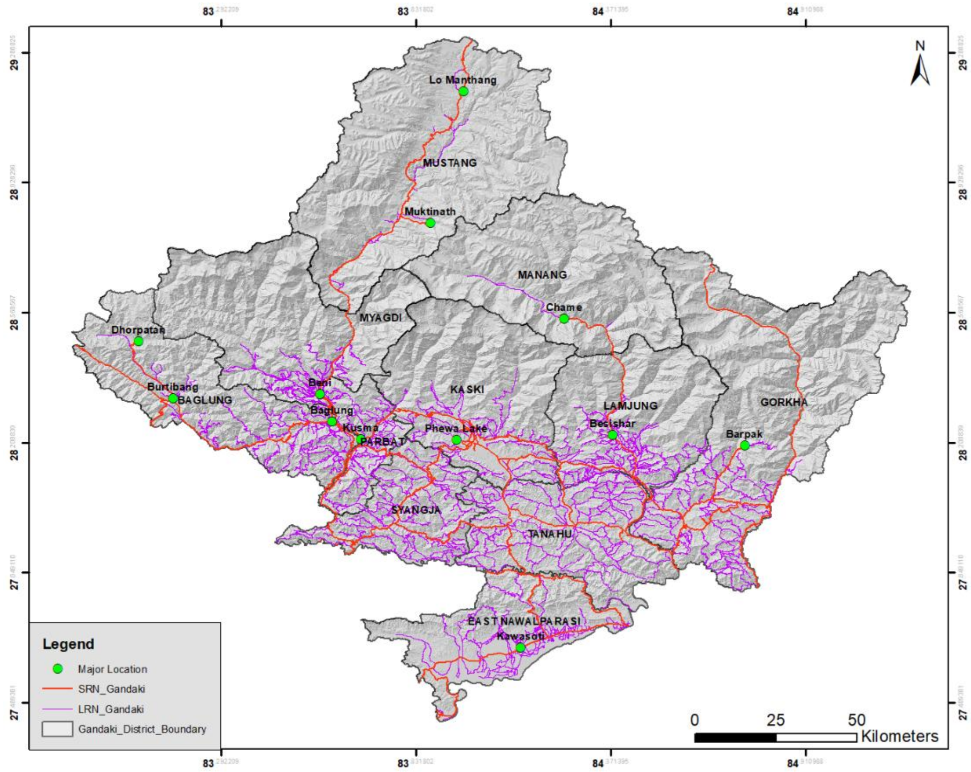


Figure 2-6. Road Network Map of Gandaki Province

Recent provincial investments have focused on upgrading road surfaces, with nearly 120 km blacktopped by mid-FY 2080/81 (MoEA, 2025). While improved connectivity enhances access to markets, services, and tourism destinations, the dominance of earthen and gravel roads, particularly in hill and mountain areas also increases vulnerability to monsoon damage, landslides, erosion, and sediment discharge into rivers. From a State of Environment perspective, this highlights the need for environmentally sensitive road design, slope stabilization, drainage management, and maintenance planning to reduce environmental and disaster risks associated with road expansion.

2) Health Services and Facilities

The province's health service network includes hospitals, primary health care facilities, and extensive outreach services that are essential for preventive care, maternal and newborn services, and emergency response during disasters. The Gandaki Province Annual Health Report (FY 2076/77) records 16 hospitals, 24 PHCCs, and 487 health posts, alongside service delivery points such as 319 birthing centers, 1,375 PHC-ORCs, and 1,787 EPI clinics, supported by 5,863 FCHVs (MoSD, 2021). These figures illustrate both the scale of the primary health network and the province's dependence on outreach platforms highly relevant in remote settings where distance and seasonality can delay care.

Some compilations present different totals depending on definition and year (e.g., whether "facilities" include all public/non-public sites or only reporting sites). For example, a province factsheet compiled from census/HMIS sources reports 756 public health facilities and 19 public hospitals, plus 96 non-public facilities and 44 non-public hospitals (MoSD, 2021; UGC, 2023). In the environmental context, Gandaki has a relatively dense service footprint in accessible areas, but service readiness and continuity remain sensitive to road disruptions, extreme weather, and the growing burden of pollution- and climate-sensitive diseases.

3) Schools and Education Services

Education infrastructure is both a development asset and a service system that depends on safe water, sanitation, energy, and resilient transport access. According to the national Flash I Report 2081 (MoEST, 2024; UGC, 2023), Gandaki has 3,890 schools in total, with 3,193 community schools (82.1%), 643 institutional schools (16.5%), and 54 religious schools (1.4%). This structure highlights the central role of community schools in service delivery, particularly beyond urban centers.

School service quality is also closely tied to basic facilities (drinking water, toilets, electricity, connectivity). Education monitoring indicates that Gandaki performs comparatively well on several school facility relative to some other provinces though gaps still persist by municipality and remoteness (MoEST, 2024; UGC, 2023). For context of environment, this matters because schools are also focal points for: (i) disaster preparedness and safe shelter use; (ii) behavior change and environmental education; and (iii) infrastructure demand (water supply, sanitation, solid waste management) in growing settlements.

4) Drinking Water Supply and Sanitation

Drinking water access in Gandaki is relatively strong overall, but service levels differ by settlement type and geography ranging from household connections in towns to shared taps, spouts, and local sources in scattered hill settlements. Based on Census 2021 (CBS, 2021b) derived WASH indicators, Gandaki households report tap/piped water within premises (52.48%) and tap/piped water outside premises (32.56%), with smaller shares using spout water (6.8%), jar/bottle (3.05%), and other sources. These figures suggest that a majority of households rely on piped systems, but a large portion still must fetch water from outside the home an important equity and resilience issue during droughts, landslides, and service interruptions.

Sanitation coverage is high by national standards in the province: households report flush toilet with septic tank (78.6%) and only 0.95% without toilet, while pit toilets account for about 20.08% (CBS, 2021b). From an environmental perspective, the sanitation profile implies growing importance of fecal sludge management, septic maintenance, and safe disposal, especially in dense urban and peri-urban areas where unmanaged effluent can affect rivers and groundwater.

2.2.6 Water Resources

Gandaki Province is one of Nepal's most water-abundant provinces, shaped by high mountain-hill physiography and a dense river network. Major river systems including Kali Gandaki, Seti, Marsyangdi, Budhigandaki, Madi, etc. and their tributaries support livelihoods and the provincial economy through energy generation, irrigation, drinking water supply, and tourism-based recreation. Rafting is a major attraction in some stretches of the rivers in Gandaki basin. At the same time, the province's steep terrain, fragile geology, and climate variability mean that water-related benefits are increasingly linked with risks such as landslides, sedimentation, flood events, and localized dry-season scarcity especially in hills and trans-Himalayan pockets.

Hydropower and Energy Use

Hydropower is one of the strongest productive uses of Gandaki's water resources and a major driver of provincial development. The Department of Electricity Development (DoED) website reports, on 12 Jan 2026, that there are a total of 58 operating hydropower stations (>1 MW) in the province with a total installed capacity 1,089.5 MW with the latest addition of the 48.5 MW Upper Rahuganga Hydropower project last year (25 October 2025). These are grid-connected hydropower stations. This represents almost a third of the nation's current production of 3757.874 MW from 188 projects. A total of 401 mini and micro hydropower projects (capacity less than 1 M.W.) with an installed capacity of 8.479 MW were operational in 2023. This brings the total installed capacity to 1097.979 MW against the theoretical potential of 5,270 MW (World Bank Group, 2019[1]).

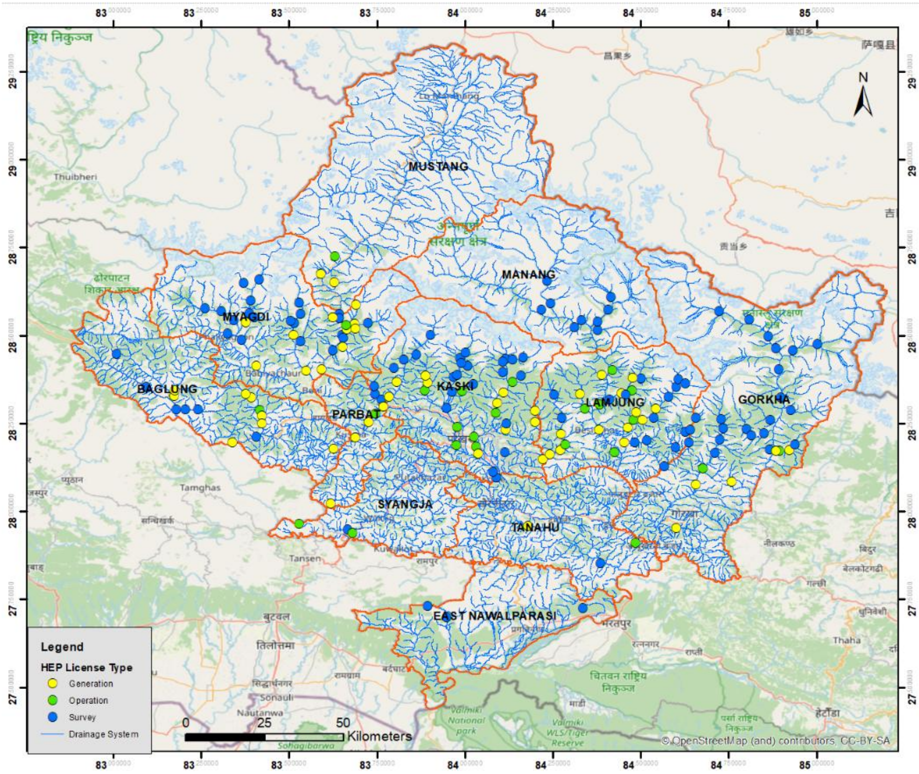


Figure 2-7. River and Drainage System and Locates of Hydropower Projects in Different Stages in Gandaki Province (Sources: DoED 2024)

The First Five-Year Plan aimed to increase the population with access to electricity from 90.7 percent to 100 percent, which was met by 99.50 percent, as of fiscal year 2022/23. This hydropower expansion brings provincial benefits (revenue potential, electrification, industrial and service growth), but it also raises environmental management needs, particularly environmental flows, aquatic habitat continuity, sediment transport, and watershed integrity**,** which are essential for long-term sustainability of both rivers and infrastructure.

[1] World Bank Group. (2019). *Nepal Energy Infrastructure Sector Assessment*. World Bank.

Irrigation and Agricultural Water Use

Water availability does not automatically translate into irrigation reliability especially in the hills where conveyance, source protection, and seasonal variability are key constraints. The Economic Survey reports that Gandaki (MoEA, 2025) has 487,578 ha of cultivable land, but only 351,597 ha (72.10%) is currently under cultivation. It also estimates that land with potential for year-round irrigation access is 272,630 ha, equivalent to 77.5% of the land currently being cultivated (MoEA, 2025).

Within this irrigable land base, the Ministry of Energy, Water Resources and Water Supply data show that the irrigation infrastructure had expanded to 70,080 ha, which is 25.70% of total irrigable land showing both progress and a substantial remaining gap for modernization and reliability. These figures indicate that the province is investing in resilient irrigation systems, source conservation, and efficient, climate-adaptive water management especially in drought-sensitive pockets and landslide-prone slopes.

2.2.7 Tourism

Tourism is one of the most important pillars of Gandaki Province's service economy, centred around Pokhara Valley and the Annapurna landscape, with strong linkages to Mustang, Manang, Gorkha and other hill–mountain destinations. National tourism statistics confirm a strong post-pandemic recovery, with international arrivals (excluding Indian tourists entering by land) increasing from 614,869 in 2022 to 1,014,882 in 2023, and further to 1,147,548 in 2024 (MoCTCA, 2023; MoCTCA, 2025). As one of Nepal's primary tourism gateways, Gandaki captures a substantial share of these arrivals, particularly for trekking, leisure, pilgrimage and adventure tourism.

The province has developed a large hospitality and tourism service base. According to the Economic Survey (2080/81), Gandaki hosts 16,976 hospitality and food service establishments, including 1,779 non-star hotels and lodges, 10 star hotels, 27 resorts, 552 homestays, and 14,502 restaurants (MoEA, 2025; NSO, 2025). Pokhara Metropolitan City represents the largest concentration of accommodation facilities, with the capacity to host several tens of thousands of visitors per night, reflecting rapid growth in hotel construction and tourism-oriented infrastructure over the past decade. The expansion of homestays across districts further demonstrates the spread of community-based tourism models, linking rural households to visitor economies while diversifying income sources beyond agriculture.

Tourism is also a significant employment generator. A national Tourism Employment Survey estimated 138,148 direct tourism jobs (GOV, 2014), highlighting the sector's major contribution to service-sector employment. The study (GOV, 2014) further noted that women accounted for roughly 20 percent of total tourism employment, with relatively higher participation in homestay operations and small enterprises. In Gandaki, tourism-related employment spans hotels, trekking and guiding services, transport operators, restaurants, handicrafts, and informal service chains. While the sector provides income opportunities for youth and rural households, employment remains seasonal and sensitive to external shocks, as demonstrated during the COVID-19 period.

At the same time, tourism growth places increasing pressure on environmental systems and infrastructure capacity (Paudel and Khatri, 2024). Concentrated accommodation facilities and visitor flows increase demand for water supply, energy, transport, and waste management services, particularly in Pokhara and along major trekking corridors. Climate change further heightens vulnerability, such as landslides, extreme rainfall, and transport disruptions directly affect accessibility, visitor safety, and the reliability of tourism services. Given that Gandaki's tourism brand is closely tied to natural landscapes, lakes, rivers, and mountain ecosystems, sustaining environmental quality is central to maintaining long-term tourism competitiveness and provincial economic resilience.

2.2.8 Climate and Climate Change

Gandaki Province sits across a sharp elevation gradient from the southern plains of Nawalparasi (East) through mid-hills and deep river valleys to high mountains and trans-Himalayan landscapes in Manang and Mustang. This geography creates very large climatic contrasts within a short distance, and it also makes the province highly sensitive to climate change. In practice, Gandaki experiences both water abundance (monsoon-fed rivers and high-rainfall pockets) and water stress (dry trans-Himalayan areas and drying springs in hills), alongside high exposure to climate-related hazards such as intense rainfall, landslides, floods, and sedimentation.

1) Provincial Climate Setting: Strong Spatial Variability

Gandaki's rainfall pattern is dominated by the summer monsoon, but the province shows major spatial differences due to topography and rain-shadow effects. Recent DHM monthly summaries illustrate this contrast clearly: during July 2024, Lumle station recorded 1,728.9 mm monthly rainfall (among the highest), while Jomsom recorded only 91.5 mm (among the lowest) showing the steep wet–dry gradient that exists within and around Gandaki's mountain system (DHM, 2024a). This kind of variability is central for the SoE because it shapes (i) where water is plentiful, (ii) where drought stress emerges in the dry season, and (iii) where intense rainfall produces landslides and flooding.

2) Observed Warming: Temperature Rising Faster at Higher Elevations

Observed climate trend analysis by Nepal's Department of Hydrology and Meteorology (DHM) shows a consistent warming signal across Nepal, with stronger warming toward higher elevations. DHM's district and physiographic analysis reports that most districts show positive maximum temperature trends higher than 0.04°C per year, and the pattern of warming generally increases from southern lowlands toward northern mountain and Himalayan regions (DHM, 2017). For physiographic regions, DHM reports that monsoon maximum temperature trends are significantly positive across all regions, with the Tarai showing about 0.036°C/yr while the High Himalayas show about 0.072°C/yr a clear indication that warming intensifies with elevation (DHM, 2017). For Gandaki, this matters particularly in districts such as Manang, Mustang, and upper catchments of major rivers, where warming influences snow/rain balance, glacier and snow melt processes, permafrost melting, high-altitude ecosystems, and water supply security during dry seasons.

3) Rainfall Trends: Mixed Signals, but Strong Concern for Extremes and Seasonal Shifts

DHM's national-scale trend analysis notes that Nepal shows a decreasing precipitation tendency in all seasons, with an annual decrease of about 1.3 mm/yr, although these national precipitation trends are generally statistically insignificant in that analysis period (DHM, 2017). At district level (which is more relevant for provinces), DHM finds that monsoon precipitation trends are increasing in only some districts and decreasing in many others, and importantly for Gandaki-area districts (DHM, 2017):

- Parbat and Syangja show positive monsoon precipitation trends significant at 95% confidence level,
- Manang is among districts showing significant negative monsoon precipitation trend (with other districts outside Gandaki also listed). For annual precipitation, DHM notes that the highest significant annual decrease is observed in Kaski, while the highest significant increase is observed in Syangja.

For the SoE narrative, the key point is not only whether average rainfall rises or falls, but that Gandaki's terrain makes the province highly sensitive to short-duration heavy rainfall, runoff concentration, and slope failure, which together drive floods, landslides, and heavy sediment loads even when long-term average trends are uncertain.

4) Climate Risks Relevant to Gandaki: Floods, Landslides, Drought Pockets, and Exposure

National risk profiling by the World Bank highlights that Nepal's major climate hazards affecting households and livelihoods include river flooding, heat exposure, drought, landslides, and related risks (Amadio et al., 2023). In Gandaki, these hazards take a distinctive form:

- Landslides and debris flows are recurrent in hill and mountain road corridors and river valleys, especially during intense monsoon rainfall. Permafrost melting also increases the likelihoods of slope failures and mass erosion.
- River flooding and bank erosion affect valley bottoms and lowland sections, including southern districts and downstream river corridors.
- Dry-season stress and spring decline are increasingly reported in hill settlements dependent on spring-fed systems (often linked with land use change and rainfall variability).
- Urban flood risk is rising in fast-growing municipal areas where drainage and river-space management lag behind expansion.

The climate evidence indicates that Gandaki Province is experiencing a warming trend consistent with national observations, with stronger warming signals at higher elevations. Rainfall trends are spatially uneven, with some Gandaki districts showing significant increases and others significant decreases in monsoon and annual precipitation. Combined with the province's fragile slopes, expanding infrastructure footprint, and concentrated settlements along river valleys, these climate signals translate into growing pressure on ecosystems, water security, agricultural stability, and disaster risk management.

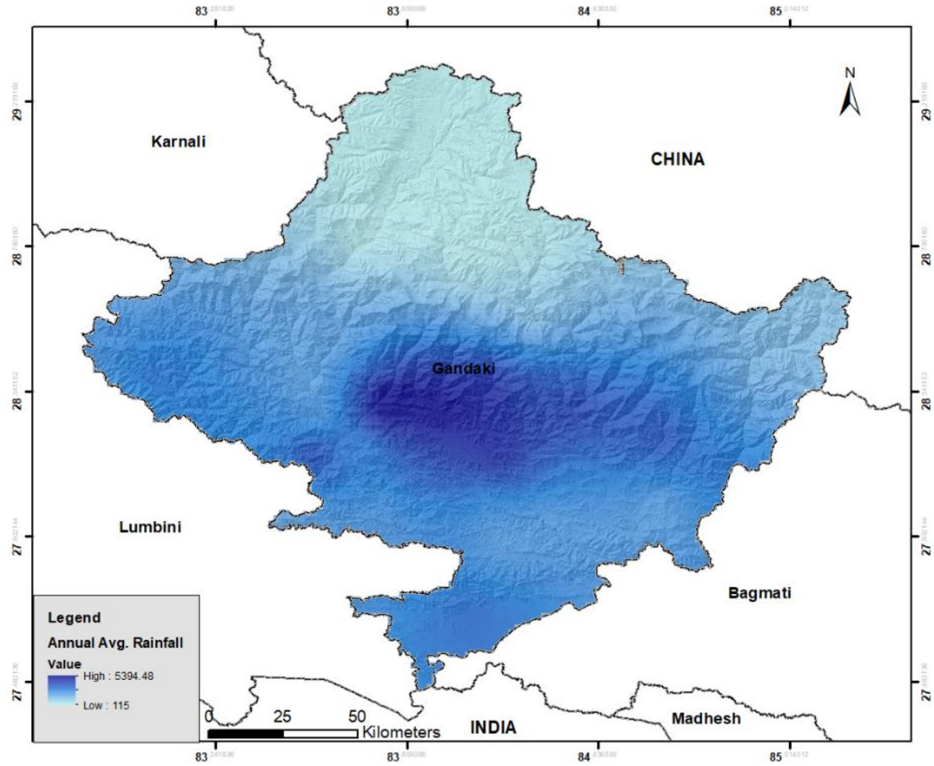


Figure 2-8. Mean (2000-2022) Annual Rainfall Map of Gandaki Province

Climate change in Gandaki is not only about future projections, but its effects are already visible through warming, variability, and hazard intensification, and these trends must be treated as a central development constraint as well as an environmental challenge.

2.3 Key Environmental Challenges and Opportunities

Despite being richly endowed with natural resources and ecological diversity, Gandaki Province is facing mounting environmental challenges that threaten its sustainability and socio-economic stability. A combination of climate change, unplanned urbanization, rapid infrastructure development, and excessive resource exploitation has placed unprecedented pressure on ecosystems. These pressures are manifesting in land degradation, biodiversity loss, pollution, and recurrent climate-induced disasters, all of which undermine the province's environmental resilience and the livelihoods of its people.

2.3.1 Environmental Challenges

*a) **Climate Change and Natural Disasters***

- Erratic rainfall, prolonged droughts, and rising temperatures disrupt agriculture and rural livelihoods.
- Glacial retreat, permafrost melting and decreasing snow cover threaten downstream water security, increases the risk of glacial lake outburst floods (GLOFs), increasing debris flows and sediment mobilization.
- Frequent floods, landslides, and avalanches pose risks to settlements, infrastructure, and human lives.
- Marginalized and poor households are disproportionately vulnerable due to limited adaptive capacity.

b) Unplanned Urbanization and Infrastructure Expansion

- Rapid growth of Pokhara and other emerging municipalities has led to uncontrolled settlement sprawl.
- Encroachment of agricultural land and wetlands, unmanaged construction, and poor drainage increase disaster risks.
- Hydropower and road projects often lack adequate environmental safeguards, causing habitat fragmentation and slope instability.
- Growing air pollution, traffic congestion, and solid waste problems enhance public health issues in urban centers.

c) Degradation of Forests and Biodiversity

- Deforestation, illegal logging, and overharvesting of forest products continue despite community forestry successes.
- Habitat loss and fragmentation threaten wildlife, leading to human–wildlife conflicts.
- Invasive alien species and land-use change undermine ecosystem integrity.
- Pressures on protected areas such as Annapurna Conservation Area from tourism and infrastructure.
- Haphazard rural road constructions leading to forest fragmentation and biodiversity loss in hill forest areas.

d) Water Resource Depletion and Pollution

- Increasing demand for hydropower, irrigation, and urban water supply stresses river ecosystems.
- Pollution from untreated sewage, solid waste, and agricultural runoff degrades water quality.
- Over-extraction of groundwater and sand/gravel mining threatens long-term water security.
- Wetlands and lakes (Phewa, Begnas, Rupa) face eutrophication and sedimentation.
- Increased sediments reduce lake areas, fill up irrigation canals, settling basins and even damage hydropower turbines.

e) Unsustainable Agriculture and Land Use

- Slope cultivation and overuse of agrochemicals accelerate soil erosion and reduce fertility.
- Encroachment of farmland by urban expansion reduces agricultural productivity.

- Mono-cropping and declining soil fertility undermines food security.

f) Pollution and Waste Management

- Solid waste mismanagement, especially plastics, is a growing issue in urban and tourist hubs.
- Medical and e-waste lack proper disposal systems.
- Air pollution from vehicles, industries, and biomass burning is rising in valley settlements.

2.3.2. Environmental Opportunities

*a) **Sustainable Tourism and Ecotourism***

- Gandaki is Nepal's premier tourism destination (Pokhara, Annapurna Circuit, Manaslu, Manang, Mustang).
- Strong potential for eco-friendly tourism, homestays, and cultural tourism that promote local livelihoods while conserving nature.
- Development of green certification for hotels and trekking services can reduce environmental footprint.

b) ***Renewable Energy and Green Growth***

- Significant hydropower potential (both large and micro-hydro) can be harnessed sustainably with safeguards.
- Solar, and biogas have untapped potential for rural energy solutions including electrification for improved stoves and heating reducing indoor pollution
- Green jobs and green economy approaches (eco-tourism, forest-based enterprises, organic farming and renewable energy) can diversify livelihoods.

*c) **Forests and Community Stewardship***

- Nepal's successful community forestry model is strong in Gandaki, providing opportunities for carbon sequestration, REDD+, and sustainable forest-based enterprises.
- Potential to expand payment for ecosystem services (PES) in water catchments and eco-tourism landscapes.

*d) **Agriculture and Sustainable Practices***

- Opportunity to promote climate-smart, organic, and agroforestry practices that improve soil health and resilience.
- High-value crops (coffee, cardamom, herbs, horticulture) offer livelihood diversification while supporting conservation.

*e) **Policy and Institutional Innovation***

- The province has enacted its Environmental Conservation Act (2076) and Protection Rules (2079).
- There is an opportunity to strengthen environmental governance by aligning policies with the SoE findings.
- Integration of SDGs, NDCs, and provincial climate strategies can attract international support and financing.
- The Gandaki Province has formulated the health sector GESI Strategy (2009).

Chapter 3. Approaches and Methodology

3.1 Overall Approach

The SoE Report for Gandaki Province was prepared using a practical, evidence-based, and participatory approach suited to the provincial context of Nepal's federal system. The methodology was designed to ensure that the report is scientifically credible, institutionally grounded, and directly relevant to provincial planning and policy processes.

Rather than strictly applying a single international template, the assessment adopted established environmental assessment principles and adapted them to the realities of available data, institutional structures, and stakeholder engagement processes in Gandaki Province. The approach combines systematic evidence review, structured consultation, spatial analysis, and policy assessment to present a clear understanding of environmental trends, their drivers, and their implications.

The objective of the methodology was not only to describe environmental conditions, but also to explain why changes are occurring, how they affect livelihoods and development pathways, and what policy and institutional responses are required.

3.2 Conceptual and Analytical Orientation

3.2.1 Use of the DPSIR Framework

The Drivers–Pressures–State–Impacts–Responses (DPSIR) framework was adopted as the core analytical structure of the SoE (Carr et al., 2007; UNEP, 2002). This framework provides a logical way to connect socio-economic development processes with environmental change and policy response (**Figure 3-1**).

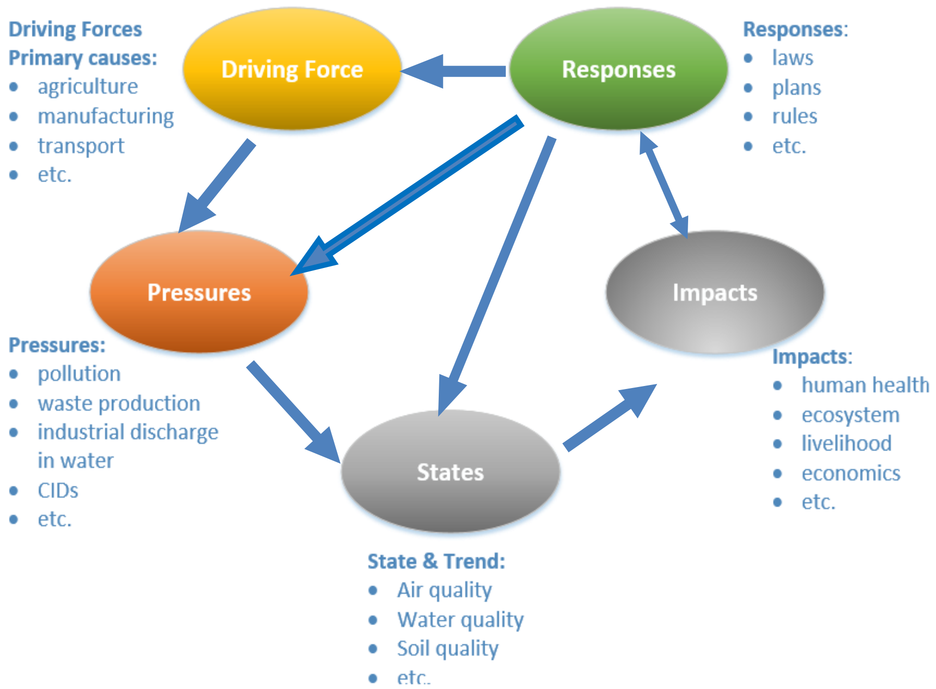


Figure 3-1. Typical DPSIR Model

Across all thematic sectors, the assessment examines:

- The underlying development of **drivers**
- The resulting environmental **pressures**

- The current **state** of environmental resources
- The ecological and socio-economic **impacts**
- The existing and potential **responses**

Using DPSIR ensured consistency across chapters and helped organize diverse information into a coherent narrative that is accessible to policymakers and planners.

3.2.2 Adapted Use of Integrated Environmental Assessment Principles

While the SoE draws inspiration from the principles of Integrated Environmental Assessment (IEA), it does not claim to follow the full procedural sequence of UNEP guidelines. Instead, selected IEA elements such as integration across sectors, policy relevance, stakeholder participation, and forward-looking analysis were incorporated in a manner appropriate to the provincial scale and scope of work.

This adaptive approach allowed the assessment to remain rigorous while being realistic about time, data, and institutional constraints.

3.3 Delineation of Thematic Environmental Sectors and Cross-Cutting Issues

3.3.1 Identification of the Seven Thematic Environmental Sectors

The selection of thematic sectors was guided by four main considerations:

1. Legal and policy mandates at federal and provincial levels
2. Ecological significance and geographic diversity of Gandaki Province
3. Development pressures affecting environmental systems
4. Availability of sufficient data to support meaningful analysis

Based on these criteria, seven core thematic environmental sectors were identified:

1. Atmosphere and Air Quality
2. Water Resources and Water Quality
3. Land Use, Soil, and Agriculture
4. Forests and Biodiversity
5. Energy and Industry
6. Urban Environment and Waste Management
7. Climate Change and Disaster Risk

Each of these sectors represents a major environmental system or pressure area relevant to the province's development trajectory. Together, they capture both natural resource conditions and emerging development-driven challenges.

3.3.2 Identification of Cross-Cutting Issues

Certain issues influence multiple environmental sectors and therefore were treated as cross-cutting rather than standalone themes.

- Gender Equality, and Social Inclusion (GESI) was integrated throughout the SoE to ensure that environmental risks, resource access, and adaptive capacities are examined from an equity perspective.
- Tourism was identified as a cross-cutting issue because it both depends on and affects forests, biodiversity, water resources, urban systems, and climate resilience.
- Migration was included due to its strong influence on land use patterns, rural livelihoods, urban expansion, consumption behavior, and remittance-driven development.

By treating these issues as cross-cutting, the SoE highlights the interconnected relationship between environment, society, and economic transformation.

3.4 Methodological Steps Followed in the SoE Preparation

3.4.1 Review of Secondary Sources

The process began with a comprehensive review of existing literature, policies, plans, sectoral reports, and scientific publications. This review established the baseline understanding of environmental trends, institutional mandates, and policy commitments relevant to Gandaki Province. It also helped identify data gaps and emerging issues requiring further exploration.

3.4.2 Stakeholder Consultation and Field Observation

Consultations were conducted with the Provincial Policy and Planning Commission, provincial ministries, District Coordination Committees, selected municipalities particularly district headquarters, and technical experts. These engagements validated documented information, clarified institutional perspectives, and brought forward locally observed environmental concerns. Field observations in selected areas further strengthened contextual understanding.

3.4.3 Data Collection from Reliable Sources

Data were collected from federal, provincial, and local government institutions, including the National Statistical Office, sectoral ministries and departments, and provincial agencies. Scientific publications and technical datasets were also used. All data were reviewed for consistency and relevance prior to analysis.

3.4.4 Use of GIS and Remote Sensing

GIS and remote sensing tools were applied to analyze land use change, urban expansion, spatial distribution of environmental pressures, and hazard-prone areas. Spatial analysis provided geographic context and supported comparative assessment across districts and physiographic regions.

3.4.5 Analysis and Thematic Synthesis

Using the DPSIR framework, data were analyzed to identify relationships between development drivers, environmental pressures, current environmental conditions, and their impacts. Emphasis was placed on producing an integrated narrative that links environmental trends with socio-economic transformation and governance structures.

3.4.6 Indicator Identification and Assessment

Indicators were selected for each thematic sector to describe baseline conditions, current state, and changes over time. Due to differences in data availability, baseline years vary across sectors. The report transparently acknowledges this limitation while prioritizing the best available evidence.

3.4.7 Institutional and Policy Analysis

A structured review of institutional arrangements, legal frameworks, and policy instruments was undertaken at both federal and provincial levels. This analysis assessed alignment, implementation gaps, and coordination challenges affecting environmental governance.

3.4.8 Development of Recommendations

Based on integrated analysis and critical review, strategic and practical recommendations were developed. These recommendations aim to strengthen environmental management, improve policy coherence, and support evidence-based planning at provincial and local levels.

3.5 Methodological Limitations and Future Improvements

While the methodology provides a robust and integrated assessment, certain limitations must be acknowledged. Data availability varies across sectors and over time, resulting in uneven baseline years and limited long-term trend analysis in some areas. Monitoring systems for certain environmental parameters remain underdeveloped at the provincial level. Inconsistencies in data reporting formats across institutions also present analytical challenges.

Future SoE reporting can be strengthened through the establishment of standardized provincial environmental monitoring systems, improved inter-institutional data collection and coordination, expanded spatial datasets, and regular updating of key environmental indicators. Strengthening local-level data systems will further enhance the accuracy and usefulness of future assessments.

Chapter 4. Socio-Economy

4.1 Introduction

Gandaki Province has a population of 2.47 million (CBS, 2021a) and recorded the lowest population growth rate in Nepal (0.25% per year during 2011–2021). At the same time, 65.8% of the population resides in urban municipalities, reflecting rapid urban concentration around Pokhara and other market centres, while many hill and mountain districts show stagnant or negative growth due to labour migration (CBS, 2021b). The CBS (2021b) reported that the average household size has declined to 3.72 persons, indicating demographic transition and changing consumption patterns.

From a human development perspective, Gandaki performs relatively well at the provincial level, with an HDI value of 0.618, second-highest among Nepal's provinces (UNDP, 2025). However, district-level disparities are pronounced. Urban and accessible districts such as Kaski exhibit higher income, education, and service access, while remote hill and mountain districts such as Gorkha, Myagdi, Manang, and Mustang face constraints related to economic diversification, service reach, and infrastructure. These disparities influence livelihood options and adaptive capacity to environmental and climate risks.

Livelihoods in Gandaki remain closely linked to natural resources. Although the service sector dominates provincial GDP, more than 50% of the economically active population is engaged in agriculture, forestry, and fisheries, particularly in hill districts. Tourism and hydropower are major economic drivers, but their benefits and pressures are spatially uneven, with concentrated impacts in urban centres and key tourism corridors.

District-level patterns of energy use further highlight environmental concerns. Despite high electrification rates (above 99%), fuelwood remains the dominant cooking energy source in several districts, particularly Gorkha, Myagdi, Baglung, Lamjung, and Parbat, where reliance on firewood is higher than the national average (NSO, 2024b; WECS, 2024). In contrast, districts such as Kaski and Mustang show much higher adoption of LPG and other clean fuels. Continued dependence on fuelwood in hill districts maintains pressure on forest resources, increases women's labour burden, and contributes to indoor air pollution, especially among poorer households and marginalized groups (WECS, 2022). Social composition adds another layer of vulnerability. Gandaki is home to large Janajati populations (notably Gurung and Magar communities) and Dalit groups, many of whom have historically faced limited access to land, secure livelihoods, and services (CBS, 2021b). These groups are more likely to depend on local forests, springs, and subsistence agriculture, increasing exposure to environmental degradation and climate-induced hazards.

In general, Gandaki Province is characterized by urban concentration, district-level inequality in human development, resource-dependent livelihoods, and uneven energy transition. These socio-economic conditions act as key drivers of environmental pressure and differential vulnerability across districts, shaping land-use change, forest dependence, water demand, and resilience to climate and disaster risks. This chapter analyzes these dynamics to support inclusive and environmentally sustainable development planning in the province.

4.1.1 Society and Culture

Gandaki Province is home to over 104 castes, more than 10 religions, and 72 mother tongues in Gandaki province (CBS, 2021b). The major caste/ethnicity populations (***Table 4-1***) include Brahmin (20.0 %), Magar (18.8 %), Chhetri (13.1 %), Gurung (11.0 %), and Bishwakarma 9.3 (%). According to CBS (2021b), the major languages spoken as the mother tongue in the province are Nepali, Magar, Gurung, and Bhojpuri. The major languages spoken are Nepali (73.39 %), Magar Dhut (9.6 %), Gurung (8.44 %), Tharu (1.74 %), Newari (1.53 %), and Tamang (1.36 %).

Table 4-1: Ethnic Distribution in Gandaki Province

Ethnic category	Number	Percent
Hill Caste	8,136,848	30
Mountain/Hill Janajati	7,067,292	26
Madhesh/Tarai Caste	4,222,087	16
Tarai Janajati	2,408,499	9
Hill Dalit	2,267,264	8
Madhesh/Tarai Dalit	1,231,429	5
Religious/Linguistic groups	1,251,623	5
Others, Foreigners & Not Stated	140,253	1
Total	**26,725,295**	**100**

Source: NSO, 2025

Religions like Hinduism, Buddhism, Islam, and Christianity influenced the cultural customs of the province. In this province, 82.22% of the population is Hindu. Buddhists are the largest minority population with 11.54 % of the population following Buddhism and Christianity is followed by 2.36% of the population in the province. Bon is practiced by 2.17% of the population, Islam by 0.91% and Prakriti by 0.67% (CBS, 2021a).

4.1.2 Demographic Features

Nepal's population stands at 29.16 million, with a sex ratio of 95.59 males per 100 females and an average density of 198 persons per sq.km, showing regional contrasts between the densely populated Terai and the thinly populated hill and mountain regions (CBS, 2021a). ***Table 4-2*** presents demographic indicators of Nepal and its provinces. Madhesh and Bagmati provinces have the largest populations, each exceeding 6.1 million, while Karnali has the smallest population at about 1.69 million. The sex ratio varies across provinces, measured males per 100 females with Madhesh (100.55) showing near parity, whereas Sudurpashchim (89.51) and Gandaki (90.37) have notably fewer males. Population density is highest in Madhesh (633 persons/sq.km), indicating high settlement concentration, and lowest in Karnali (60 persons/sq.km), reflecting sparse habitation due to mountainous terrain.

Table 4-2: Population and Sex-Ratio by Province

Province	Total Population	% of population	Male Population	Female Population	Total Households	Sex Ratio (Males per 100 Females)	Population Density (Persons/sq. km)
Koshi	4961412	17	2417328	2544084	1191556	95.02	192
Madhesh	6114600	21	3065751	3048849	1156715	100.55	633
Bagmati	6116866	21	3048684	3068182	1570927	99.36	301
Gandaki	**2466427**	**8**	**1170833**	**1295594**	**662480**	**90.37**	**115**
Lumbini	5122078	18	2454408	2667670	1141902	92.01	230
Karnali	1688412	6	823761	864651	366255	95.27	60
Sudur-pashchim	2694783	9	1272786	1421997	577102	89.51	138
Nepal	**29164578**	100	**14253551**	**14911027**	**6666937**	**95.59**	**198**

Source: NPHC, 2021

The "Population growth" figure shows a steady rise from 1911 to 2021, with a sharp surge beginning around 1971 due to improved public health and reduced mortality. While the population reached nearly 30 million by 2021, recent decades reveal a demographic shift Total Fertility Rate fell from 6.39 in the 1980s to 1.94

in 2021 (CBS, 2021a), leading to a drop-in annual growth rate from 1.35% in 2011 to 0.92% in 2021. These trends, drawn from the CBS (2021a), signal significant changes for future.

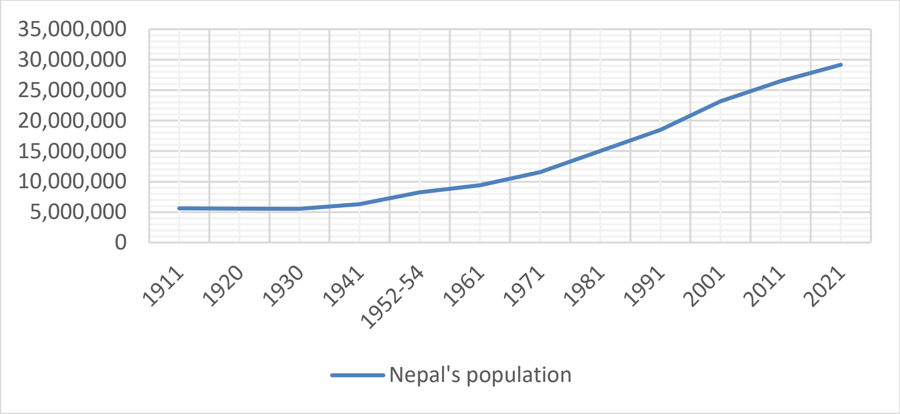


Figure 4-1: Population Growth of Nepal

The population in 1991 was 1,968,233, which increased to 2,316,702 in 2001, showing a compound annual growth rate (CAGR) of 1.64%. From 2001 to 2011, the population grew from 2,316,702 to 2,403,757, reflecting a much slower growth of 0.37%. The population further increased to 2,466,427 by 2021, but at an even slower pace, with a growth rate of 0.25% over the 2011-2021 period (CBS, 2021a). This data highlights a declining growth rate in the province over the last three decades.

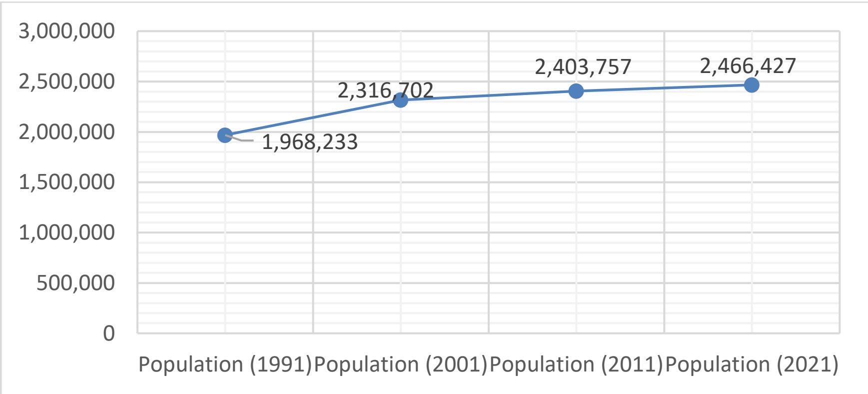


Figure 4-2: Population Growth of Gandaki Province[2]

Among the 85 Palikas in Gandaki, Kawasoti Municipality experienced the highest growth rate (3.17%), while Rhishing Rural Municipality experienced the lowest growth rate (-3.52%) during the period. Out of eighty-five Palikas, sixty-six Palikas had a negative growth rate and nineteen Palikas had a positive growth rate (CBS, 2021b) while eleven Palikas had an average annual growth rate greater than the national average annual growth rate (0.92%).

Table 4-3: Population Growth Rate by Province, Nepal, 2011-2021

Province	Average Annual Growth Rate of Population
	2011-2021
Nepal	0.92
Koshi	0.86

[2] https://www.citypopulation.de/en/nepal/admin/

Province	Average Annual Growth Rate of Population
	2011-2021
Madhesh	1.19
Bagmati	0.97
Gandaki	**0.25**
Lumbini	1.24
Karnali	0.70
Sudur Paschim	0.52

Source: NPHC, 2021

According to CBS (2021a) Lumbini and Madhesh had the highest growth rates at 1.24% and 1.19% respectively, indicating higher population expansion. In contrast, Gandaki recorded the lowest rate at 0.25%, suggesting slower demographic change. Other provinces like Bagmati (0.97%), Koshi (0.86%), Karnali (0.70%), and Sudur Paschim (0.52%) showed moderate growth. These differences reflect regional disparities in fertility, migration, and development dynamics.

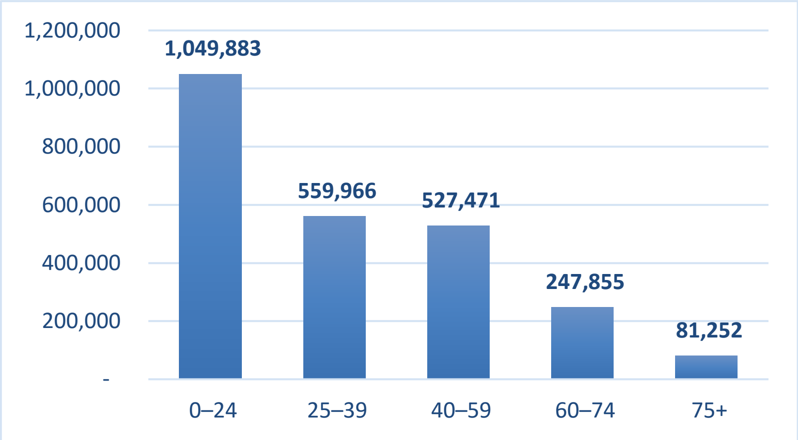


Figure 4-3: Population by Age Group in Gandaki Province

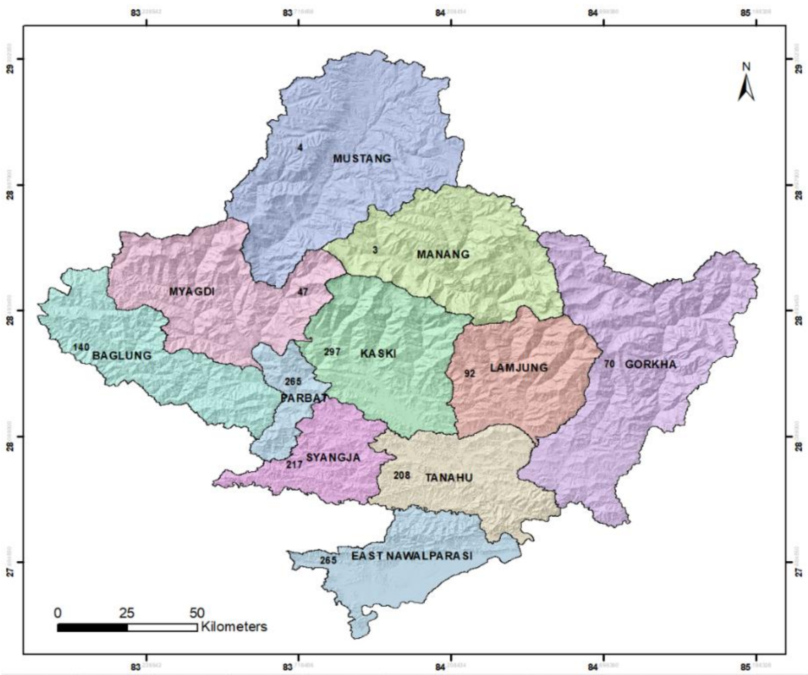


Figure 4-4. Population Density Map of Gandaki Province (the nos shows the population density, Unit person/km^2)

Figure *4-3* shows a population across all age groups in Gandaki province (CBS, 2021b). Figure shows the breakdown of the population by different age groups. The population is mainly young, with the 0-24 age group being the largest, at over 1 million. This indicates a large, youthful population that will need plenty of support in terms of education, healthcare, and job opportunities as they grow older. The 25-39 and 40-59 age groups are also significant, showing a workforce that requires attention in terms of career development, healthcare, and financial stability. While the elderly population (60-74 and 75+) is smaller, it will become more important as life expectancy increases.

Household and Household Size

Nepal has about 6.67 million households, with an average household size of 4.37 persons (CBS, 2021a). On average, each house accommodates 1.23 households (each house is shared by more than one household) and 5.38 persons per house. Madhesh has the largest household size (5.29) and the highest persons per house (6.66), reflecting larger family structures and more households sharing a single house. Bagmati shows the smallest household size (3.89) but the highest households per house (1.39), indicating smaller families but more nuclear households living in the same building i.e. urban housing concentration in urban areas like Kathmandu. Gandaki also has a relatively small household size (3.72) and fewer persons per house (4.49), indicating smaller family units (CBS, 2021b).

Table 4-4: Distribution of House, Household and Average Household Size

Province	Number of Household	Average household size	Average household per house	Average person per house
Nepal	**6,666,937**	**4.37**	**1.23**	**5.38**
Koshi	1,191,556	4.16	1.14	4.76
Madhesh	1,156,715	5.29	1.26	6.66
Bagmati	1,570,927	3.89	1.39	5.42
Gandaki	**662,480**	**3.72**	**1.20**	**4.49**
Lumbini	1,141,902	4.49	1.18	5.28
Karnali	366,255	4.61	1.14	5.27
Sudurpaschim	577,102	4.67	1.17	5.47

Source: NPHC, 2021

The average household size trend shows a consistent decline in average household size in both Gandaki Province and Nepal from 2001 to 2021 (***Figure 4-5***). Gandaki has consistently had smaller household sizes compared to the national average, with the gap widening over time. This trend reflects broader demographic changes, including urbanization, economic factors, and shifting family structures, leading to smaller family units in the region.

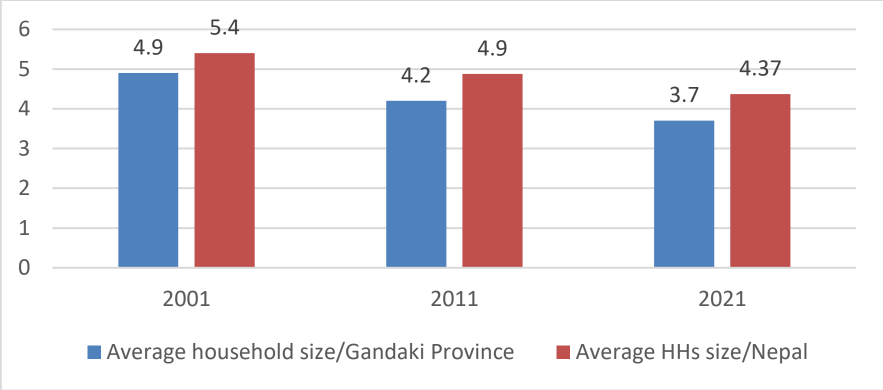


Figure 4-5: Average Household Size Trend

4.2 Social Conditions

4.2.1 Household Basic Utility Services

Access to basic household utility services such as safe drinking water, sanitation, electricity, clean cooking fuel, and waste management shapes the everyday lived experience of people in Gandaki Province and directly influences environmental conditions. These services sit at the intersection of social wellbeing and ecological sustainability: they determine health outcomes, reduce drudgery (especially for women), influence migration decisions, and affect pressure on forests, rivers, and air quality. While Gandaki has made notable progress in expanding electricity access and improving sanitation coverage, disparities persist across districts, rural–urban locations, and socio-economic groups. Understanding who has access, how services are delivered, and what environmental trade-offs are involved is essential for assessing both human development and the province's environmental trajectory.

Drinking water

Drinking water access across Nepal's provinces varies and so in the province. Among the provinces, Gandaki and Bagmati (**Table 4-5**) have high use of tap/piped water (52% and 44% within premises). Madhesh, Koshi and Sudur Paschim rely more on tubewells/handpumps (72%, 40% and 37%). Lumbini and Karnali use tap water within premises (38% and 36%) followed by Koshi (34%) and Sudurpaschim (21%). Karnali notably uses spout water (13%) followed by Gandaki (7%) and Sudurpaschim (6%).

Table 4-5: Percentage Distribution of HHs Using Main Sources of Drinking Water (in %)

Name of Province	Tap/piped water (within premises)	Tap/piped water (outside premises)	Tubewell/handpump	Covered well/kuwa	Uncovered well/kuwa	Spout water*	River/stream	Jar/bottle	Other
Nepal	35	22	30	2	2	4	0	5	1
Koshi	34	20	40	1	2	2	0	0	0
Madhesh	15	7	72	1	2	1	0	0	1
Bagmati	44	24	5	2	3	4	0	17	1
Gandaki	**52**	**33**	**2**	**1**	**2**	**7**	**0**	**3**	**0**
Lumbini	38	20	33	3	2	3	0	1	1
Karnali	36	44	0	2	3	13	1	0	0
Sudur Paschim	21	32	37	1	1	6	1	0	0

Source: NPHC, 2021

Figure 4-6 illustrates the percentage of basic drinking water sources across various regions of Nepal. Koshi and Madhesh have the highest percentages at 95.64% and 95.33%, respectively. Overall, Nepal's national average stands at 92.90%, while Gandaki have 90.92 % showing a percentage of basic water sources, though some areas, like Karnali, still lag behind with 82.72% of basic drinking water by source.

Among Kaski and Lamjung districts, 66% households relied on tap/piped water (within premises) followed by Manang district (63%). In Nawalparasi (East), 60% of households used tap/piped water (within premises). Other districts like Myagdi (36%) and Gorkha (40%) also had significant reliance on this source. Baglung appears to have the poorest access to drinking water, as 31% of households rely on tap/piped water (within premises), which typically indicates less convenient access to water. Tubewell/handpump usage was recorded at 11% in Nawalparasi (East). Overall, while tap/piped water remains the dominant source, other water sources like spouts, rivers, and tubewells also play significant roles in different regions.

Figure 4-6: Percentage of HHs Using Basic Drinking Water by Source

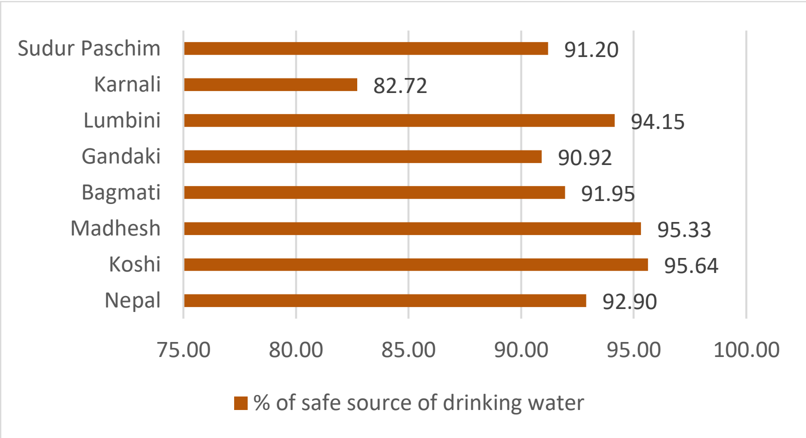


Table 4-6: District Wise Water Use (in %)

Area	Tap/piped water (within premises)	Tap/piped water (outside premises)	Tubewell/handpump	Covered well	Uncovered well	Spout water	River stream	Jar/bottle	Other
Myagdi	36	55	0	0	0	8	0	0	0
Kaski	66	16	0	0	1	5	0	12	0
Lamjung	66	25	0	0	1	6	1	0	0
Tanahu	52	34	0	2	4	6	0	1	0
Nawalparasi (East)	60	20	11	4	2	2	0	0	0
Syangja	42	47	0	1	1	8	0	0	0
Parbat	53	41	0	0	1	5	0	0	0
Baglung	31	61	0	0	1	6	0	1	0
Gorkha	40	37	0	1	2	20	0	0	0
Manang	63	35	0	0	0	2	0	0	0
Mustang	56	34	0	1	0	5	3	0	0

Source: Based on NPHC, 2021b

Households by Toilet Facilities

The 2021 census (CBS, 2021b) have recorded a large increase in access to toilet facilities compared to 2001, 2011 censuses (Table 4-7). Households with flush toilets increased from 23.0 % in 2001 to almost two-thirds (64.9%) by 2021. This progress has led to a large decrease in the number of households relying on squat/ordinary/pit toilets − decreasing from 53 percent of households in 2001 to only around 30 percent by 2021.

Table 4-7: Households by Toilet Facilities (in %)

Name of Province	Flush toilet using Households (%)	Ordinary toilet	Public toilet	% of HHS Without toilet facility
Nepal	64.9	30.1	0.5	4.5
Koshi	63.2	33.1	0.5	3.2
Madhesh	38.5	48.6	0.9	12.0
Bagmati	82.3	16.2	0.3	1.2
Gandaki	**78.6**	**20.1**	**0.3**	**1.0**
Lumbini	62.6	31.4	0.4	5.6
Karnali	62.4	34.6	0.4	2.6
Sudur Paschim	64.1	30.9	0.6	4.4

Source: NPHC, 2021

Table 4-7 highlights the variations in toilet facilities and access to sanitation across the provinces of Nepal. In overall country, 64.9% of households use flush toilets, while 30.1% rely on ordinary toilets and 0.5% have access to public toilets. Despite this, 4.5% of households still lack toilet facilities. Bagmati stands out with 82.3% of households using flush toilets, the highest among the provinces followed by Gandaki province with 78.6%. On the contrary, Madhesh has the highest percentage (12%) of households without toilets, and it also has the largest proportion (48.6%) of households using ordinary toilets.

Table 4-8 shows the percentage of households using flush toilets in 11 districts of Gandaki province, highlighting notable differences in sanitation access. Districts like Kaski and Manang have the highest usage rates, with 91.31% and 95.93% of households using flush toilets, respectively, indicating better sanitation infrastructure. Similarly, Lamjung, Syangja, and Gorkha, also have relatively high flush toilet usage, with percentages of 79.33%, 76.81% and to 76.82% respectively. However, districts like Parbat (53.68%) show lower adoption of flush toilets, suggesting a need for improvements in sanitation facilities in these areas.

Table 4-8: District-wise Access to Toilet (in %)

Districts	Flush toilet using Households (%)
Myagdi	74.37
Kaski	91.31
Lamjung	79.33
Tanahu	74.02
Nawalparasi (East)	74.36
Syangja	76.81
Parbat	53.68
Baglung	76.4
Gorkha	76.82
Manang	95.93
Mustang	74.79

Source: NPHC, 2021b

4.3 Electricity

Hydropower has been recognized as a sustainable source of energy in Nepal's context. Nepal's huge potential in hydropower is still untapped. The available water resources and altitudinal topography provide the ideal situation for the generation of hydropower. Nepal, since about the century ago had started to generate hydro energy but its development over the time is sluggish and importing fossil-based fuel significantly. Replacement of imported fossil fuel by its self-reliant hydro energy is very urgent action to be adopted but it's quite challenging. The socioeconomic transformation of country by utilizing its own generated energy is the most effective way to gear toward the path of prosperity.

The total electricity production for Nepal, including non-grid sources, is 3,345 Megawatts, with 99.5% of the population having access to electricity[3]. In 2024/25, Nepal's electricity production across its provinces varies significantly, with Bagmati leading at 1,588 Megawatts, followed by Gandaki at 1,002 Megawatts. The province with the highest percentage of the population accessing electricity from the national grid is Madhesh, at 100%, while Karnali has the lowest at 73.4%. Other provinces such as Koshi, Lumbini, and Sudurpashchim have access rates of over 98%, while Bagmati also boasts near-total access at 99.97%.

Table 4-9: Electricity Production and Population with Access to Electricity (2024/25)

Province	Electricity Production (in Megawatt) (2024/25)	Provincial population with access to electricity from the national transmission grid (in %) (2024/25)
Koshi	631	99.3
Madhesh	35	100
Bagmati	1588	99.97
Gandaki	**1,002**	**99.5**
Lumbini	78	98.5
Karnali	11	73.4
Sudurpashchim	167	86.6
Nepal (along with	3,345	99

Source: Ministry of Energy, Water Resources and Irrigation, 2024

In Gandaki Province, 99.40 percent of electrification has been achieved by year 2023. Among its districts, full electrification has been completed only in Parbat, Syangja, Kaski, and Tanahun districts. Nawalpur has achieved 99.36 percent electrification, Baglung 99.96 percent, Myagdi 99.70 percent, Mustang 99.98 percent, Lamjung 99.99 percent, and Gorkha 95.64 percent. In Gandaki Province, the Chumanubri Rural Municipality of Gorkha district and Narfu Rural Municipality of Manang district have yet to be connected to the national transmission line. Manang has the lowest electrification rate in Gandaki Province, by 87.81 percent. However, these areas rely on electricity generated from small hydropower projects, solar energy, and other alternative sources outside the national grid (NEA, 2025).

Lighting Sources

In Nepal, a significant majority of households have access to clean lighting sources, with a national average of 98.8%. The province of Bagmati stands out with the highest percentage, at 99.7%, followed by Gandaki at 99.5%. Other provinces such as Madhesh and Koshi also show high levels of clean lighting access, at 98.8% and 98.7%, respectively. Karnali and Sudurpashchim, however, have lower percentages at 97.57% and 97.62%, indicating relatively fewer households with access to clean lighting. The most common clean lighting source across the country is electricity, followed by solar power, with kerosene usage being minimal.

Table 4-10: Households by Type of Lighting Facilities (in %)

Name of Province	Electricity	Solar	Kerosene	Biogas	Other	Clean Source of Lighting
Nepal	92.2	6.6	0.6	0.0	0.6	98.8

[3] Out of the total installed capacity, 3,336 MW comes from hydropower, 175 MW from solar energy, 90 MW from micro-hydropower, 53.4 MW from thermal plants, and 6 MW from electricity co-generated in sugar mills (Economic survey, 2024).

Name of Province	Electricity	Solar	Kerosene	Biogas	Other	Clean Source of Lighting
Koshi	93.7	5.0	0.8	0.0	0.4	98.7
Madhesh	97.9	0.8	0.9	0.1	0.3	98.8
Bagmati	97.3	2.3	0.1	0.0	0.2	99.7
Gandaki	**97.6**	**1.9**	**0.2**	**0.0**	**0.2**	**99.5**
Lumbini	93.7	4.5	1.0	0.0	0.8	98.1
Karnali	49.6	47.9	0.5	0.0	1.9	97.6
Sudurpashchim	81.3	16.3	0.3	0.0	2.1	97.6

Source: NPHC, 2021

Bagmati province leads in clean cooking fuel usage, with 71.1% of households using clean fuels, followed by Gandaki at 52.7%. Other provinces, such as Lumbini (44.1%) and Koshi (43%), show moderate adoption rates. In contrast, Madhesh (30.2%) and Sudurpaschim (29.5%) have relatively lower percentages, while Karnali has the lowest, with just 17.4% of households using clean energy. The provinces with the highest reliance on wood as a fuel source are Karnali (82.2%) and Sudurpashchim (70.3%), while Bagmati has a much lower dependency at 29%. LPG usage is highest in Bagmati (69.8%), followed by Gandaki (51.5%), while it is much lower in Karnali (16.9%) and Sudurpashchim (25.8%). Electricity usage is minimal across all provinces, with the highest at 0.8% in Madhesh.

The graph highlights a significant shift towards electricity as the primary lighting source in Nepal, with its share rising from 39.8% in year 2001 to 92.2% in year 2021. In contrast, reliance on kerosene dropped sharply from 57.7% in 2001 to just 0.6% in 2021. Solar lighting represented a modest increase, rising from virtually non-existent in 2001 to 6.6% by 2021. The use of biogas remained minimal over the years and likely had no significant role in lighting by 2021. This trend reflects Nepal's rapid electrification and a clear decline in the use of traditional fuels like kerosene, large electrification through grid programme.

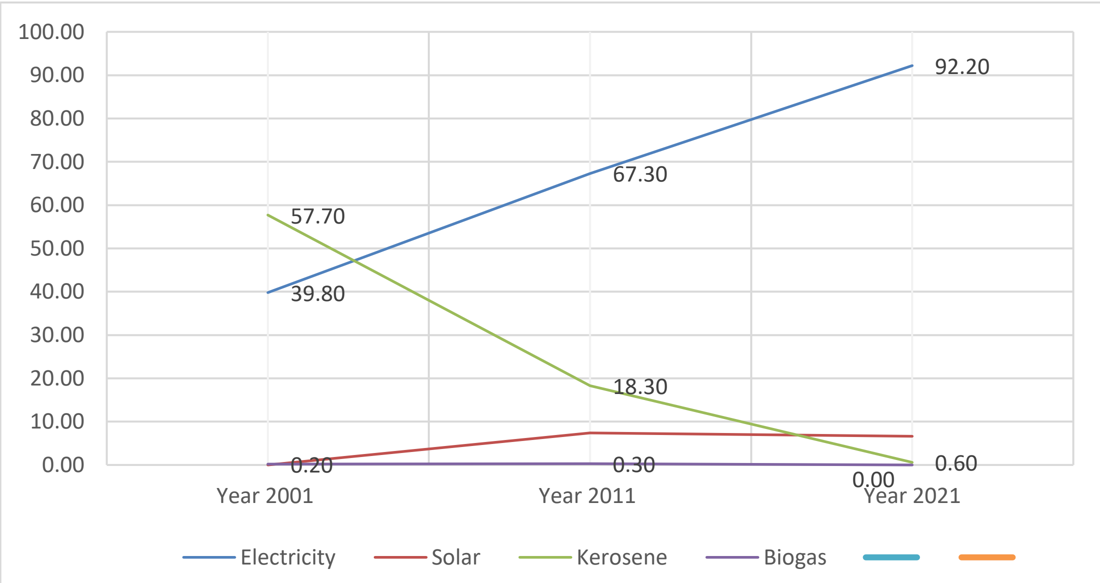


Figure 4-7: Proportion of Households by Main Source of Lighting, 2001−2021

Cooking Fuels

The main types of cooking fuel in Nepal are firewood, kerosene, LP gas, biogas, and cow dung. Other sources include leaves, straw, and thatch. The 2021 census found that firewood remained the most widely used cooking fuel. It causes indoor air pollution that has detrimental effects on health. Almost 50 percent of households used mostly firewood as their main type of cooking while about 45 percent used liquefied petroleum gas (LPG). The majority of households in Karnali (82%) used firewood as cooking fuel followed by Sudurpaschim (70.3%) and Madhesh (58.6%). Cow dung was used for cooking by over 10 percent of Madhesh households.

Table 4-11 :Cooking Sources

Fuel-types	Nepal	Koshi	Madhesh	Bagmati	Gandaki	Lumbini	Karnali	Sudurpaschim
Wood (%)	51.0	53.4	58.6	29.0	**47.1**	53.7	82.2	70.3
Liquefied Petroleum Gas (%)	44.3	41.2	28.7	69.8	**51.5**	42.2	16.9	25.8
Electricity (%)	0.5	0.5	0.8	0.6	**0.2**	0.4	0.1	0.3
Cow Dung (%)	2.9	3.4	10.9	0.0	**0.0**	2.1	0.1	0.1
Biogas (%)	1.2	1.3	0.7	0.6	**1.0**	1.5	0.4	3.4
Kerosene (%)	0.0	0.0	0.0	0.0	**0.0**	0.1	0.2	0.0
Other (%)	0.1	0.2	0.2	0.0	**0.0**	0.1	0.1	0.1
Clean Cooking Fuel (%)	46.0	43.0	30.2	71.1	**52.7**	44.1	17.4	29.5

Source: NPHC,2021

However, between 2011 and 2021, there was a significant decline in wood/firewood and kerosene usage across most districts, notably in Gorkha and Manang. LPG adoption surged, especially in Mustang and Kaski, while cow dung usage sharply decreased, particularly in Tanahu and Baglung. However, there is increased in used of cow dung reported by 3% and Biogas by 9% in Mustang between 2001 to 2021. The use of electricity for cooking increased significantly besides Mustang and Syangja. This may be due to low of rice cooker due to easy availability of LPG use.

Table 4-12: Decadal Changes in Cooking Energy Sources Across Districts (2011 - 2021)

Districts	Wood / Firewood	Kerosene	LP Gas	Cow Dung	Biogas	Electricity	Others
Gorkha	-20.4	-0.2	23.2	0	-2.2	0.1	-0.5
Manang	-29.5	0	27.7	0	1.9	0.1	-0.1
Mustang	-20.5	-1.5	36	3.1	9	-0.6	-0.5
Myagdi	-13.1	-0.2	13.6	0	-0.1	0.1	-0.3
Kaski	-16.4	-1.3	22.1	0	-3.9	0.1	-0.6
Lamjung	-17.5	-0.4	26.8	-0.1	-8.7	0.2	-0.4
Tanahu	-23.3	-0.4	31.5	-0.1	-7.3	0.1	-0.6
Nawalparasi	-35.7	-0.5	45.8	-5.3	-3.6	0.2	-1
Syangja	-16.4	-0.4	18.7	0	-1.5	-0.1	-0.3
Parbat	-14.2	-0.4	14.9	0	-0.2	0	-0.3

Baglung	-10.4	-0.2	11.1	0	-0.1	0.1	-0.5

Source: Based on NPHC,2021 and NPHC, 2011

Although these changes highlight a clear shift toward cleaner, more sustainable energy sources due to improved infrastructure and government efforts. The use of wood as cooking fuel remains higher than the national average (51%) in districts including Gorkha, Manang, Myagdi, Syangja, Parbat, Baglung, and Lamjung.

According to the NSO (2024b), nearly three-quarters of households use solid fuels as their primary energy source for cooking while more than a quarter use liquid petroleum gas (LPG). More than 50% of households have still wood (51%) for cooking. The proposed targets for 2030 include 10 percent of households using firewood for cooking.

4.4 Occupation

Recent trends in Nepal indicate a gradual decline in the agricultural sector, with the non-agricultural sector increasingly taking a more prominent role. A key factor driving this shift is the substantial employment of Nepalese workers abroad. This reflects in Province level too.

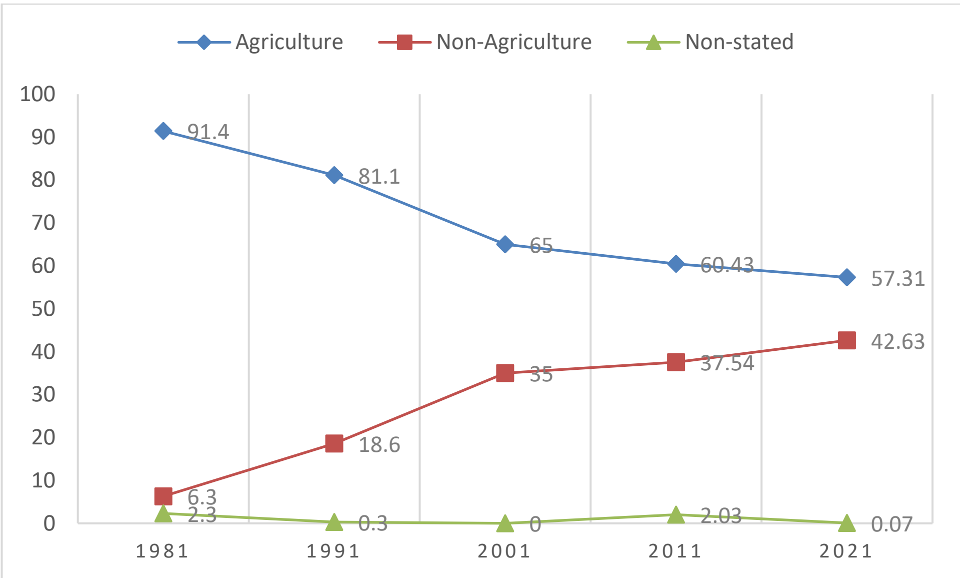


Figure 4-8: Trend of Nepalese Population by Sector

Out of 2,095,474 population aged 10 years or above residing in Gandaki 1,376,396 persons (65.7 percent) were classified as economically active and 693,053 persons (33.1 percent) not economically active while 26,025 (1.24%) persons did not report their status. Among 1,320,194 persons engaged in any economic activity during the reference period, highest share of people (51.62%) is in agriculture, forestry and fishery skilled workers, second largest share is elementary workers (19.20%) followed by managers (7.03%), service and sales workers (5.77%), crafts and trade workers (5.16%), professionals (4.31%), plant and machine operators (2.85%), technician and associate professionals (1.76%), office assistants (1.33%) and armed force (0.73%) respectively (CBS, 2021b).

Table 4-13: Gandaki Province Population with Economic Activity in Last 12 Months by Major Occupation and Gender

Occupation	% of Population Engaged	Male	Female	Total
Agriculture, forestry and fishery skilled	51.62	21.65	29.97	681,475
Elementary workers	19.20	8.08	11.11	253,463

Occupation	% of Population Engaged	Male	Female	Total
Managers	7.03	4.31	2.72	92,825
Service and sale workers	5.77	3.18	2.59	76,142
Craft and related trade workers	5.16	4.14	1.02	68,150
Professionals	4.31	2.24	2.08	56,934
Plants and machineries operators &	2.85	2.71	0.13	37,611
Technicals and associate professional	1.76	1.02	0.74	23,250
Office assistance	1.33	0.64	0.69	17,529
Armed forces	0.73	0.68	0.05	9,597
Not stated	0.24	0.12	0.12	3,218
Total	**100.00**	**48.76**	**51.24**	**1,320,194**

Source: NPHC, Gandaki Province (2021)

4.5 Education

Nepal has clearly articulated constitutional provisions guaranteeing the right to free and compulsory basic education. Community schools receive regular government grants, whereas institutional schools are funded by school's own or other non-governmental sources. Likewise, the Sustainable Development Goals (SDGs) for 2030 set ambitious targets through a transformative framework for achieving inclusive, equitable, and quality education, in line with SDG 4. Several studies show notable progress in increasing literacy rates, school enrolment, and vocational training opportunities. However, challenges persist, including regional disparities, gender inequalities, inadequate teacher training, weak public–private partnerships, and limited digital infrastructure.

The ***Table 4-14*** below presents provincial literacy rates in Nepal, showing significant gender disparities. Koshi has the highest literacy rate at 79.7%, while Madhesh has the lowest at 63.5%. Overall, male literacy rates are higher than female rates across all provinces, with notable gaps in Madhesh and Karnali. Bagmati and Gandaki have relatively high literacy rates for both genders, while Lumbini, Karnali, and Sudurpashchim show lower female literacy compared to males. However, overall literacy rate of Nepal is 76.2 percent; with male literacy rate is 83.6 percent compared to female literacy rate is 69.4 percent of the country.

Table 4-14: Provincial Literacy Rate

Provinces	Male	Female	Total
Nepal	83.6	69.4	76.3
Koshi	86.1	73.6	79.7
Madhesh	72.5	54.7	63.5
Bagmati	88.3	76	82.1
Gandaki	**88.8**	**75.3**	**81.7**
Lumbini	85.2	71.7	78.1
Karnali	83.3	69.4	76.1

Sudurpashchim	85.4	68.2	76.2

Source: NPHC, 2021

Literary rate of Nepal stood at 54.1 in 2001, the value, showing a modest figure. By 2011, it had increased to 65.9, reflecting steady progress. However, the most notable rise occurred between 2011 and 2021, where the value surged to 76.2, indicating a significant improvement over the last decade.

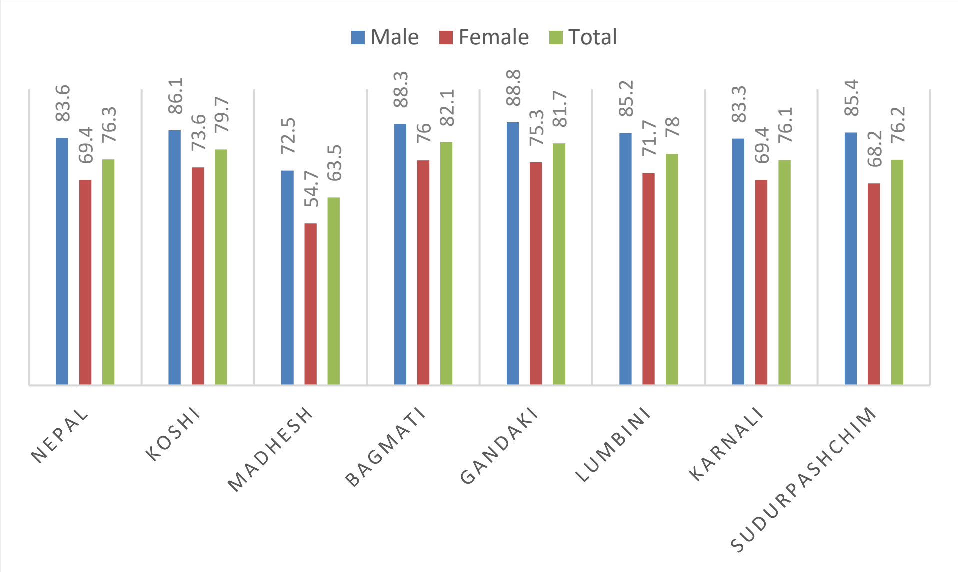


Figure 4-9: Literacy Rate by Provinces

4.5.1 School Completion Rate

Nepal has a high primary completion rate at 82% but completion rates decline steeply for lower and upper secondary education, with 73% completing lower secondary and only 27% completing upper secondary. Among children not completing primary, the majority are in Madhesh and Lumbini Province. At the primary level, Gandaki Province has the lowest out of school children rate and Lumbini Province has the largest (UNICEF Nepal, 2022).

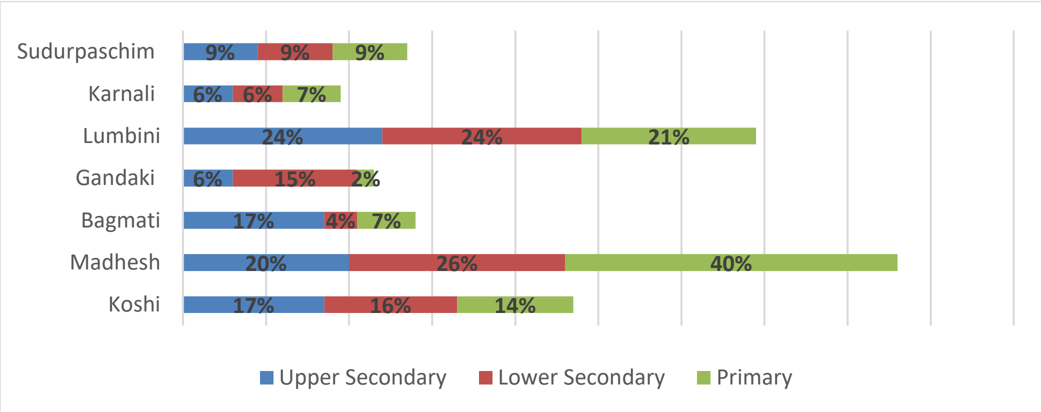


Figure 4-10: Profile of Children Who Do Not Complete School, by Province

4.5.2 Numbers of Schools by Province Level

Nepal has a total of 45,898 schools, combining community and institutional schools across all levels. Bagmati Province has the highest number of schools (9,036), followed by Lumbini with 8,523 and Koshi with 6,949. Madhesh has 6,433 schools, while Gandaki, Karnali and Sudurpashchim have 5,110, 4,982 and 4,875 schools respectively.

The Environment Education (EE) in school education of Nepal has been started teaching before 1973. EE, which has been teaching as a compulsory subject in both grades 9 and 10 since academic years 1998/99 and 1999/2000, respectively. The EE has been providing in both Basic and Secondary Educations of Nepal and exposing the young to the information and issues of the environment and its development so that students are beings conscious, enthusiastic, and active for the protection of the environment in and around their localities.

Table 4-15: Numbers of Schools by Province Level

Province/ level	Basic Level (1-5)		Basic level (6-8)		Secondary School (9-10)		Higher Secondary School (11-12)		Total
	Community	Institutional	Community	Institutional	Community	Institutional	Community	Institutional	
Koshi	2022	595	1553	484	1158	455	454	228	6949
Madhesh	2057	412	1574	334	1159	308	425	164	6433
Bagmati	2322	1171	1736	915	1155	737	556	444	9036
Gandaki	**1713**	**249**	**1315**	**239**	**882**	**214**	**317**	**181**	**5110**
Lumbini	2943	417	2116	368	1608	327	535	209	8523
Karnali	1915	129	1387	125	978	107	255	86	4982
Sudurpaschim	1765	176	1316	171	922	150	284	91	4875
Nepal	**14737**	**3149**	**10997**	**2636**	**7852**	**2298**	**2826**	**1403**	**45898**

Source: Ministry of Education, Science & Technology, 2024

According to the Ministry of Education, Science and Technology (MoSTE, 2024) Nepal has a total of 6,827,000 students by province, out of which Madhesh has the largest share of students (25%), followed by Bagmati (19%), Lumbini (18%), and Koshi (13%). Gandaki, Karnali, and Sudurpaschim each have about 8–9% of the total students. In almost all levels, the number of female students is slightly lower than male students in Gandaki province (**Table 4-16**).

Table 4-16: Number of School Students in Gandaki Province (in '000)

Education Level/Sex in Gandaki Province	Number (in '000)
Basic Level (Grades 1–5)	
Male	143
Female	135
Total	278
Basic Level (Grades 6-8)	
Male	84
Female	83
Total	167
Secondary Level (9-10)	

Education Level/Sex in Gandaki Province	Number (in '000)
Male	41
Female	40
Total	81
Secondary Level (11-12)	
Male	34
Female	33
Total	67
Overall total	**593**

Source: Ministry of Education, Science & Technology, 2024

Follwoing ***Figure 4-11*** illustrates the student per school across various provinces in Nepal, measured by the number of students. Madhesh has the highest student ratio per school, with 261 students per school, significantly higher than country load (149 students), Lumbini (145 students), and Bagmati (142 students). The other regions, such as Koshi, Sudurpashchim, Gandaki, and Karnali show relatively lower student loads, with Karnali having least at 103 students per school.

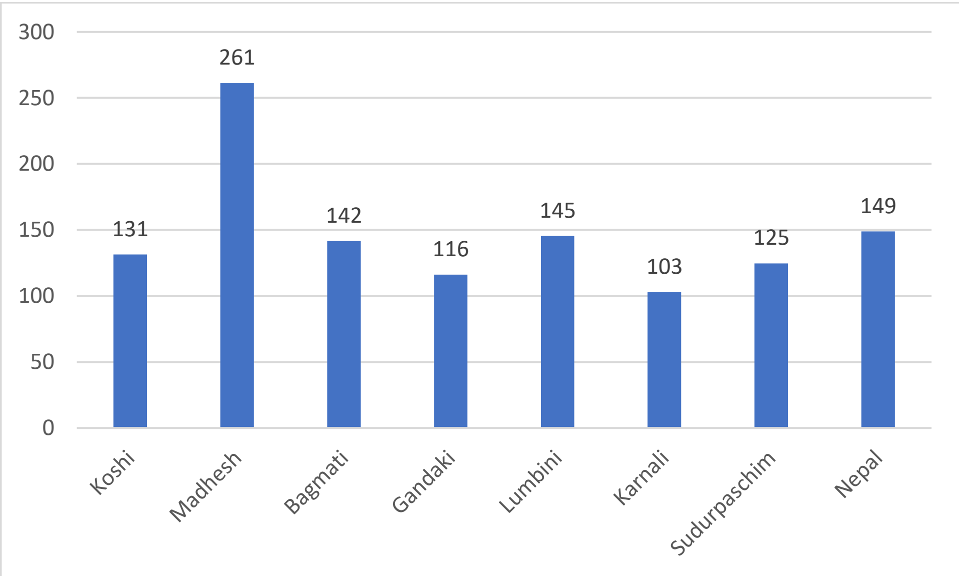


Figure 4-11: Student Ratio Per School (in number)

4.5.3 Technical Education and Vocational Training Institution

In Gandaki, Technical Education and Vocational Training (TVET) provision is mainly led by 124 CTEVT-affiliated schools, indicating strong alignment with the national CTEVT framework. The province also has 8 CTEVT constituent schools. Technical Education in Community Schools (55 TECS) help expand local access by integrating technical programs into public schools, while 53 private TVET institutions highlight the role of the private sector in skills training.

Table 4-17: Number of TVET Schools by Types

School Category	Count in Gandaki Province
CTEVT-affiliated schools	**124**
Constituent schools	**8**
Technical Education in Community Schools (TECS)	**55**
Private schools	**53**

Source: Ministry of Education, Science & Technology, 2022

The province offered about 339 TVET programs with an enrollment capacity of roughly 14,500 students. However, only around 8,000 students were actually enrolled, which suggests that many training seats remain vacant. Engineering programs attract the highest number of students, followed by agriculture and health-related courses. Access to TVET education is fairly widespread, with nearly three-quarters of local levels having at least one TVET institution.

Table 4-18: TVET Enrollment Capacity and Utilization in Gandaki Province

Indicator	TVET Program and Enrollment Overview
TVET schools/institutes	**339** total programs offered in the province (Out of 2,543 programs)
Enrollment capacity (total)	**14,562** (of 107,411 nationwide)
Share of national enrollment	Around 13.6%
Actual enrollments	7,956 students
Actual fill rate	55% of the enrollment capacity
Enrollment capacity (program	Pre-Diploma: 4,344, Diploma: 6,234, Technical stream: 3,984
Sector breakdown (approx):	Engineering: 4,778, Agriculture: 1,674, Health: 1,499, Forestry: 47

Source: MoEST (2022)

Female participation is relatively strong at about 45 percent, slightly higher than the national average. Although many institutions provide internships or on-the-job training through industry linkages, business involvement in school management is still limited, indicating the need for closer cooperation between training providers and employers.

4.5.4 Higher Education

Gandaki Province has three universities, 17 constituent campuses, 83 community colleges, and 52 private colleges, making a total of 152 higher education institutions. Approximately 39,185 students were enrolled in the academic year 2024/25.

4.6 Disability Population

In Nepal about 205,555 (or 3.1%) of all the 6.7 million households reported having at least one member with disability (CBS, 2021b). The proportion of such households varied from 4.6 percent of Karnali to 2.2 percent of Madhesh households, from 4.3 percent of Mountain to 2.7 percent of Tarai households and 3.9 percent of urban and 2.7 percent of rural municipality households. About 1.94 percent of the population have one or more types of disabilities. In Gandaki about 1.53 percent of the population lives with a disability (53% are males and 47% are females), which is below the national average (CBS, 2021b). District-wise, Gorkha has the highest number of households, with 3,536 households, making up 4.9% of the total. Manang, on the other hand, has the lowest number, with just 103 households, but its percentage stands at 6.6%. Other districts like Kaski and Myagdi show moderate household numbers and percentages, with Kaski having 4,198 households (2.6%) and Myagdi 1,739 households (6.0%).

Table 4-19: Distribution of Households With At Least One Person With Disability

Name of Province	Households with at least one person with disability	Percent of HHs with at least one person with disability
Nepal	205,555	3.1
Koshi	36,311	3.0
Madhesh	25,620	2.2

Name of Province	Households with at least one person with disability	Percent of HHs with at least one person with disability
Bagmati	41,217	2.6
Gandaki	**25,239**	**3.8**
Lumbini	37,419	3.3
Karnali	16,886	4.6
Sudurpashchim	22,863	4.0

Source: NPHC, 2021b

Table 4-20: District Wise Number of HHs With At Least One Person with Disability

District	Number of Households	Percentage (%)
Gorkha	3,536	4.9
Manang	103	6.6
Mustang	156	4.2
Myagdi	1,739	6.0
Kaski	4,198	2.6
Lamjung	2,015	4.6
Tanahu	2,855	3.2
Nawalparasi East	3,987	4.2
Syangja	2,411	3.5
Parbat	1,674	4.6
Baglung	2,565	4.0
Total	**25,239**	**3.8**

Source: NPHC, 2021b

4.7 Tourism

Nepal has become one of the world's major tourist destinations from a natural, cultural, adventure, historical, and religious perspective. The Constitution of Nepal has adopted a policy of developing this sector as a major pillar of the national economy by protecting, promoting, and diversifying such places and heritages, and developing them as tourist destinations. Nepal's tourism sector, despite its vast potential with a strong hospitality base, remains underutilized, contributing only 2% to GDP and employing 200,000 people.

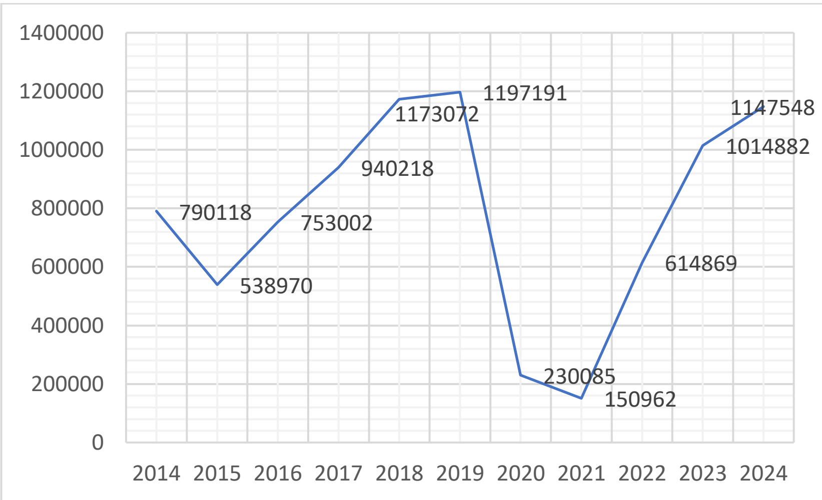


Figure 4-12: Number of Tourists Visiting Nepal in Recent Years

The figure ***Figure 4-12*** above shows the total number of tourists visiting Nepal from 2014 to 2024. Tourist arrivals declined sharply in 2015 due to the earthquake, then increased steadily and peaked in 2018–2019 at over 1.1 million visitors. In 2020 and 2021, the numbers dropped drastically because of global travel restrictions during the COVID-19 pandemic, reaching the lowest point in 2021. From 2022 onwards, tourism has been recovering strongly, with numbers rising above 1 million again by 2023, and continuing upward in 2024, indicating a return to pre-pandemic levels. Despite tourist arrivals fell after the 2015 earthquake, peaked in 2018–19, collapsed during COVID-19, has returned to its pre-COVID state. As the tourism sector has gained momentum, the hotel business has become more dynamic, and the income from tourists has also increased significantly.

Trekking remains a central pillar of Nepal's adventure tourism industry. Trekking enthusiasts traveled to Nepal's diverse landscapes, from the green foothills of Annapurna (Gandaki province) to the high-altitude trails in Khumbu and Langtang. In 2024, a total of 1,147,548 tourists visited Nepal, with a notable 166,394 embarking on trekking journeys across the country (MoCTCA, 2025).

The surge in arrivals also highlights a shift in the dynamics of international tourism to Nepal, with changes in the patterns of origin countries. In 2024, India continues to dominate as the largest source of tourists, contributing a substantial 27.69% of the total tourist arrivals. This is consistent with Nepal's geographic proximity and strong cultural, religious, and economic ties with India. However, the composition of international visitors has evolved, with the United States emerging as the second-largest source country, accounting for 9.69% of tourist arrivals. China, another significant source of tourists, contributed 8.88% of total arrivals in 2024. Despite geopolitical challenges and previous travel restrictions, Nepal remains an attractive destination for Chinese visitors, particularly those interested in Tibet, trekking, and Nepal's rich cultural heritage. The United Kingdom ranks fourth, contributing 4.77% of the tourist traffic, and Bangladesh rounds out the top five, with 4.59% of arrivals, which reflects the close cultural and historical connections between Nepal and its neighboring country.

Excluding Indian tourists arriving by land, tourist arrivals increased in 2022 to 614,869, while in 2023, such numbers increased by a high of 65.0% to 1,014,882. In 2024, tourist arrivals increased by 13.07% compared to 2023, reaching 1147,548. ***Table 4-21*** shows the number of various types of hotels in seven provinces of Nepal. Gandaki Province has a total of 16,976 hospitality and food service establishments, making it one of the moderately concentrated provinces in Nepal. Among these, non-star hotels/lodges dominate with 1,779 units, followed by home stays at 552, reflecting the region's appeal for domestic and international tourism. The province has a smaller number of star hotels (10) and resorts (27), indicating limited high-end accommodation.

Table 4-21: Tourist Arrivals in Nepal

Year	Tourist Arrivals (Excluding Indian Tourists by Land)	Increase (%)
Average of (2014-23)	661,000	-
2022	614,869	-
2023	1,014,882	+65.0%
2024	1147,548	+13.07%

Source: Based on Economic Survey, 2025

Other provinces like Karnali and Sudurpaschim have fewer hotels overall. The data highlights the growing hospitality sector in Nepal, with Gandaki showing an emphasis on mid-range lodging and restaurant services, aligning with its reputation as a popular tourist destination with diverse accommodation and dining options.

Table 4-22: Number of Star Hotels and Restaurant by Establishment by Province

Province	Star Hotel	Non-Star Hotel/Lodge	Resort	Home Stay	Hostel	Restaurant	Catering/Party Palace	Total
Nepal	126	11,919	126	1,345	1,047	126,859	801	142,223
Koshi	7	2,328	9	246	53	23,110	135	25,887
Madhesh	10	224	0	15	5	11,460	27	11,740
Bagmati	75	2,625	84	350	946	47,545	497	52,123
Gandaki	**10**	**1,779**	**27**	**552**	**17**	**14,502**	**89**	**16,976**
Lumbini	20	1,296	3	135	24	18,635	45	20,158
Karnali	0	2,414	1	5	1	4,689	0	7,110
Sudur-	4	1,253	2	42	1	6,918	7	8,228

Source: NSO (2024)

Key challenges for Nepal's tourism sector include inadequate infrastructure, limited affordability of tourism services, weak digital and integrated marketing, underdeveloped public–private partnerships, and insufficient support for inclusive business development. Addressing these gaps is essential to building a resilient, competitive, and sustainable tourism economy in Nepal.

4.7.1 Tourism Destinations

The province spans from Dhaulagiri Himal in the north to Nawalparasi-East (Bardaghat Susta East) district in the south, covering an area of 21.7 square kilometers. It includes three mountains higher than 8,000 meters above sea level *Dhaulagiri, Manaslu, and Annapurna* along with other smaller peaks. The province is also home to *Tilicho Lake* (4,919 m), one of the world's highest lakes, as well as lakes such as *Kyanjin Himal*, Phewa, Begnas, and *Rupa,* and *various waterfalls*.

Table 4-23: Tourist Destinations Identified by the Government of Nepal for Tourism Promotion and Development in Gandaki Province

District	Destinations to be Established and Promoted	Destinations to be Innovated and Developed
Gorkha	Manakamana Temple, Gorkha Durbar (Palace), Manaslu Circuit Trail (Arughat, Chumnubri, Dharke Rural Municipality)	Chumbvalley (Chumnurbi Rural Municipality
Lamjung	Ghalegaun	Kaulepani
Tanahun	Bandipur	Tanahun Kalika Sahidh and Shanti Park, Byas 4, Siddhagufa, Bhimad
Kaski	Pokhara, Sarangkot, Panchase, Pumdikot	Kanhun Dharahara Tourist Area, Mauja Homestay, Sikles Tourist Area
Manang	Tilicho Lake, Annapurna Trekking Route	Narphu Trail (Seven Pass Trail)
Mustang	Muktinath, Jomsom, Damodar Kunda	Lomanthang Palace and Cave Area
Parbat	Shaligram Setibeni, Gupteshwor Cave, Sirubari	Durlung Canyoed, Ceaving, and Homestay (Kusma-3), Mahashila, Satau–Chandikalika Area (Putalibazar Municipality)
Syangja	Shwarek Field Paragliding (Bhirkot Municipality)	Alamdevi (Kaligandi Rural Municipality)
Baglung	Kalika Bhagwati Temple (Baglung Municipality, 1), Panchakot Religious Tourism Area	Bhakunde Bhairavsthan Gajako Daha; Dhorpatan Reserve Area (Dhorpatan Municipality and Nisikhola Rural Municipality)

District	Destinations to be Established and Promoted	Destinations to be Innovated and Developed
Nawalparasi East	Maula Kalika, Tribeni, Amaltari Homestay, Shashwat Dham	Daunnedebi
Myagdi	Poon Hill, Tatopani, Galeshwar Temple, Dhaulagiri Round, Garja Himal	Ghodepani Mohredanda Tourist Area

Source: Minister of Culture, Tourism and Civil Aviation, 2025

Diverse types of forests and wildlife found from the Himalayan region to the Terai plains, tributary rivers of the Gandaki River system, the world-famous Annapurna and Manaslu trekking routes, religious sites such as *Muktinath, Baglung Kalika, Manakamana, and Bindhyabasini temples, Devghat Dham, Triveni Dham, Ramdhuni Dham, Modi Beni, Patihari, Dahare Khola* and *Chitwan National Park* adjoining *Nawalpur side* are located within this province. Government of Nepal Identified Tourist Destinations for Tourism Promotion and Development. Under this provision, Gandaki province includes various historical, religious, cultural, geographical, and tourist destinations that have been identified and developed as key attractions for tourism.

In the context of tourism development, growing visitor numbers, along with rural–urban migration and industrial sector expansion, are expected to significantly increase both liquid and solid waste generation in key destinations and urban centers. This trend highlights the urgent need for improved solid waste management, wastewater treatment, and environmentally friendly roads and transportation systems to ensure that tourism growth remains sustainable and does not degrade the urban environment on which it depends. Environmental degradation, and insufficient sustainable practices have put immense pressure on the local natural resources. Deforestation, waste accumulation and strain on water resources are just a few of the pressing issues. The rising number of trekkers has led to waste accumulation, including human waste, plastic, and discarded equipment in the high Himalayan region.

4.8 Public Health System

4.8.1 Basic Health Services

Access to free Basic Health Services (BHS) is considered a fundamental right guaranteed by the constitution; thus, the Government of Nepal is committed to delivering these services free of cost to every citizen primarily through public health networks and, where appropriate, in partnership with non-state providers. In the 1990s, most healthcare was delivered through public facilities, but rapid economic liberalization resulted in the expansion of the private sector. Today, private facilities offer a majority of facilities and healthcare expenditure. Most private facilities are based in major cities and advanced ones are concentrated in the Kathmandu Valley, while public facilities are more widely dispersed. People in lower income brackets and inhabiting remote and underserved provinces such as Karnali, Sudurpaschim, Lumbini, and Madhesh often have poorer outcomes compared to those with higher incomes and residing in provinces such as Bagmati, Koshi, and Gandaki. This is partly due to the fact that these population groups have less access to health care services, including preventative and curative care services which can result in delayed access to health care and poorer health outcomes (ADB, 2024).

A total of 452 health facilities is listed nationwide, including 190 public hospitals, 186 primary health care centers, 48 community or private hospitals, and 28 eye hospitals. Among the provinces, Koshi has the highest number of facilities (110), followed by Bagmati (95) and Madhesh (63). In contrast, Karnali (33) and Sudurpashchim (36) have the lowest numbers, reflecting regional disparities in the availability of health services. Overall, the data suggest that health infrastructure is more concentrated in the eastern and central provinces compared to the mid-western and far-western regions of Nepal. Similarly, hospitals per 100,000 population shows better availability to hospitals relative to the population in Koshi and Gandaki province while a lower availability in Madhesh province.

Table 4-24: Distribution of Health Facilities by Provinces

Province	Public Hospital	Primary Health Care Center	Community/Private Hospital	Eye Hospital	Total	Hospitals per 100,000 Population
Koshi	44	40	19	7	110	2
Madhesh	16	34	8	5	63	1
Bagmati	51	30	8	6	95	2
Gandaki	**24**	**24**	**4**	**1**	**53**	2
Lumbini	23	28	5	6	62	1
Karnali	16	14	1	2	33	2
Sudurpashchim	16	16	3	1	36	1
Total (National)	**190**	**186**	**48**	**28**	**452**	**2**

Source: Based on Health Insurance Board Data, 2022

4.8.2 Health Outcomes Across Provinces in Nepal

The ***Table 4-25*** below displays the prevalence of mortality rates and stunting rates across different provinces. Neonatal mortality rates (NMR) in Sudurpaschim (37 deaths per 1,000 live births), Madhesh (27), and Karnali (26) are highest, as well as under-5 mortality rates (Sudurpaschim is at 49, Karnali at 46, and Madhesh at 43). Gandaki (19 deaths per 1,000 live births) and Bagmati (21) have the lowest infant mortality rates (IMR) and under-5 mortality rates (Gandaki at 23 and Bagmati at 24). Gandaki has the lowest NMR at 8 per 1,000 live births. Similarly, Karnali has the highest prevalence of stunting, with 36% children affected, followed by Madhesh 29% and Sudurpaschim at 28%. These rates are higher than the national average of 25% and those observed in other provinces.

Table 4-25: Selected Health Outcomes by Provinces

Province	NMR	IMR	Under-5 MR	Health Facility	Childhood
Koshi Province	20	28	34	81.5	20
Madhesh Province	27	38	43	66.8	29
Bagmati Province	18	21	24	88.3	18
Gandaki Province	**8**	**19**	**23**	**87.8**	**20**
Lumbini Province	24	34	41	84.4	25
Karnali Province	26	36	46	72.4	36
Sudurpashchim Province	37	40	49	86.8	28
Nepal	**21**	**28**	**33**	**79.4**	**25**

Source: Ministry of Health and Population [Nepal], New ERA, and ICF(2023). 2022. Kathmandu, Nepal: Ministry of Health and Population [Nepal].
Note: NMR = neonatal mortality rate, IMR = infant mortality rate, MR = mortality rate.
Note: NMR, IMR, and Under-5 MR are measured per 1,000 live births.

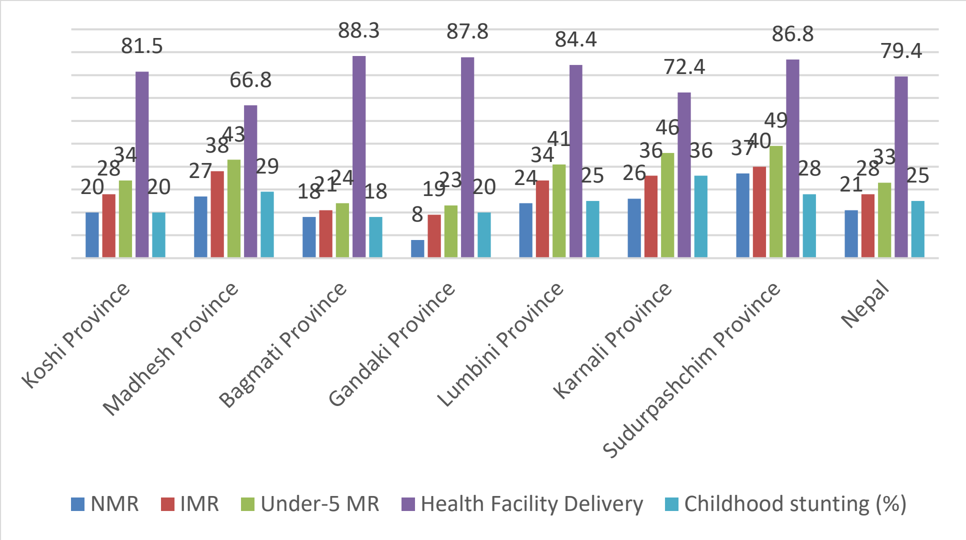


Figure 4-13: Selected Health Outcomes by Provinces

4.8.3 Development of Health Insurance

Government of Nepal decided to prioritize health insurance from FY2011–2012 and enacted National Health Insurance Policy. In FY 2015/16, the Government established social health security development committee and social health security (i.e. health insurance) was initiated; health insurance program was piloted in three districts (Kailali, Baglung, and Ilam). By 2022, health insurance program was expanded to 77 districts of Nepal.

Between FY 2018/19 and 2023/24, household enrollment in Nepal's insurance program rose significantly, reaching 28% of the national population. However, only 17% remain actively insured, revealing a notable drop-off. Provinces like Koshi and Gandaki show strong uptake and retention, while Madhesh lags with just 6% active coverage despite steady enrollment growth. This gap between enrollment and active participation highlights challenges in renewal, accessibility, and sustained engagement across the provinces.

Table 4-26: Details of Active Insured Population

province	Enrolled households (FY 2018/19)	Enrolled households (FY 2023/24)	% of total population enrolled (till FY 2023/24) according to census 2021	Active insured population (FY 2023/24)	Percentage of active insured individuals in the FY 2023/24.
Koshi	534,496	2,404,772	48%	1,436,605	29%
Madhesh	46,405	635,718	10%	363,653	6%
Bagmati	386,008	1,920,579	31%	1,364,553	22%
Gandaki	**264,735**	**1,098,354**	**45%**	**755,967**	**31%**
Lumbini	323,995	1,179,568	23%	633,485	12%
Karnali	128,603	475,037	28%	212,211	13%
Sudurpashchim	170,529	578,113	21%	245,739	9%
Total	**1,854,771**	**8,292,141**	**28%**	**5,012,213**	**17%**

Source: Based on Health Insurance Board, 2024 (annual report)

4.9 Human Development Index

From 1990 to 2023, Nepal's Human Development Index (HDI) rose significantly from 0.404 to 0.622, a 54 percent increase, fueled by major gains in life expectancy, education, and income (UNDP, 2025).

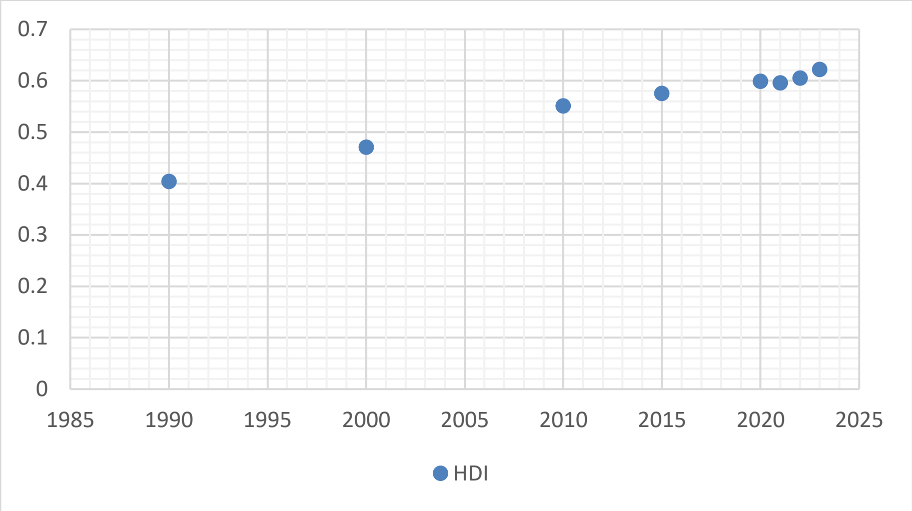


Figure 4-14: HDI Trend of Nepal

Province wise, in year 2023, Bagmati has the highest HDI with a value of 0.661, indicating relatively better human development. It is followed by Gandaki (0.618) and Koshi (0.580), reflecting moderate levels of development. Lumbini comes next with an HDI of 0.563, while Sudurpashchim (0.547) and Karnali (0.538) have lower HDI values, showing development challenges. Madhesh has the lowest HDI at 0.510, indicating the most significant unemployment and poverty rates.

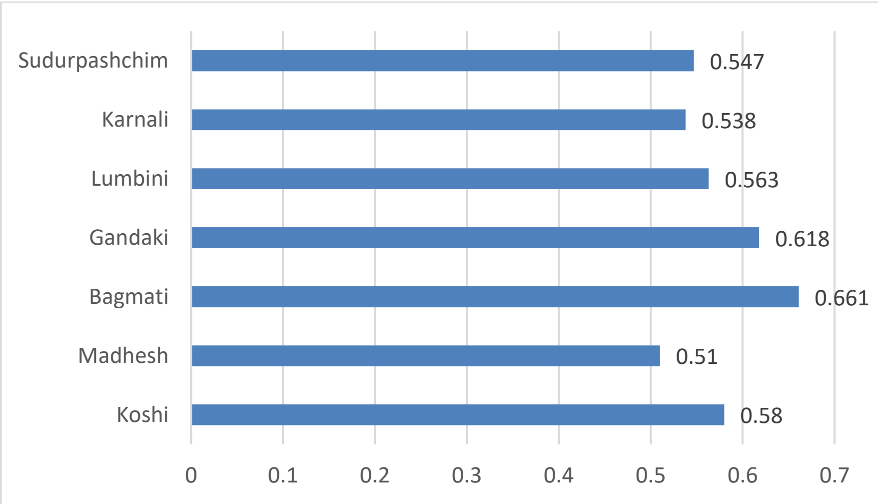


Figure 4-15: HDI Among Provinces of Year 2023

4.10 Economic Performances

Like many developing countries, Nepal has faced its share of challenges. In the late 1990s and early 2000s, political transition, limited industrial capacity, and repeated natural disasters slowed down economic progress. Disasters such as the 2015 earthquake, pandemic COVID-19 and recurring floods certainly set the economy back, but Nepal has repeatedly shown resilience, rebuilding and returning to a path of moderate growth. As infrastructure improves and reforms continue, the country aims to move toward a more modern, stable, and people-centered economy.

The ***Figure 4-16*** shows the national economic growth rate and inflation rate from 2014/15 to 2024/25. It shows that during periods of high economic growth, such as in 2015/16, inflation also rises sharply. However, when economic growth contracts, as seen in 2019/20, inflation remains moderate. From 2020/21 onward, economic growth gradually recovers, while inflation decreases significantly, reaching a low point in 2023/24.

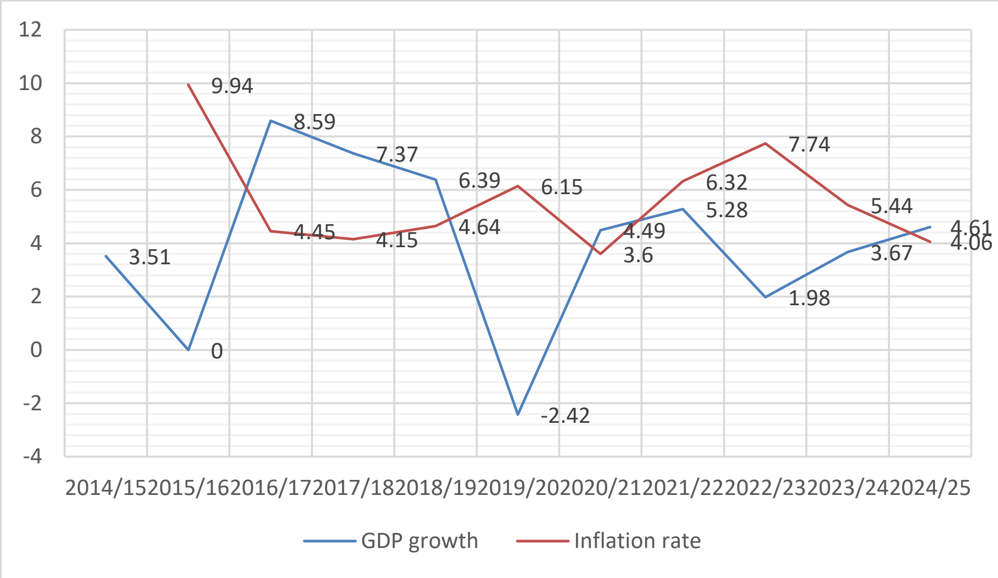


Figure 4-16: Economic Growth Rate and Consumer Inflation Rate (%)

4.11 Sector Wise Growth

Agriculture continues to be the mainstay for a large portion of Nepal's population, even as the economy gradually shifts toward non-agricultural sectors. Agriculture in Gandaki accounts for around 27 % of the provincial GDP, engaging 58% of the economically active population. While the agricultural sector's contribution to the national GDP has declined to 25.16%, the industrial and service sectors contribute 12.83% and 62.01%, respectively (Economic Survey, 2025).

Figure 4-17: Share of GDP by Different Sectors of Gandaki Province

Gandaki has a significant growth and has estimated 5.51 percent followed by Bagmati (5.18 percent) for year 2024/25. While Madesh shows a slight decrease in the 2023/24 period, the overall trend indicates a general upward trajectory in the data across all regions for the years to come. The national average also demonstrates growth, with the projections for 2024/25 at 4.61.

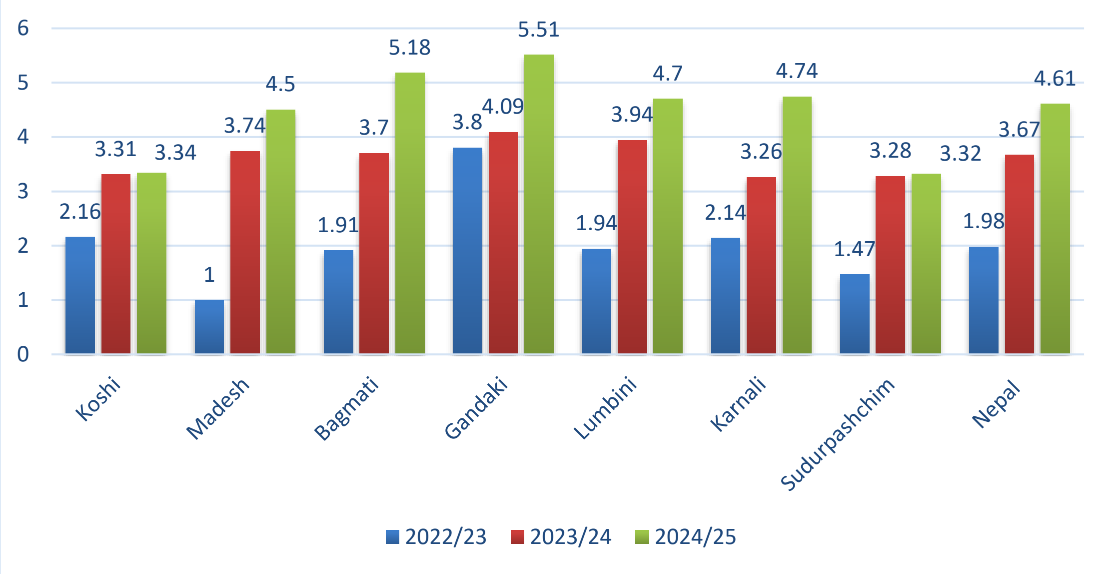


Figure 4-18: Province-wise Economic Growth Rate

Nepal GDP per Capita reached US$ 1445.2 in 2024 from last year US$ 1389 in 2023 (Economic Survey, 2024/25). The bar graph displays the GDP per capita across various provinces in Nepal for 2024, measured in US dollars. Bagmati stands out with the highest GDP per capita of $2492, followed by Gandaki at $1570. The Koshi and Lumbini provinces have relatively close GDPs, at $1352 and $1167, respectively. Madhesh has the lowest GDP per capita at $903, while Sudurpashchim and Karnali show similar values of $1122 and $1076, respectively (Economic Survey, 2024/25). This distribution highlights the economic disparities between the provinces, with Bagmati leading significantly in economic output, while Madhesh lags behind.

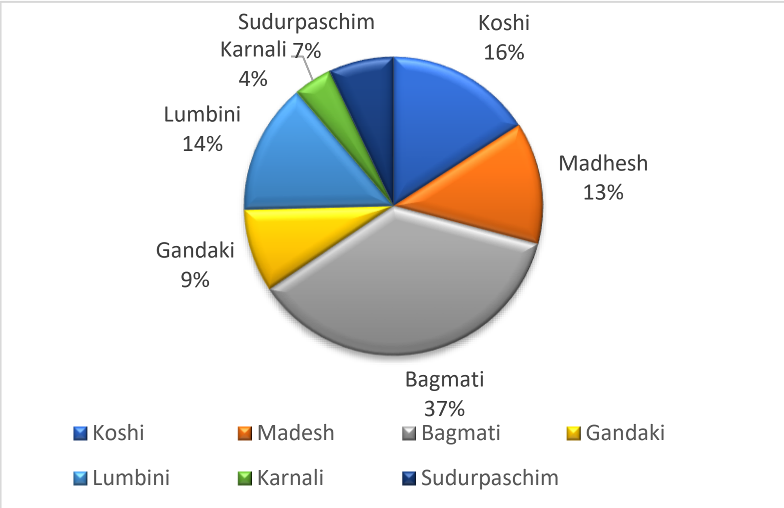


Figure 4-19: Province-wise Contribution to GDP (in %)

Bagmati Province leads Nepal's GDP contribution with 37%, followed by Koshi (16%), Lumbini (14%), and Madhesh (13%). Gandhaki adds 9%, while Sudurpashchim contributes 7%. Karnali has the smallest share at 4%, mainly due to limited infrastructure and economic activity.

4.11.1 Provincial Share in Agricultural

Koshi Province is the largest contributor to Nepal's agricultural production, accounting for 22%, meaning nearly one-fourth of the country's total crop output comes from this region. Madhesh Province follows with 19%, supported by fertile soil and extensive farmland that make it a major agricultural hub. Bagmati and Lumbini Provinces each contribute 17%, indicating strong and balanced agricultural activity in both areas. Gandaki Province provides 10%, where farming is present but limited by the region's hilly terrain.

Sudurpashchim Province also contributes 10%, showing moderate agricultural involvement. Karnali Province has the smallest share at 5%, largely due to its mountainous landscape, limited cultivable land, and lower levels of commercial farming.

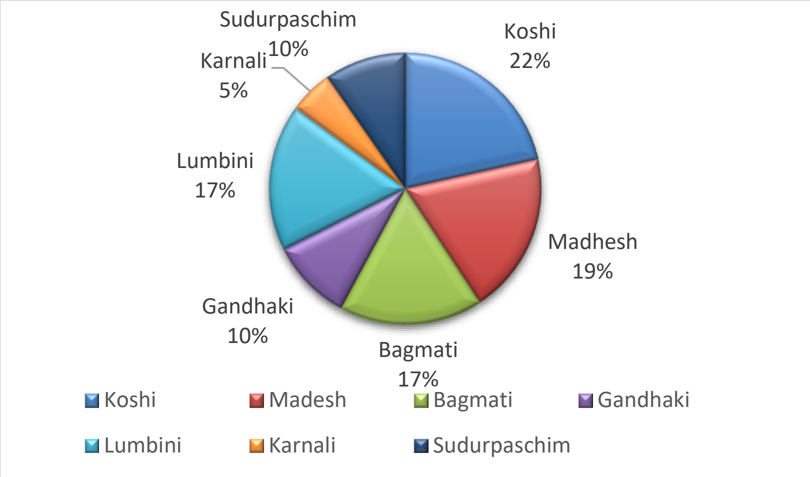


Figure 4-20: Provincial Share in Agricultural Production (in %)

4.12 Sustainable Development Goals

The Sustainable Development Goals (SDGs) Localization Roadmap (2022-2030) has been developed to make the internalization of SDGs in Gandaki more effective and result-oriented (UNDP, 2022). The province government had endeavored to localize the internalization of SDGs starting from the First Five-Year Plan, determining baseline for a total of 275 indicators. This table highlights some promising goals and indicators; the province has made for achieving the SDGs by 2030.

Table 4-27. SDGs Indicators with Current Status and Future Goal

SDGs no.	SGDs	Indicators	Unit	2022/23 status	2026/27 goal	2029/30 goal
1	**No poverty**	Poverty rate	percent	11.88	8.6	7.0
		GNI Per Capita income	US$	1499	2000	2500
2	**Zero hunger**	Low weight below five years old Child	Percent	18.1	11	7
		Per person food availability (in kg)	in kg	435	438.3	440
		Population with High-risk food security	percent	0.8	0.4	0.2
3	**Good health and well-being**	Death rate of children below 5 years (in 10000)	number	30		22
		Maternal death rate (Per live birth in 100,000)	number	161	100	70
4		Literacy rate (Above 5 years)	Percent	81.7	83.5	85

SDGs no.	SGDs	Indicators	Unit	2022/23 status	2026/27 goal	2029/30 goal
	Quality education	Enrollment rates in primary level (1-8th grade)	Percent	95.7	77	98
5	**Gender equality**	Gender equality index	indicator	0.896	0.954	0.97
		Women (aged 14 t0 49) with single ownership (real estate)	Percent	14.12	18	20
		Women participation in workforce	percent	28	32	35
6	**Clean water and sanitation**	Access to Basic Drinking Water Services:	percent	94.25	98	100
		Households with private piped drinking water	percent	59.5	84	95
		Population using flush toilets in households	percent	80	93	100
7	**Affordable and clean energy**	Population with access to electricity	percent	99.5	100	100
		Electricity generation capacity	percent	733	1600	2500
		Per capita electricity consumption (kilowatt-hour)	kWh	216	300	500
8	**Decent work and economic growth**	Unemployment rate	Percent	-	6	5
		Population employment ratio	percent		42	50
		Economic growth rate	Percent	3.69	8.85	10.38
9	**Industry, innovation and infrastructure**	Road density (in density)	Km/sqkm.	0.56	0.64	0.72
		Population with access to road transportation within 30 minutes	percent	99	100	100
10	**Reduced inequalities**	Gini coefficient	indicator	0.29	0.28	0.27
		Employment for disability population in the workforce	number	500	900	1100
11	**Sustainable cities and communities**	Number affected with natural disaster in 1000 population	Per person in 1000	18	15	12
		Households living in their own owned housing	percent	81.7	85	90
13		Climate friendly village/tole	number	48	60	85

SDGs no.	SGDs	Indicators	Unit	2022/23 status	2026/27 goal	2029/30 goal
	Climate Action	Glacier hazard prevention and early warning systems	Number	-	5	8
15	**Life on land**	Covered by forest area	percent	47.4	48	50
		Quantity of timber production from government, private, community, and religious forests	100,000 cubic feet	11.17	12	15
16	**Peace, justice, and strong institutions**	Population affected by domestic violence in 12 months.	number	-	800	600
		Proportion of reported gender-based violence and investigation	percent	82.7	90	95

Source: Based on Second Five years' plan, Gandaki Province (FY 2024/25 2028/29)

The SDGs represent a global agenda to address critical challenges such as poverty, inequality, climate change, and peace by 2030. In this provincial context, the SDGs offer a clear framework to guide national policies and strategies, ensuring that development is inclusive and benefits all segments of society. Achieving these goals requires collaboration between governments, businesses, communities, and individuals to address pressing issues like poverty, education, healthcare, gender equality, and access to clean energy. By aligning local initiatives with global targets, Gandaki province can drive meaningful progress while contributing to a more sustainable and prosperous future for their populations.

Chapter 5. Environmental Governance

5.1 Institutional Framework for the Environment-Governance Functions

Environmental governance in Gandaki Province operates within Nepal's federal governance system, characterized by a constitutionally defined division of powers and responsibilities across federal, provincial, and local governments. While institutional mandates for environmental management are formally articulated through constitutional schedules, acts, and regulations, effective environmental governance depends not only on the existence of institutions but also on how core governance functions are performed in practice. These functions include policy formulation and planning, regulation and enforcement, service delivery, data generation and monitoring, inter-governmental coordination, and partnerships with non-state actors. Accordingly, this section examines the institutional framework for environmental governance in the Province through a governance-function lens, highlighting the roles of key actors across governance levels and assessing how institutional performance shapes environmental outcomes. Understanding these governance functions and their performance is critical for explaining observed environmental trends, policy and institutional gaps, and implementation challenges discussed in subsequent sections of this chapter.

Table 5-1. Environmental Governance Functions and Responsible Institutions in Gandaki Province

Governance Function	Federal Actors	Provincial Actors	Local Actors
Policy, Planning and Strategic Direction	Ministry of Forests and Environment (MoFE); National Planning Commission	Provincial Policy and Planning Commission (PPPC); sectoral ministries (Forestry & Environment, Agriculture, Industry & Tourism, Physical Infrastructure, Energy/Water, Social Development) & Provincial Disaster Management Authority; Provincial Committee for Climate Change	Municipalities (urban and rural)
Regulation, Compliance and Governance Administration	MoFE (framework policies); Ministry of Federal Affairs and General Administration (MoFAGA)	Ministry of Forestry and Environment; Ministry of Internal Affairs and Law	Municipalities (local enforcement, compliance monitoring)
Service Delivery and Sector Operations	DWSS; Nepal Water Supply Corporation; Dept. of Water Resources & Irrigation; Dept. of Electricity Development; Dept. of Urban Development; Dept. of Local Infrastructure Development; Department fo Education; DOLMA; Dept. of Agriculture	Agriculture, Land Management & Cooperatives; Physical Infrastructure & Transport; Energy, Water Resources & Water Supply; Industry & Tourism	Municipal service delivery (waste, water, land use, local infrastructure)
Environmental Data, Monitoring and Knowledge Systems	Department of Hydrology and Meteorology (DHM); National Statistics Office (NSO)	PPPC (data aggregation and planning interface)	Municipal records, local monitoring and reporting
Coordination and Inter-governmental Linkages	MoFAGA	PPPC	District Coordination Committees (DCCs); Municipalities

Governance Function	Federal Actors	Provincial Actors	Local Actors
Partnerships and Development Support	UNDP, ADB, FAO, WWF, IUCN, IFC, World Bank, ICIMOD, Nepal Red Cross Society	Provincial line ministries (project coordination)	Local NGOs (LIBIRD, Clean Air Network Nepal, Prakriti Resources Center, etc.), communities

5.2 Functional Performance and Governance Implications

5.2.1 Policy, Planning and Strategic Direction

Environmental policy frameworks are well developed across federal and provincial levels, with strong alignment to national priorities and sectoral strategies. However, translation into actionable, locally adapted plans remains uneven, particularly in rapidly urbanizing municipalities. The PPPC has a critical but under-leveraged role in ensuring cross-sector policy coherence and environmental mainstreaming.

5.2.2 Regulation, Compliance and Governance Administration

While regulatory mandates are clearly defined, enforcement capacity remains weak, especially at the municipal level due to staffing, technical, and legal constraints. Overlapping federal–provincial jurisdictions create ambiguity, reducing accountability and consistency in compliance. This gap contributes to persistent non-compliance in air quality, waste management, and resource extraction.

5.2.3 Service Delivery and Sector Operations

Environmental outcomes are strongly shaped by sectoral service delivery in water, energy, infrastructure, agriculture, environmental education curriculum and awareness and urban development. Environmental safeguards are often secondary to service expansion, leading to trade-offs such as river degradation, unmanaged waste, and land-use change. Limited integration of environmental standards into sector operations constrains sustainability.

5.2.4 Environmental Data, Monitoring and Knowledge Systems

Nepal has strong federal data institutions, particularly for climate and statistics, but data fragmentation persists across agencies and levels. Provincial and local governments rely heavily on federal datasets, with limited localized environmental monitoring. The absence of an integrated provincial environmental data system weakens evidence-based planning and adaptive governance. This is the area where provincial planning commission could be a crucial institution to develop an integrated environmental information system or platform for preparation of the future evidence based periodic provincial plan.

5.2.5 Coordination and Inter-Governmental Linkages

Formal coordination mechanisms exist, but functional coordination remains weak, particularly between sector ministries and municipalities. DCCs play a limited coordinating role, often without clear authority or resources. Weak vertical and horizontal coordination undermines integrated environmental management across river basins, urban regions, and landscapes.

5.2.6 Partnerships and Development Support

Development partners and I/NGOs play a significant catalytic role in conservation, climate adaptation, disaster risk reduction, and innovation. However, partner-led initiatives are often project-based and fragmented, with limited institutionalization within government systems. Stronger alignment with provincial priorities could enhance long-term governance impacts.

5.3 Policy, Legal and Regulatory Framework for Environmental Governance

Environmental governance in Gandaki Province is guided by a multi-layered policy and legal framework spanning international commitments, national legislation, provincial acts, and local-level regulations. Nepal's ratification of major international environmental conventions covering climate change, biodiversity, water resources, disaster risk reduction, and sustainable development provide an overarching normative foundation. These commitments are operationalized through national policies and sectoral laws, which in turn inform provincial legislation and municipal by-laws.

At the national level, environmental governance is anchored by framework legislation such as the Environment Protection Act, sector-specific acts on forests, water resources, energy, agriculture, urban development, and disaster risk reduction, and cross-cutting policies on climate change and sustainable development. Collectively, these instruments provide broad policy coverage across all major environmental themes, establishing standards for environmental assessment, pollution control, resource conservation, and climate resilience.

Following federal restructuring, Gandaki has enacted a growing body of provincial legislation and regulations to operationalize national mandates within the provincial context. These include province-specific environment protection rules, sectoral acts related to forestry, irrigation, energy, industry, and disaster management, as well as development plans that integrate environmental considerations. Municipalities have further complemented this framework through local acts, guidelines, and procedures addressing waste management, water supply, land use, disaster preparedness, and social inclusion.

Despite the breadth of this policy framework, policy density has not translated into policy coherence or effective implementation. Overlapping mandates between federal, provincial, and local governments particularly in areas such as land use regulation, environmental impact assessment, water resource management, and industrial licensing have created ambiguity in authority and accountability. In several thematic areas, provincial and local policies advance progressive objectives, but enforcement mechanisms, technical standards, and financing arrangements remain weak or inconsistent.

Moreover, while municipalities have demonstrated innovation through locally tailored regulations—especially in urban environment management, disaster risk reduction, and natural resource conservation—these efforts are often fragmented and uneven across the province, reflecting disparities in institutional capacity, technical expertise, and fiscal resources.

Overall, Gandaki Province possesses a comprehensive but fragmented environmental policy framework, characterized by strong normative commitments but limited operational integration. These structural weaknesses particularly related to coordination, enforceability, and institutional capacity directly contribute to the policy and institutional gaps identified in Section 3.3 and shape the environmental governance challenges discussed later in this chapter. *Detailed listings of international commitments, national legislation, provincial regulations, and municipal-level instruments are provided in Annex Tables A1–A5.*

5.3.1 Policy Coherence Matrix by Environmental Theme

This matrix assesses the coherence, enforceability, and functional alignment of environmental policies across governance levels for key thematic areas. It highlights where strong policy coverage exists, where fragmentation persists, and where governance weaknesses contribute to environmental risks.

Table 5-2. Policy Coherence and Governance Performance by Theme

Environmental Theme	Policy Density*	Vertical Coherence**	Enforceability	Key Governance Issue
Air Quality & Atmosphere	High	Weak	Low	Strong national standards exist, but absence of dedicated provincial and municipal air quality

Environmental Theme	Policy Density*	Vertical Coherence**	Enforceability	Key Governance Issue
				legislation and limited monitoring capacity undermine enforcement.
Water Resources & Quality	Medium–High	Moderate	Low–Moderate	Fragmented mandates across water supply, irrigation, hydropower, and sanitation hinder integrated river basin and wastewater management.
Land Use, Soil & Agriculture	High	Weak	Low	Jurisdictional conflicts between federal, provincial, and local responsibilities createimplementation gaps, particularly in land-use control and sustainable farming practices.
Forest & Biodiversity	High	Moderate	Moderate	Strong legal framework exists, but outdated management plans, weak biodiversity integration, and limited monitoring reduce effectiveness.
Energy & Industry	Medium	Weak	Low	Policy contradictions in licensing, regulation, and revenue-sharing weaken environmental compliance and cumulative impact management.
Urban Environment & Waste Management	Medium	Weak	Low	Rapid urbanization outpaces municipal capacity; lack of provincial technical support and unclear road and land-use jurisdiction exacerbate environmental pressures.
Climate Change & Disaster Risk Reduction	Medium	Moderate	Low	Multiple policies exist, but weak mainstreaming into sectoral and local development planning limits adaptive and preventive action.
Cross-cutting (GESI, Social Protection)	Medium	Weak	Low	Implementation deficits and limited institutional capacity constrain equitable participation and inclusive environmental governance.

* ***Policy Density***: *Extent of laws, policies, and regulations across governance levels*
** ***Vertical Coherence***: *Alignment across federal–provincial–local levels*

Key Insights from the Policy Coherence Matrix

- Gandaki Province demonstrates high policy density across most environmental themes, indicating strong normative commitment.
- Vertical coherence is weak in sectors with shared or overlapping mandates, particularly land use, air quality, energy, and urban infrastructure.
- Enforceability remains the weakest dimension across almost all themes, reflecting capacity constraints, unclear accountability, and limited technical and financial resources at sub-national levels.
- Themes with comparatively stronger governance performance (e.g., forest and biodiversity) benefit from long-standing institutional arrangements, while emerging pressures (urbanization, climate change) expose structural governance gaps.

This matrix underscores that environmental challenges in Gandaki Province are driven less by the absence of policies and more by weaknesses in policy coherence, institutional capacity, and implementation effectiveness issues explored further in Section 3.3.

5.4 Policy and Institutional Gaps in Environmental Governance

Despite the presence of a comprehensive policy and institutional framework, environmental outcomes in Gandaki Province continue to reflect persistent governance weaknesses. These weaknesses arise not from policy absence, but from structural gaps in coherence, capacity, enforcement, coordination, and data systems across governance levels. This section synthesizes thematic policy and institutional gaps identified across environmental sectors into cross-cutting governance gap categories, highlighting their causes and environmental implications.

5.4.1 Cross-Cutting Governance Gap Typology

Based on thematic analysis across air quality, water resources, land and agriculture, forests and biodiversity, energy and industry, urban environment, climate change, and social inclusion, five major governance gap categories are identified.

Table 5-3. Core Governance Gap Types in Gandaki Province

Governance Gap Type	Description	Environmental Implications
Jurisdictional and Mandate Fragmentation	Overlapping or unclear division of responsibilities among federal, provincial, and local governments	Delayed decisions, regulatory loopholes, weak accountability
Enforcement and Compliance Deficits	Weak inspection, monitoring, and sanctioning capacity	Persistent pollution, resource overuse, unmanaged urban waste
Institutional Capacity Constraints	Limited staffing, skills, and technical resources at provincial and local levels	Poor service quality, ineffective safeguards
Policy Coherence and Integration Gaps	Sectoral policies not aligned with environmental objectives	Trade-offs favor development over sustainability
Data, Monitoring, and Accountability Gaps	Fragmented data systems and weak transparency mechanisms	Evidence-poor planning and delayed corrective action

5.4.2 Sectoral Manifestation of Governance Gaps

Air Quality and Atmosphere

Air quality governance is characterized by high policy intent but low operationalization. Dedicated air quality legislation and monitoring infrastructure at the provincial and municipal levels remain inadequate, while enforcement of vehicle and construction-related emissions is weak. Institutional fragmentation and limited public awareness further constrain effective air pollution control.

Water Resources and Quality

Water governance suffers from sectoral isolation, with water supply, irrigation, hydropower, sanitation, and river conservation managed independently. Environmental flow provisions and wastewater regulations are inconsistently enforced, leading to river water biodiversity degradation, water quality decline, and downstream livelihood impacts.

Land Use, Soil, and Agriculture

Conflicting federal, provincial, and local mandates create implementation paralysis in land-use regulation and agricultural extension services. Inconsistent guidance on mechanization, fertilizer use, and climate-smart agriculture exacerbates soil degradation, erosion, and water pollution, particularly in fragile hill and mountain ecosystems.

Forest and Biodiversity

While legal frameworks for forestry and biodiversity are relatively strong, institutional capacity and monitoring gaps limit effectiveness. Outdated community forest management plans, weak biodiversity integration, and fragmented human–wildlife conflict management undermine ecosystem resilience and conservation outcomes.

Energy and Industry

Environmental governance in energy and industry is constrained by regulatory inconsistencies and weak cumulative impact management. Contradictions in licensing authority, insufficient monitoring of extractive industries, and limited environmental oversight of hydropower and tourism-related infrastructure increase ecological risks.

Urban Environment and Waste Management

Rapid urbanization has outpaced municipal governance capacity, resulting in chronic waste management failures and unplanned land conversion. Jurisdictional ambiguity in road infrastructure, absence of provincial technical support systems, and inadequate urban planning exacerbate pollution, public health risks, and ecosystem degradation. Clearity of federal and provincial institutions responsibility in waste management.

Climate Change and Disaster Risk Reduction

Although multiple policies address climate change and disaster risk, mainstreaming into sectoral and local development planning remains weak. Limited institutional capacity, fragmented financing mechanisms, and insufficient community engagement reduce preparedness and adaptive resilience to climate-induced hazards.

Cross-Cutting Social and Inclusion Dimensions

Implementation gaps in GESI and social protection policies constrain equitable participation in environmental governance. Marginalized groups often experience disproportionate environmental risks while remaining underrepresented in decision-making processes, weakening governance legitimacy and effectiveness.

5.4.3 Synthesis: Why These Gaps Persist

Across all thematic areas, governance gaps persist due to:

- Federalism transition challenges, particularly unclear authority and accountability;
- Under-resourced provincial and local institutions;
- Weak enforcement incentives and limited sanctioning power;
- Fragmented environmental data systems; and
- Limited integration of social equity considerations into environmental decision-making.

These systemic weaknesses directly shape the environmental trends and risks documented in other chapters of this State of Environment report and underscore the need for governance reforms that prioritize coherence, capacity, and accountability.

5.5 Governance Reform Priorities and Strategic Opportunities

Environmental governance in the Province is at a critical transition point. Rapid urbanization, climate change impacts, infrastructure expansion, and increasing competition over natural resources are intensifying environmental pressures, while institutional arrangements and governance practices struggle to keep pace. At the same time, federal restructuring, expanding provincial authority, and growing community engagement create strategic opportunities to strengthen environmental governance and improve environmental outcomes. This section outlines priority governance challenges and reform opportunities across thematic areas, emphasizing systemic solutions rather than sector-specific responses.

5.5.1 Strategic Governance Challenges

Urbanization and Infrastructure Pressure

Accelerated urban growth particularly in urban centers such as Pokhara has placed unprecedented strain on land, water, waste management systems, and surrounding ecosystems. Governance mechanisms have not adequately integrated environmental safeguards into urban planning, resulting in unmanaged waste, land conversion, and pressure on peri-urban ecosystems.

Climate Change and Disaster Risk Intensification

Climate-induced hazards, including floods, landslides, heat stress, and changing hydrological regimes, are increasing in frequency and intensity. Governance responses remain largely reactive, with limited mainstreaming of climate adaptation and disaster risk reduction into sectoral planning and municipal development processes. The road infrastructure is passing through the sensitive fragile cold arid desert landscape which needs timely consideration of the climate change impacts as experiencing more intense rain falls.

Institutional Fragmentation and Coordination Deficits

Environmental governance continues to be undermined by fragmented mandates and weak coordination among federal, provincial, and local actors. Sectoral silos persist, particularly in land use, water resources, energy, and infrastructure development, limiting integrated landscape and river-basin management.

Capacity and Enforcement Constraints

Provincial and municipal institutions face persistent capacity gaps related to staffing, technical expertise, enforcement authority, and financing. These constraints weaken regulatory compliance, monitoring, and service delivery, particularly in emerging priority areas such as air quality management and urban waste systems.

5.5.2 Strategic Governance Reform Opportunities

Strengthening Functional Coordination and Accountability

A key opportunity lies in reinforcing function-based governance, clarifying roles related to planning, regulation, service delivery, and monitoring across governance levels. Strengthening the coordinating role of the Provincial Policy and Planning Commission and formalizing inter-sectoral coordination mechanisms can enhance policy coherence and accountability.

Institutionalizing Environmental Mainstreaming

Embedding environmental safeguards, climate risk screening, and social inclusion criteria into provincial and municipal planning, budgeting, and project approval processes can significantly improve environmental outcomes. Environmental governance should be positioned as a core development function, not a sectoral add-on.

Enhancing Sub-National Capacity and Technical Support

Establishing provincial-level technical support units particularly for environmental impact assessment, urban waste management, climate finance, and monitoring can help bridge capacity gaps at the municipal level. Targeted training and resource mobilization are critical for translating policies into action.

Strengthening Environmental Data and Monitoring Systems

Integrating environmental data across sectors and governance levels presents a major opportunity to improve evidence-based decision-making. Strengthening linkages between federal data institutions and provincial and local planning processes can support adaptive management and early warning systems.

Leveraging Partnerships and Community-Based Governance

Development partners, civil society organizations, and community institutions play a critical role in innovation, service delivery, and local stewardship. Better alignment of partner-supported initiatives with provincial priorities, along with institutionalization of community-based governance models, can enhance sustainability and ownership.

5.5.3 Pathways for Improved Environmental Governance Outcomes

Realizing these governance reform opportunities requires a shift from compliance-focused regulation to outcome-oriented governance, where environmental performance, resilience, and equity are central to decision-making. Priorities include:

- Integrating governance reforms into provincial development planning and investment decisions;
- Aligning climate, urban, and sectoral policies under a shared environmental governance framework; and
- Strengthening transparency, accountability, and participation across all levels of governance.

Together, these reforms can enable Gandaki Province to move toward more coherent, resilient, and inclusive environmental governance, better equipped to address current pressures and future uncertainties.

5.4 Conclusion: Strengthening Environmental Governance

Environmental governance in Gandaki Province is underpinned by an extensive institutional, policy, and legal framework that reflects strong normative commitment to environmental protection, sustainable development, and climate resilience. Federal restructuring has expanded provincial and local responsibilities, creating new opportunities for context-specific environmental governance while also introducing challenges related to coordination, capacity, and enforcement.

This chapter demonstrates that environmental governance challenges in the Province are driven less by the absence of policies and more by weaknesses in policy coherence, institutional performance, and implementation effectiveness. High policy density across environmental themes contrasts with persistent gaps in enforcement, fragmented mandates across governance levels, limited technical and financial capacity at sub-national levels, and weak integration of environmental considerations into sectoral development decisions.

At the same time, Gandaki Province is well positioned to advance governance reforms that can significantly improve environmental outcomes. Strengthening function-based coordination, mainstreaming environmental and climate considerations into planning and budgeting, enhancing sub-national capacity and data systems, and institutionalizing inclusive and participatory governance approaches represent key pathways for reform. Strategic partnerships with development partners, civil society organizations, and community institutions further offer opportunities to translate policy commitments into tangible results.

The governance reform priorities outlined in this chapter provide a practical roadmap for the period 2025–2030 **(Annex A6)**, linking governance improvements directly to environmental performance, resilience, and equity. Effective implementation of these reforms will be critical for addressing the environmental trends and risks documented in subsequent thematic chapters of this State of Environment report and for supporting Gandaki Province's transition toward more coherent, resilient, and inclusive environmental governance.

Chapter 6. Key Environmental Issues

6.1 Atmosphere and Air Quality

6.1.1 Atmosphere

The atmospheric environment of Gandaki Province is shaped by its exceptional altitudinal variation, extending from the subtropical lowlands at about 110 m above sea level to the high Himalayan and trans-Himalayan regions exceeding 8,000 m. This extreme vertical range creates strong gradients in temperature, precipitation, wind systems, radiation balance, and atmospheric circulation. As a result, the province represents one of the most climatically complex and environmentally sensitive regions of Nepal.

The atmosphere functions as the primary regulator of climate, hydrological processes, ecosystem dynamics, disaster risk, and air quality. Variations in atmospheric temperature, circulation, and stability directly influence rainfall patterns, snow and glacier behaviour, forest fire occurrence, and the dispersion or accumulation of air pollutants. Therefore, assessing atmospheric conditions provides the scientific foundation for understanding both climate-related risks and air quality conditions in Gandaki.

In the SoE context, “Atmosphere” refers to the broader climatic and physical system, including temperature regimes, circulation processes, aerosols, and extreme events. “Air Quality,” discussed in the subsequent section, represents a specific component of this system, focusing on pollutant concentrations and their implications for human health and the environment.

6.1.2 Atmospheric Characteristics

Atmospheric processes in Gandaki Province are strongly controlled by its rugged topography and landscape. Mountain–valley systems dominate air movement, creating complex local circulation patterns that differ significantly from those of the open plains. Key characteristics include:

- Valley and slope winds that transport air masses between lowlands and higher elevations,
- Mountain–plain circulation that influences temperature and humidity contrasts, and
- Frequent temperature inversions in enclosed basins such as Pokhara Valley, where cold air becomes trapped below warmer air layers, restricting vertical mixing.

These processes create spatial variability in atmospheric stability and ventilation. During stable conditions, especially in winter, valleys become highly susceptible to haze formation and accumulation of aerosols and pollutants. In contrast, periods of strong convection and rainfall promote effective atmospheric cleansing. The province experiences four distinct seasonal atmospheric regimes:

- **Winter (December–February):** Characterized by stable atmospheric conditions, low wind speeds, frequent temperature inversions, and weak vertical mixing. These conditions favour the accumulation of aerosols and haze in valleys and basins.
- **Pre-monsoon (March–May):** Marked by rising temperatures, increased convective instability, strong surface heating, dust transport, and high incidence of forest fires. This season contributes significantly to atmospheric aerosol and black carbon loading.
- **Monsoon (June–September):** Dominated by strong vertical mixing and heavy rainfall. Wet deposition efficiently removes aerosols and pollutants from the atmosphere, resulting in the cleanest atmospheric conditions of the year.
- **Post-monsoon (October–November):** Characterized by clear skies, improved visibility, and relatively stable atmospheric conditions with gradually declining humidity.

These seasonal regimes control not only climatic variability but also the dispersion, accumulation, and removal of atmospheric pollutants, thereby forming a direct link between atmospheric dynamics and air quality in Gandaki Province.

6.1.3 Temperature and Thermal Regime by Physiography

Temperature variation in Gandaki Province is primarily governed by altitude and physiographic setting. The province exhibits one of the strongest temperature gradients in Nepal, with both maximum and minimum temperatures decreasing systematically with elevation (Adhikari and Mathema, 2023; DHM, 2024b). This gradient is a fundamental indicator of climate sensitivity and environmental vulnerability.

Terai and Inner Terai (Lowland River Valleys)

Elevation: approximately 300–600 m

- Summer maximum temperature: 35–40 °C
- Winter minimum temperature: 7–12 °C

These areas experience intense summer heat and an increasing frequency of heat extremes. Thermal stress is becoming a significant concern for public health, agriculture, and water demand. Lowland areas are becoming hotter and more thermally stressful, increasing vulnerability of human health and agricultural productivity.

Siwalik (Chure) Hills

Elevation: approximately 600–1,500 m

- Summer maximum temperature: 30–35 °C
- Winter minimum temperature: 5–10 °C

This zone acts as a climatic transition belt between the lowlands and middle mountains, with high diurnal temperature variation and sensitivity to land-use change. Rising temperatures increase the risk of forest fires and soil moisture stress, particularly during the dry and pre-monsoon seasons.

Middle Mountains

Elevation: approximately 1,500–2,500 m

- Summer maximum temperature: 25–30 °C
- Winter minimum temperature: 0–5 °C

Although this region historically enjoyed moderate temperatures, increasing night-time warming and strong valley inversion effects are becoming more evident, especially in enclosed basins such as Pokhara Valley. Climatic moderation is being replaced by increasing thermal variability and warming nights, influencing crop cycles, human comfort, and atmospheric stability.

High Mountains

Elevation: approximately 2,500–4,000 m

- Summer maximum temperature: 10–20 °C
- Winter minimum temperature: –5 to –15 °C

This zone is highly sensitive to climate change. Small increases in temperature have large impacts on snow persistence, permafrost conditions, and alpine ecosystems. Elevation-dependent warming is shifting snowlines and altering alpine ecological processes.

High Himalaya and Trans-Himalaya (Manang and Mustang)

Elevation: above 4,000 m

- Summer maximum temperature: 5–15 °C

- Winter minimum temperature: –15 to –30 °C

These areas experience a cold desert climate with intense solar radiation and strong sensitivity of glaciers and snowfields to atmospheric warming. Despite low absolute temperatures, this region is highly vulnerable to climate warming, with serious implications for glaciers, water resources, and traditional livelihoods.

Table 6-1. Comparative Summary of Elevation and Temperature Variation

Physiographic Region	Elevation (masl)	Max Temp (°C)	Min Temp (°C)	Key Atmospheric Concern
Terai / Inner Terai	<100–600	35–40	7–12	Heat stress
Siwalik Hills	600–1,500	30–35	5–10	Fire risk
Middle Mountains	1,500–2,500	25–30	0–5	Inversion & variability
High Mountains	2,500–4,000	10–20	–5 to –15	Snowline shift
High Himalaya / Trans-Himalaya	>4,000	5–15	–15 to –30	Glacier retreat

This strong temperature gradient reflects the phenomenon of elevation-dependent warming observed across the Himalaya and highlights the high climate sensitivity of the Province.

6.1.4 Emerging Atmospheric Issues

Several atmospheric trends are becoming increasingly evident in Gandaki Province (Adhikari and Mathema, 2023; DHM, 2024b; Khadka et al., 2023):

- Rising atmospheric temperatures, particularly in high-altitude regions, consistent with Himalayan warming patterns.
- Increased climate variability, including prolonged dry spells, heat extremes, and more intense rainfall events.
- Enhanced aerosol and black carbon loading, especially during winter and pre-monsoon seasons, affecting atmospheric radiative balance and snow albedo.
- Changing cloud formation and precipitation characteristics, influencing hydrology, agriculture, and ecosystem processes.

Black carbon deposition on snow and glaciers reduces surface reflectivity and accelerates melting, linking atmospheric pollution directly with cryosphere degradation and downstream hydrological changes.

6.1.5 Implications for Environment and Society

Atmospheric change in Gandaki Province has wide-ranging impacts (Avis, 2024):

- **Cryosphere:** Accelerated glacier retreat and reduced snow persistence affect river flow regimes and long-term water security.
- **Ecosystems:** Altered phenology, increasing forest fire risk, and stress on alpine and forest ecosystems.
- **Disaster Risk:** Greater atmospheric instability contributes to extreme rainfall, floods, landslides, and drought stress.
- **Public Health:** Rising temperatures increase heat stress, while stable atmospheric conditions increase vulnerability to air pollution episodes.

- **Livelihoods and Tourism:** Climatic uncertainty affects agricultural productivity and reduces the reliability of tourism dependent on clear visibility and stable weather.

The atmospheric system of the province remains relatively clean in remote and high-altitude areas but is increasingly stressed by rising temperatures, climate variability, and aerosol loading. Elevation-dependentwarming, enhanced black carbon deposition, and growing frequency of extreme weather events are emerging as major atmospheric challenges. Strengthening climate and atmospheric monitoring, integrating atmospheric risks into land-use and disaster planning, and promoting climate-resilient development practices are essential to safeguard environmental sustainability and human well-being in the province.

6.1.6 Air Quality

Air quality of the province reflects a contrast between relatively clean background conditions in high mountain and remote rural areas and localized pollution hotspots in urban valleys and along major transport corridors (Sadavarte et al., 2019). The dominant air pollutant is particulate matter, particularly fine particulate matter ($PM_{2.5}$), which poses the greatest risk to human health and the environment.

Nepal is ranked among the most polluted countries in the world based on satellite-derived $PM_{2.5}$ concentrations (Sadavarte et al., 2019). The national population-weighted annual mean $PM_{2.5}$ concentration lies in the low-40 µg/m³ range, which is several times higher than the World Health Organization (WHO) guideline. Long-term exposure to $PM_{2.5}$ is estimated to reduce average life expectancy in Nepal by about 3.4 years. This national context provides a critical background for understanding air quality conditions in Gandaki Province.

Air quality in the province is strongly controlled by atmospheric processes discussed above. Temperature inversions, valley enclosure, weak winter ventilation, forest fires in the pre-monsoon season, and the cleansing effect of monsoon rainfall determine whether pollutants accumulate or are dispersed. Thus, air quality represents the combined outcome of emission sources and atmospheric dynamics.

National Ambient Air Quality Standards and Benchmarks

The National Ambient Air Quality Standards (NAAQS) in 2012 provide permissible limits for major air pollutants to protect public health and the environment. These standards cover particulate matter, trace gases, heavy metals, and toxic organic compounds. Comparison with the World Health Organization (WHO) guidelines shows that Nepal's standards (GOVN, 2012) are generally less stringent, reflecting capacity constraints and gradual policy transition (***Table 6-2***).

Table 6-2. National Air Quality Standards (2012)

SN	Parameter	Unit	Averaging Time	Nepal Standard	WHO Guideline (2021)
1	$PM_{2.5}$	µg m⁻³	24-hour	40	15
2	PM_{10}	µg m⁻³	24-hour	120	45
3	TSP	µg m⁻³	24-hour	230	–
4	Ozone (O_3)	µg m⁻³	8-hour	157	100
5	Sulphur Dioxide (SO_2)	µg m⁻³	Annual	50	–
			24-hour	70	40
6	Nitrogen Dioxide (NO_2)	µg m⁻³	Annual	40	10
			24-hour	80	25

SN	Parameter	Unit	Averaging Time	Nepal Standard	WHO Guideline (2021)
7	Carbon Monoxide (CO)	μg m^{-3}	8-hour	10,000	4
8	Lead (Pb)	μg m^{-3}	Annual	0.5	–
9	Benzene	μg m^{-3}	Annual	5	–

These standards form the regulatory benchmark for air quality management in the province. However, in practice, systematic enforcement and spatial coverage of monitoring remain limited, especially outside major urban centers. This shows that even when national standards are met, air quality may still pose health risks according to international benchmarks. The large gap between NAAQS and WHO values highlights the need for more stringent long-term air quality management.

Air Quality Monitoring Network and Data Availability

From 2016 to June 2021, the total number of air quality monitoring stations in Nepal reached 27, including a black carbon monitoring station at Yala, Langtang (DOE, 2021). In Gandaki Province, continuous ground-based monitoring is concentrated mainly in Pokhara Valley, where three automatic stations are operational:

- Pokhara GBS
- Pokhara DHM
- Pokhara University

These stations provide the principal empirical basis for provincial air quality assessment. Outside Pokhara, systematic monitoring is very limited. Air quality conditions in other districts must therefore be interpreted using satellite-derived $PM_{2.5}$ maps, land-use patterns, population density, transport corridors, household fuel use, and forest fire occurrence. This uneven monitoring coverage represents a major limitation for comprehensive air quality assessment in Gandaki Province.

Current Status of Air Quality

Monitoring data from Pokhara Valley clearly indicate that particulate pollution is the dominant air quality concern. $PM_{2.5}$ concentrations show strong seasonal variation (DOE, 2021).

Table 6-3. Current status of Air-Quality of Pokhara Valley (2021)

Station	Monsoon (μg/m³)	Dry season (μg/m³)
Pokhara DHM	≈ 20.8	≈ 43.4
Pokhara GBS	≈ 15.2	≈ 35.2
Pokhara University	≈ 10.9	≈ 39.6

These values show that:

- During the monsoon, $PM_{2.5}$ levels remain close to or slightly above WHO guidelines but mostly below the national standard.
- During the dry season, $PM_{2.5}$ frequently exceeds WHO guidelines and in some cases approaches or exceeds the NAAQS value of 40 μg/m³.

This confirms that air pollution in Gandaki Province is a seasonally intensified problem, with the highest risk occurring in winter and pre-monsoon periods when dispersion is weak and emissions accumulate in valley environments. Gaseous pollutants such as NO_2, SO_2, and CO are generally lower than particulate pollution but show increasing levels along traffic-dense corridors (Sadavarte et al., 2019).

Spatial and Seasonal Patterns

The air quality profile of Gandaki Province is defined by a sharp geographical contrast and a heavy reliance on seasonal meteorological cycles (***Figure 6-1***). While the high mountain and trans-Himalayan districts maintain lower background pollutant levels, the southern, more urbanized regions particularly Pokhara Valley experience significantly higher concentrations of PM2.5. These spatial distributions are further modulated by four distinct seasonal regimes: the monsoon serves as a critical "cleansing" period due to wet deposition, whereas the winter and pre-monsoon months trigger acute pollution episodes. During these drier months, the combination of frequent temperature inversions, weak vertical mixing, and the episodic influx of smoke from forest fires traps pollutants within valley basins, often pushing concentrations toward or beyond national air quality benchmarks. Satellite-derived $PM_{2.5}$ maps show that:

- Southern and urbanized parts of the province experience higher $PM_{2.5}$ concentrations.
- High mountain and trans-Himalayan districts maintain lower background levels.

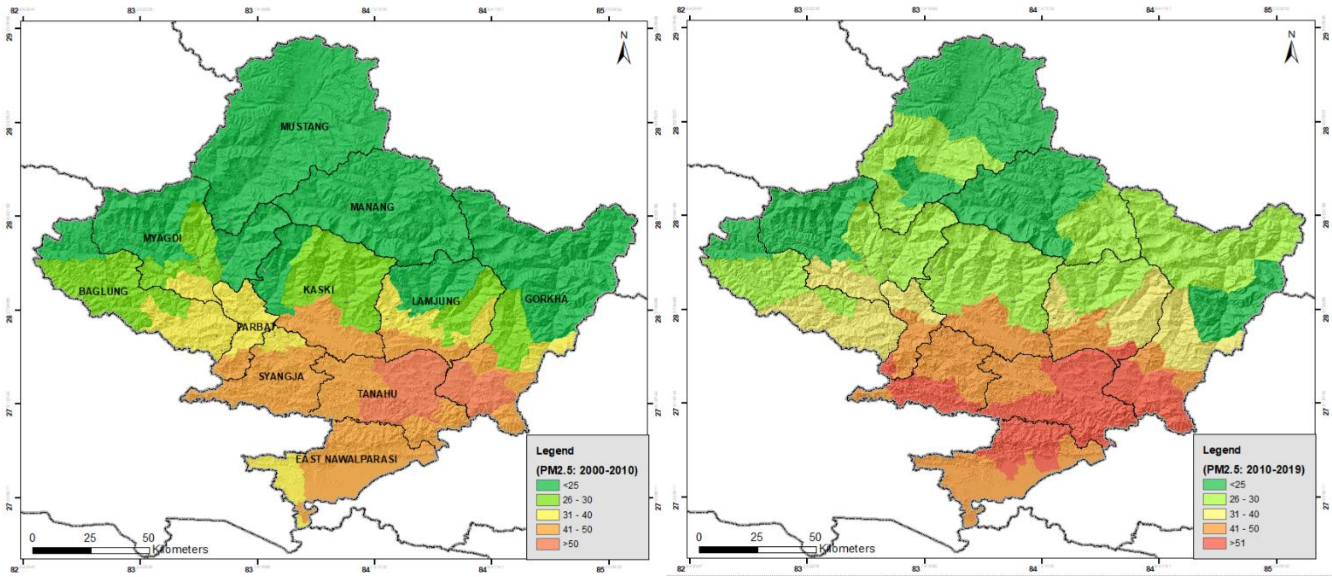


Figure 6-1. Pre-monsoon Season Air Quality Map of Gandaki Province; left: PM2.5 (2000-2010) and right PM2.5 (2011-2019); derived from Satellite Imagery).

However, the maps also indicate that no area is completely isolated from pollution, as forest-fire smoke and regional aerosol transport affect even remote regions.

Seasonally:

- **Winter and pre-monsoon**: highest pollution due to inversion, dry conditions, forest fires, and weak winds.
- **Monsoon**: lowest pollution due to rainfall and strong atmospheric mixing.
- **Post-monsoon**: transitional conditions with gradual pollution buildup.

6.1.7 Major Sources of Air Pollution

Vehicular Emissions

Transport is one of the most important and rapidly growing pollution sources in Gandaki Province. Although motorcycles dominate in number, diesel-powered buses, trucks, tractors, and construction machinery dominate $PM_{2.5}$ and NO_x emissions (EEA, 2025).

One diesel bus or truck can emit as much $PM_{2.5}$ as several hundred petrol cars. In Pokhara Valley, where traffic density is high and dispersion is restricted by inversion layers, vehicular emissions are the dominant driver of wintertime pollution peaks. Vehicular emissions represent the most critical controllable source of

$PM_{2.5}$ in urban Gandaki. The public domain is from the Transport Management Office (Kaski) as reported in national media: 318,372 vehicles registered in Gandaki Province (as of Oct 2024). According to the Transport Management Office the fleet composition (***Table 6-5***), which is useful for explaining emissions patterns.

Table 6-4. Estimated Pollutants of Vehicular Emission

Vehicle type	$PM_{2.5}$ (g/km)	NO_x (g/km)	CO (g/km)
Petrol car	0.005–0.02	0.2–0.5	1.5–3.5
Motorcycle	0.01–0.03	0.1–0.3	5–12
Diesel car	0.05–0.15	0.6–1.5	0.3–0.8
Diesel bus/truck	0.2–1.0	4–12	1–3

Table 6-5. Registered Vehicles in Gandaki Province (Oct 2024)

Type of Vehicles	No (Oct 2024)
Motorcycles/scooters	249,438
Cars/jeeps/vans	20817
Buses/minibuses/mini-trucks	10846
Microbuses	14513
Tractors & power tillers	12212
Heavy equipment & trucks (incl. excavators/dozers/cranes)	7089
Pickup vans	3410
Tempos	47
Electric vehicles registered (since FY 2018/19)	990

- Gandaki's fleet is two-wheeler dominated. That matters because two-wheelers, even when individually "small", can collectively contribute a lot to CO, hydrocarbons (VOCs), and secondary PM formation when numbers are high, especially with older engines and weak inspection/maintenance.
- A smaller fraction of the fleet such as diesel buses, trucks, and construction/heavy equipment typically drives a disproportionate share of PM2.5 and NOx (the pollutants most linked to haze and health risk), particularly when engines are older or poorly maintained.

Household Fuelwood and Biomass Combustion

Despite increasing electrification, many households still rely on firewood and biomass for cooking and heating. Typical emission factors (Sadavarte et al., 2019):

Table 6-6. Emission Factor for HH Fuelwood and Bio-mass Combustion

Pollutant	Emission factor
$PM_{2.5}$	5–12 g per kg of wood
CO	60–120 g per kg
Black carbon	0.3–1 g per kg

If a household burns 3 kg of firewood per day, it emits:

- $PM_{2.5}$: 15–36 g/day

- Black carbon: up to 3 g/day

This is comparable to the daily $PM_{2.5}$ emissions of hundreds of petrol vehicles. Household fuelwood combustion is a major background source of $PM_{2.5}$ and black carbon, especially in winter and in rural and peri-urban areas.

Industrial and Construction Activities

Industrial and construction activities also produce a considerable amount of emissions in the province (***Table 6-7*****).** The table below present the likely emission from different activities in industrial and construction sector (EEA, 2025; Sadavarte et al., 2019).

Table 6-7. Possible Emission in Industrial and Construction Activities

Source	Typical $PM_{2.5}$ emission
Diesel generator	1–5 g per kWh
Brick kiln (traditional)	0.5–2 kg per 1,000 bricks
Heavy construction machinery	0.3–1.2 g per km-equivalent

Rapid urban expansion in Pokhara and infrastructure development increase dust and combustion emissions, particularly during the dry season. Construction and small industries significantly intensify urban particulate pollution (Pandey et al., 2024).

Forest Fires

Forest fires are the most important episodic source of air pollution in Gandaki Province. According to the Bipad-Portal, 153 forest fire incidents (2021-2024) occurred in the province. It has been identified that forest fire is one of the major sources of air pollution. The emission from forest fire is considerable; however, it is difficult to estimate as the report does not mention the forest destroyed by the fire. The table (***Table 6-8***) presents the likely emissions per square kilometer of area (Baasansuren et al., 2019; Sadavarte et al., 2019).

Table 6-8. The Likely Emission From Forest Fire

Parameter	Emission per km^2 burned
$PM_{2.5}$	6–20 tonnes
Black carbon	0.2–1 tonne
CO	100–300 tonnes

A single moderate forest fire can emit more $PM_{2.5}$ than all vehicles in the province emit over several weeks. Smoke affects both urban valleys and remote mountain areas. Forest fires dominate short-term air quality degradation and link climate variability directly with pollution episodes.

Construction-Induced Air Pollution

Construction activity is emerging as a major *local* driver of air pollution in Gandaki, particularly in fast-urbanizing municipalities and along strategic road corridors. The most visible pathway is construction dust generated from excavation, earthworks, cutting and filling, demolition, stockpiling of sand/aggregate, and especially from vehicle movement on dusty or damaged road surfaces. In addition, construction machinery (mixers, generators, excavators, loaders) and material transport trucks contribute to combustion emissions, but in many municipalities the dominant day-to-day nuisance is the coarse dust fraction (TSP/PM10) that becomes airborne and is repeatedly re-suspended.

Pokhara Valley: high exposure near highways and repair/construction zones.

Recent in-situ measurements from Pokhara (peak pollution season, April 2024) show that particulate pollution at busy roadside/workplace locations is extremely elevated (Regmi et al., 2024). Regmi et al.

(2024) reported that, across 10 sampling sites, the measured average PM2.5 = 201.4 μg/m³ and PM10 = 98.3 μg/m³; on the same day, the reported city-wide average was PM2.5 = 190 μg/m³ and PM10 = 71 μg/m³. The study notes that highway and high-traffic sites showed higher particulate levels and highlights the likely roles of heavy-vehicle movement and construction materials used in highway repairs in increasing particulate loading, in addition to traffic emissions. This pattern is consistent with local urban conditions where road widening, drainage works, utility trenching, and periodic repairs occur alongside dense traffic flows and limited dust suppression during the dry season.

Seasonality matters: rainy-season monitoring can understate dust risk.

A road ESIA (PMC, 2019) monitoring record from the Pokhara corridor (Talchowk area, June 2019) reported relatively low 24-hour concentrations (TSP 24.54 μg/m³, PM10 22.08 μg/m³, PM2.5 17.17 μg/m³) and explicitly notes that rainfall during monitoring likely reduced measured pollutants ("washed away" airborne particles). This illustrates why dry-season monitoring and construction-phase spot checks are important: dust impacts typically intensify during winter and pre-monsoon months, when surfaces are dry, winds increase resuspension, and road works often accelerate.

Box 1: Dust Pollution from Roads: Impacts in Kathekhola–Bihukot, Baglung

In Kathekhola Rural Municipality, residents have endured persistent dust pollution linked to unfinished and unpaved road sections along a key segment of the Mid-Hill Highway (Khahare–Ghodabandhe road). This 20-kilometre stretch connects remote wards of Kathekhola to the Baglung district headquarters but has remained incomplete for decades, creating chronic air quality problems in surrounding communities. Because vehicles must travel frequently on the dry, unsealed surface, clouds of dust cover nearby homes, fields, and village centres. Residents describe the dust as a permanent feature blanketing vegetation, contaminating food, and reducing visibility and say it has led to respiratory problems, allergies, eye irritation, and other health complaints among children, older people, and those with chronic illnesses.

Locals also report that the dust is not only a nuisance but a barrier to daily life and economic activity. Agriculture and dairy products produced in the area (estimated locally at tens of millions of rupees annually) are harder to market because of road conditions, and some households have even relocated to escape the dust and associated health burdens.

The ongoing problem links directly to inadequate road construction and maintenance, including repeated contract delays and unfinished blacktopping of key sections. These conditions mean that dry season dust generation is a persistent source of local air pollution around Kathekhola and Bihukot villages. Environmental and health impacts include:

- **Air quality degradation:** Visible dust layers on homes and vegetation and daily exposure to airborne particles.
- **Community health concerns:** Reported increases in breathing difficulties, coughing, and allergies, especially in children and the elderly.
- **Livelihood disruptions:** Agricultural produce and daily activities are disrupted by dust settling in fields and homes.

This case highlights how infrastructure gaps especially incomplete road works can become significant local sources of air pollution, with both health and economic consequences for rural communities in Gandaki Province.

Road construction and dust in Baglung and the mid-hill corridors.

In Baglung Municipality, a road upgrading ESMP reports 24-hour averages of TSP 154.1 μg/m³, PM10 67.8 μg/m³, and PM2.5 18.6 μg/m³ in the project area (BM, 2024). The comparatively high TSP/PM10 values suggest a dust-dominated profile typical of road works and resuspension especially relevant for hill towns where steep gradients, frequent surface disturbance, and heavy truck movement can amplify dust emissions. Community-facing impacts are repeatedly reported along corridors where roads remain unsealed or repeatedly damaged; for example, local reporting from Kathekhola (Baglung) describes persistent dust exposure and associated health complaints linked to a long-unfinished road, while reporting on the Pokhara–Baglung highway warns of worsening dust problems during the dry season when road conditions deteriorate (Baral, 2024).

Other growing municipalities: Kawasoti, Waling, Palungtar, Gorkha:

Although routine station-based monitoring is limited outside major hubs, the construction dust mechanism is highly relevant to rapidly growing municipalities such as Kawasoti, Waling, Palungtar and Gorkha, where municipal road upgrading, building construction, riverbed material use, and corridor traffic are increasing. In these towns, the most important exposure settings are typically: (i) roadside residences and schools along upgrading sections, (ii) market areas where construction materials are stored and handled, and (iii) corridors with heavy vehicles transporting sand/aggregate. In the absence of continuous local measurements, the SoE can flag these municipalities as data gaps + priority monitoring locations, because the exposure pathway is clear and the potential for preventable harm is high.

6.1.8 Relative Importance of Sources

Emission is highly variable according to source. Following table (***Table 6-9***) presents importance of spatial and temporal emission from different sources (Baasansuren et al., 2019; Hoffmann et al., 2021; Sadavarte et al., 2019).

Table 6-9. Spatial and Temporal Importance of Different Emission Sources

Source	Spatial influence	Temporal pattern	Main pollutants
Vehicles	Urban & highways	Chronic, winter peaks	$PM_{2.5}$, NO_x
Fuelwood	Rural & peri-urban	Chronic, winter	$PM_{2.5}$, BC
Construction/industry	Urban	Dry season	PM_{10}, $PM_{2.5}$
Forest fires	Province-wide	Pre-monsoon	$PM_{2.5}$, BC, CO

6.1.9 Atmosphere vs Air Quality

Although atmosphere and air quality are closely linked, they represent different dimensions of the environmental system and must be treated distinctly. The atmosphere refers to the broader climatic and physical system that controls temperature, precipitation, circulation, radiation balance, aerosols, and extreme weather. It operates at provincial to regional scales and determines long-term climate trends, disaster risk, cryosphere dynamics, and ecosystem functioning.

Air quality, in contrast, refers to the concentration of pollutants in the ambient air and the degree to which they affect human health and ecosystems. It is largely a local to urban-scale issue and is directly influenced by emission sources and short-term atmospheric conditions.

Table 6-10. Different Aspects of the Atmosphere and Air Quality

Aspect	Atmosphere	Air Quality
Primary focus	Climate, circulation, radiation, aerosols	Pollutant concentration and exposure
Spatial scale	Provincial to regional	Local to urban

Aspect	Atmosphere	Air Quality
Time scale	Long-term trends and extremes	Short-term variability and episodes
Key issues	Warming, climate variability, black carbon, extreme events	$PM_{2.5}$, PM_{10}, NO_2, CO, combustion emissions
Main drivers	Climate change, topography, land–atmosphere interaction	Transport, fuel combustion, construction, fires
Policy focus	Climate change adaptation and mitigation	Pollution control and public health protection

The atmosphere provides the physical setting within which air pollution either disperses or accumulates. Poor air quality in Gandaki Province is therefore not only a result of emission sources but also of atmospheric conditions such as temperature inversions, weak ventilation, and seasonal circulation patterns. Effective environmental management requires addressing both climate–atmosphere processes and air pollution sources together, rather than treating them as separate problems.

6.1.10 Environmental Implications of Atmosphere and Air Quality

The atmospheric system and air quality conditions of Gandaki Province have direct and long-term implications for its natural environment (Avis, 2024; Karki et al., 2016; Sadavarte et al., 2019). Because the province spans from lowland river valleys to high Himalayan and trans-Himalayan zones, atmospheric change affects multiple ecological systems simultaneously. The combined influence of warming temperatures, changing circulation patterns, aerosol loading, and particulate pollution is reshaping ecosystem processes, cryosphere dynamics, hydrology, and overall environmental stability.

Health and Environmental Implications

Air quality is critically important because the dominance of $PM_{2.5}$ pollution poses serious risks to both human health and the environment (DOE, 2021; Hoffmann et al., 2021). Fine particulate matter penetrates deep into the lungs and bloodstream, increasing the incidence of respiratory and cardiovascular diseases, while children, the elderly, and outdoor workers face especially high exposure and vulnerability. Poor air quality also reduces visibility, diminishing the aesthetic value of landscapes and negatively affecting tourism. Beyond human health, $PM_{2.5}$ settles on forests, crops, and fragile alpine ecosystems, impairing ecological health and agricultural productivity. Most concerning, black carbon particles deposited on snow and glaciers darken their surfaces, increasing heat absorption and accelerating melting, which intensifies climate change impacts and threatens long-term water security. Together, these effects highlight that improving air quality is not only a public health priority but also essential for environmental protection, climate resilience, and sustainable development. Dominance of $PM_{2.5}$ pollution leads to:

- Increased respiratory and cardiovascular diseases
- Higher exposure risk for children, elderly, and outdoor workers
- Reduced visibility affecting tourism
- Deposition of pollutants on forests, crops, and alpine ecosystems
- Black carbon deposition on snow and glaciers, accelerating melting

Thakmarpha Jomsom

One of the most critical environmental implications relates to the cryosphere. Rising atmospheric temperatures and increased black carbon deposition accelerate the melting of glaciers and seasonal snow cover in high mountain districts such as Manang and Mustang (Adhikari and Mathema, 2023; DHM, 2023; DOE, 2021). Black carbon reduces the albedo of snow and ice surfaces, causing them to absorb more solar radiation and melt faster. This has several consequences:

- Reduced glacier mass balance and faster glacier retreat
- Changes in seasonal river flow patterns

- Increased risk of glacial lake outburst floods (GLOFs)
- Long-term uncertainty in water availability for downstream irrigation, hydropower, and domestic use

Thus, atmospheric pollution and warming directly affect the hydrological security of the entire Gandaki river system.

Impacts on Forests and Terrestrial Ecosystems

Atmospheric change and air pollution place increasing stress on forest ecosystems, which cover a large portion of Gandaki Province.

- Rising temperatures and prolonged dry periods increase forest fire risk, particularly in the Siwalik, middle mountain, and hill regions.
- Forest fires not only degrade forest biodiversity and soil quality but also create a feedback loop by releasing massive amounts of $PM_{2.5}$, black carbon, and greenhouse gases back into the atmosphere.
- Deposition of particulate matter on leaves reduces photosynthetic efficiency and weakens plant health.
- Changing temperature and precipitation regimes alter vegetation composition and species distribution, particularly in sensitive alpine and sub-alpine ecosystems.

These changes threaten forest productivity, biodiversity conservation, and ecosystem services such as carbon sequestration and soil stabilization.

Impacts on Agricultural Systems

Atmospheric conditions strongly influence agricultural productivity in the Province.

- Increasing temperature variability affects crop growing seasons and phenology.
- Heat stress reduces crop yields in lowland and inner-Terai areas.
- Frost risk in higher elevations remains a threat to winter crops.
- Deposition of airborne pollutants on crop surfaces can reduce photosynthesis and contaminate food products.
- Altered precipitation patterns increase vulnerability to droughts and intense rainfall events, both of which damage crops and farmland.

Together, these changes undermine agricultural stability and food security, especially for smallholder farmers.

Impacts on Aquatic and Freshwater Ecosystems

Airborne pollutants eventually settle into rivers, lakes, and wetlands through dry and wet deposition.

- Particulate matter and associated chemicals can degrade water quality.
- Increased sedimentation following forest fires and heavy rainfall affects aquatic habitats.
- Changes in temperature and hydrological flow alter aquatic species composition.

In sensitive water bodies such as Phewa Lake and other mid-hill lakes, atmospheric deposition and changing rainfall patterns can accelerate eutrophication and ecosystem degradation.

Impacts on Biodiversity and Habitat Stability

Gandaki Province hosts a wide range of biodiversity due to its altitudinal diversity. Atmospheric change threatens this balance:

- Shifts in temperature zones force species migration to higher elevations.
- Alpine species face habitat contraction as suitable climate zones shrink.
- Increased frequency of forest fires destroys wildlife habitats.
- Air pollution stress weakens plant resilience and increases vulnerability to pests and diseases.

These processes can lead to long-term loss of biodiversity and ecosystem instability.

Impacts on Landscape Stability and Soil Systems

Atmospheric instability, particularly intense rainfall events, increases erosion, landslides, and slope failure risks.

- Heavier rainfall events increase soil loss in middle mountain and Siwalik regions.
- Deforestation combined with atmospheric stress accelerates land degradation.
- Dust generation from exposed soils contributes to particulate pollution, forming a feedback between land degradation and air quality.

Thus, atmospheric change and land degradation reinforce each other.

Impacts on Tourism and Scenic Environment

The natural landscape and clear mountain visibility are central to tourism in Gandaki Province.

- Haze, dust, and smoke from forest fires reduce scenic visibility.
- Degradation of snow and glacier landscapes diminishes aesthetic and recreational value.
- Increased climatic unpredictability reduces tourism reliability.

Air quality degradation, therefore, directly affects the environmental economy of the province.

6.1.11 Future Outlook

Air quality in Gandaki Province is already highly seasonal and strongly controlled by topography and weather. Data from the Department of Environment (DoE) show that particulate matter ($PM_{2.5}$) concentrations in Pokhara are consistently much higher in winter and pre-monsoon months than during the monsoon. In most years, monsoon $PM_{2.5}$ levels fall close to or below national standards, while winter values frequently exceed both the National Ambient Air Quality Standards and WHO guideline values. This confirms that pollution in Gandaki is not uniform throughout the year but is dominated by short periods of very poor air quality.

The Department of Hydrology and Meteorology (DHM) climate projections indicate rising temperatures, more intense heat during pre-monsoon, and increasing variability in rainfall patterns. These changes are important for air quality because warmer and drier conditions favor dust generation, forest fires, and longer periods of stagnant air. At the same time, Bipad Portal records show that forest fire incidents peak in March–May and have shown an increasing tendency in recent years, directly corresponding with the worst air quality episodes reported by air quality stations and satellite observations. Therefore, future air quality in Gandaki will depend on three interacting factors:

- how fast emissions from transport, construction, and households increase or decrease,
- how climate change modifies temperature, rainfall, and fire risk, and
- how effectively monitoring and management systems are strengthened.

On this basis, four realistic future scenarios can be described.

Scenario 1: Business-as-usual – "Clean monsoon, polluted dry season"

Under a business-as-usual future, current trends continue with only gradual improvements. Urbanization, road expansion, and vehicle numbers increase steadily, while emission controls and clean energy adoption improve slowly.

In this scenario, DoE data patterns observed today continue into the future. Pokhara's $PM_{2.5}$ concentrations would remain lowest during June–September and highest during December–February and March–May. Winter inversions will still trap pollution in valley cities. Key features of this scenario are:

- Annual average air quality improves only slightly, but peak pollution episodes become more frequent.
- Winter $PM_{2.5}$ levels remain the main health concern, often exceeding national standards.
- Pre-monsoon forest fires recorded in the Bipad Portal and the Nepal Forest Fire Detection System continue to cause sharp pollution spikes.
- Air quality improvements during monsoon hide the seriousness of dry-season exposure when annual averages are used alone.

This scenario reflects what is already visible in Pokhara today: relatively good air for half the year and very unhealthy air for several weeks during winter and pre-monsoon.

Scenario 2: Managed transition – "Valleys breathe better"

This scenario assumes strong policy intervention and coordinated planning. Transport electrification accelerates, public transport improves, construction dust is regulated, and clean cooking energy expands rapidly.

In this future, DoE monitoring would show a visible reduction in winter $PM_{2.5}$ peaks, even if monsoon levels remain similar to today. The difference between dry and wet seasons would shrink. Main characteristics include:

- A declining winter-to-monsoon $PM_{2.5}$ ratio, showing real emission reduction.
- Lower roadside NO_2 concentrations due to cleaner vehicles.
- Shorter and weaker pollution episodes during temperature inversion periods.
- Smoke from forest fires still occurs but starts from a much cleaner background level.

Here, air quality becomes more controlled by weather than by human activity, and Gandaki gains a reputation as a relatively clean and climate-resilient province.

Scenario 3: High-growth, weak control – "Pollution spreads beyond Pokhara"

In this scenario, economic and infrastructure growth is rapid, but environmental regulation remains weak. Construction, road building, and diesel transport expand faster than pollution control systems. Evidence from DoE shows that PM_{10} rises significantly in areas with high construction and traffic. If this continues, several new urban centers in Gandaki may begin to experience pollution levels similar to Pokhara. Key outcomes would be:

- Expansion of pollution hotspots to towns such as Baglung, Kusma, and Besisahar.
- Increased PM_{10} from road dust and construction activities.
- Higher NO_2 along highways and freight corridors.
- Winter haze becoming a province-wide issue, not just a Pokhara problem.

This scenario threatens tourism and public health and weakens Gandaki's environmental image.

Scenario 4: Climate–fire amplified – "Smoke years become normal"

This scenario is driven mainly by climate change rather than local emissions. DHM projections suggest warmer pre-monsoon temperatures and longer dry spells, which increase forest fire risk. Bipad Portal data already show that forest fire incidents are concentrated in March–May and are increasing in extreme years.

- A few weeks of heavy smoke dominate annual exposure.
- $PM_{2.5}$ concentrations during fire events become several times higher than normal background levels.
- High mountain areas that are usually clean also experience smoke intrusion.
- Black carbon deposition increases the risk of snow and glacier melting.

Even with good urban emission control, this scenario shows that air quality will remain vulnerable without strong forest fire management.

6.1.12 DPSIR Analysis for Atmosphere and Air Quality

The DPSIR framework provides a structured approach to understanding the linkages between human activities, atmospheric change, air pollution, and environmental and social consequences.

Drivers

The main drivers influencing atmospheric conditions and air quality in Gandaki Province include:

- **Climate change**, manifested through rising temperatures, increased climate variability, and more frequent extreme weather events.
- **Urbanization and population concentration**, especially in Pokhara Valley and emerging municipal centers.
- **Growth in transport and mobility**, including rapid increase in vehicle numbers and dependence on fossil fuels.
- **Household energy practices**, with continued reliance on fuelwood and biomass in rural and peri-urban areas.
- **Infrastructure development**, including road construction, hydropower projects, and urban expansion.
- **Land-use change and forest degradation**, increasing vulnerability to forest fires and dust emissions.

These drivers operate across scales and interact to intensify both climate stress and air pollution pressures.

Pressures

Drivers create multiple direct pressures on the atmosphere:

- **Emission of air pollutants**, including $PM_{2.5}$, PM_{10}, NO_x, CO, and black carbon from vehicles, households, industries, construction, and forest fires.
- **Greenhouse gas emissions**, contributing to long-term warming trends.
- **Increased aerosol loading**, altering radiation balance and cloud processes.
- **Land–atmosphere feedbacks**, where vegetation loss and soil exposure increase surface heating and dust emissions.
- **Seasonal forest fires**, producing massive episodic emissions of particulates and black carbon.

In valley environments such as Pokhara, limited air circulation and frequent temperature inversions further amplify these pressures.

State

The current state of the atmosphere and air quality in Gandaki Province is characterized by:

- Rising temperatures and increased climate variability, particularly at higher elevations.
- Strong seasonal contrasts in atmospheric stability and ventilation.
- Frequent winter and pre-monsoon $PM_{2.5}$ exceedances in urban valleys.
- Cleaner background air in high mountain regions, but increasing exposure to smoke and regional aerosol transport.
- Growing presence of black carbon in the atmosphere, with implications for snow and glacier melt.

This state reflects a system that is still relatively clean in remote areas but increasingly stressed in urban and climate-sensitive regions.

Impacts

Atmospheric change and air pollution generate compound impacts:

Public health impacts

- Increased respiratory and cardiovascular diseases.
- Higher exposure risks for children, elderly, and outdoor workers.

Disaster risk amplification

- Increased likelihood of floods and landslides due to intense rainfall events.
- Higher forest fire frequency under warmer and drier conditions.

Ecosystem impacts

- Stress on forests and alpine ecosystems.
- Changes in phenology and habitat stability.

Cryosphere impacts

- Accelerated glacier retreat and snowline shift due to warming and black carbon deposition.

Economic and livelihood impacts

- Reduced tourism value from haze and visibility loss.
- Impacts on agriculture and hydropower reliability.

These impacts show that atmospheric change and air pollution are cross-sectoral risks affecting nearly all aspects of development in Gandaki Province.

Responses

Key responses required include:

Strengthening monitoring systems

- Expansion of air quality stations beyond Pokhara Valley.
- Integration of meteorological and air-quality observations.

Cleaner transport systems

- Promotion of electric mobility.
- Stricter vehicle emission standards and inspection systems.

Clean energy transition

- Accelerated adoption of clean cooking technologies.
- Reduction of fuelwood dependence.

Urban and land-use planning

- Protection of ventilation corridors.
- Dust control at construction sites.

Forest fire management

- Early warning systems.
- Community-based forest fire prevention.

Climate integration

- Incorporation of atmospheric risks into Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) planning.

Table 6-11. DPSIR Synthesis – Atmosphere and Air Quality.

DPSIR Element	Description	Key Evidence	Synthesis
Drivers	Long-term forces that create pressure on the atmosphere and air quality	• Climate change and rising temperature • Rapid urbanization (Pokhara & emerging towns) • Growth in vehicle numbers (318,000+ registered vehicles) • Dependence on biomass and LPG for cooking • Infrastructure expansion and land-use change • Increasing forest-fire incidence	These drivers reflect development transition and climate stress. Without policy control, they will continue to intensify pollution and atmospheric instability.
Pressures	Direct stresses placed on the atmosphere	• Emissions of $PM_{2.5}$, PM_{10}, NO_x, CO, Black Carbon • Diesel transport and construction dust • Fuelwood combustion in households • Seasonal forest-fire smoke (6–20 tonnes $PM_{2.5}/km^2$ burned) • Greenhouse gas emissions and aerosol loading • Valley inversion trapping pollutants	Pressures are both chronic (vehicles, fuelwood) and episodic (forest fires). Valley topography amplifies pollution accumulation.
State	Current condition of atmosphere and air quality	• Rising temperature, especially at high elevations • Strong seasonal variation (clean monsoon, polluted winter/pre-monsoon) • $PM_{2.5}$ dry season: ~35–45 µg/m³ in Pokhara • Limited monitoring outside Pokhara • Increasing black carbon presence	The province is still relatively clean in remote areas but urban valleys are increasingly stressed. Pollution is seasonal but structurally persistent.
Impacts	Environmental, social, and economic consequences	**Health:** Respiratory & cardiovascular disease **Cryosphere:** Glacier retreat & snowline shift from warming + black carbon **Disaster risk:** Increased forest fires, floods, landslides **Ecosystems:** Forest stress, alpine habitat shift **Agriculture:** Heat stress & deposition impacts **Tourism:** Reduced visibility and scenic degradation	Air pollution is not only a health issue. It affects water security, hydropower, tourism, biodiversity, and long-term climate resilience. It is cross-sectoral.

The atmospheric system of Gandaki is undergoing rapid change under the combined influence of climate warming, land-use transformation, urbanization, and increasing emission pressures (Bhattarai and Conway, 2020). While remote and high-altitude areas still maintain relatively clean background air, urban valleys and transport corridors are experiencing growing air quality stress, particularly from fine particulate matter ($PM_{2.5}$) (Avis, 2024; Sadavarte et al., 2019).

Atmospheric processes such as temperature inversion, weak winter ventilation, forest-fire smoke transport, and monsoon cleansing play a decisive role in shaping air quality outcomes. Vehicular emissions dominate urban pollution, household fuelwood combustion sustains rural background pollution, and forest fires drive extreme episodic degradation across the province.

From a State of Environment perspective, atmosphere and air quality must be addressed as an integrated system. Climate change is intensifying atmospheric instability and warming, while air pollution is increasing health risks and accelerating cryosphere degradation through black carbon deposition. Without coordinated action, these interacting pressures will increasingly undermine public health, ecosystem stability, disaster resilience, and sustainable development in Gandaki Province.

6.1.13 Baseline Atmosphere and Air Quality

This subsection summarizes the baseline and current state of key atmosphere, air quality, and energy indicators for Gandaki using the best available national and provincial data. Air quality baselines are drawn from a few years' data available, particularly for Pokhara Valley, while conditions in other parts of the province are interpreted using nationally recognized proxy datasets. Energy indicators reflect both infrastructure availability and actual patterns of use, highlighting the gap between access to clean energy and its adoption.

Table 6-12. Baseline Indicators, State and Synthesis

Indicator	Baseline (value & year)	State (value & year)	Synthesis
$PM_{2.5}$ concentration – Pokhara Valley (seasonal mean)	Dry season: ~35–45 µg/m³; Monsoon: ~15–20 µg/m³ (2021, DoE reference year)	Similar seasonal pattern persists (2022, Status of Air Quality Report)	Air quality in Pokhara remains strongly seasonal, with dry-season pollution persistently exceeding WHO guideline values, indicating structural emission sources rather than isolated events.
Ground-based air quality monitoring coverage	Limited to Pokhara; monitoring expansion phase 2016–2021	Continuous monitoring still largely confined to Pokhara (2022)	Spatial monitoring gaps limit understanding of air-quality exposure across lowland corridors and high-mountain districts.
Total installed hydropower capacity located in Gandaki Province	687 MW operational projects (2022, DoED-based provincial inventory)	≈1089 MW (IPPAN production-licence portfolio, incl. private + public, 2025)	Gandaki is one of Nepal's strongest hydropower provinces; differences in reported totals reflect scope (operational vs licensed), not inconsistency.
Mini and micro hydropower capacity (<1 MW)	8.48 MW operational (2022)	Additional ~0.64 MW under construction (2023)	Mini/micro hydro plays a targeted but important role in off-grid and remote-area electrification, particularly in high-mountain districts.
Solar PV capacity (grid-connected & institutional)	9.54 MW operational (2022)	Additional 7.5 MW in survey/licensing phase (2023)	Solar deployment remains modest but strategically important for diversifying clean energy beyond hydropower.
Households with access to electricity	99.5% of households (2021, Census)	Near-universal access maintained (2023)	Electricity access is no longer the limiting factor for energy transition in Gandaki.
Electricity as primary cooking energy	<2% of households (2021)	Early adoption stage; no major increase reported (2023)	A large gap persists between electricity access and its use for clean cooking, limiting air-quality co-benefits.
Primary cooking fuel – firewood	47.1% of households (2021)	Still widely used (2023)	Continued biomass dependence links household energy use with forest pressure and indoor air pollution.
Primary cooking fuel – LPG	51% of households (2021)	Remains dominant (2023)	LPG has displaced kerosene but maintains reliance on fossil fuels.
Total energy consumption (province)	42.1×10^{15} joules (2020)	No newer consolidated provincial total available	Household demand dominates overall energy use.

Indicator	Baseline (value & year)	State (value & year)	Synthesis
Share of residential sector in total energy use	79.1% (2020)	Remains dominant	Residential energy use is the key leverage point for cleaner air and lower emissions.
Petroleum product consumption	FY 2020/21: ~9% of national sales	Increasing trend over last three fiscal years	Rising transport fuel use risks offsetting gains from clean electricity.
Electric vehicles – share of registered vehicles	~0.6% (FY 2022/23)	~1% early progress (FY 2023/24)	EV adoption is emerging but still marginal at provincial scale.
Estimated number of EVs (derived)	~140 EVs (FY 2022/23, estimated)	~230 EVs if ~1% share (FY 2023/24, indicative)	Provides a sense of scale; figures should be treated as indicative pending official EV registry data.

Notes:

1. *Where long-term time-series data are unavailable, the publication year of authoritative national or provincial reports (e.g., DoE 2021; Environment Statistics of Nepal 2024; IPPAN Energy Statistics 2025) is used as the baseline reference year, consistent with State of Environment reporting practice.*
2. *Ground-based air quality indicators are based on measured data from Pokhara Valley, where continuous monitoring exists; for other areas of Gandaki Province, spatial patterns are interpreted using national assessments and proxy indicators.*
3. *Energy indicators combine administrative records, census data, and sectoral inventories, and reflect reported values rather than modeled estimates unless explicitly stated.*

6.1.14 Institutional Arrangements for Atmosphere and Air Quality Management

Institutional Arrangements

Management of atmospheric environment and air quality in Gandaki requires a multi-sectoral and multi-level institutional framework because pollution sources are diverse and interlinked with transport, energy use, industry, construction activities, forest management, and urban services. Effective air-quality governance therefore depends on coordination among federal, provincial, and local institutions.

a) Federal Institutions

Institution	Mandate Relevant to Atmosphere and Air Quality
Ministry of Forests and Environment (MoFE)	National lead agency for environmental protection, climate change policy, and air-quality governance; formulation of national environmental standards, policies, and international reporting obligations.
Department of Environment (DoEnv)	Technical authority for air-quality management; operation and expansion of national air-quality monitoring systems; development of air-quality action plans; formulation of pollution control guidelines and standards.
Department of Hydrology and Meteorology (DHM)	Provision of meteorological and climatological data essential for understanding dispersion patterns, temperature inversion, pollution episodes, heat waves, and climate–air quality interactions.
Ministry of Physical Infrastructure and Transport (MoPIT)	Development of national vehicle emission standards, transport policy, and fuel quality regulations that directly influence urban and roadside air pollution.
Ministry of Energy, Water Resources and Irrigation (MoEWRI)	Promotion of clean energy systems and renewable energy transitions that reduce dependence on biomass and fossil fuels.

Institution	Mandate Relevant to Atmosphere and Air Quality
National Disaster Risk Reduction and Management Authority (NDRRMA)	Coordination of disaster preparedness and response, including forest fires and extreme pollution episodes caused by wildfire smoke and climatic extremes.
Ministry of Health and Population (MoHP)	Monitoring health impacts of air pollution; development of public health advisories during high pollution episodes.

Federal institutions provide the regulatory backbone, technical standards, and national monitoring systems that provincial and local governments build upon.

b) Provincial Institutions

Institution	Mandate Relevant to Atmosphere and Air Quality
Ministry of Forest and Environment, Gandaki Province (MoFE–Gandaki)	Lead provincial agency for environmental protection; implementation of provincial environmental legislation; coordination of air-quality management, climate-change integration, and environmental monitoring initiatives.
Ministry of Industry and Tourism (MoIT), Gandaki Province	Regulation and promotion of industries and tourism-related enterprises; support for cleaner production practices and environmental compliance.
Ministry of Energy, Water Resources and Water Supply (MoEWRWS), Gandaki Province	Promotion of clean and renewable energy, electrification, and energy efficiency to reduce combustion-based emissions.
Ministry of Physical Infrastructure Development and Transport (concerned divisions)	Management of road infrastructure, traffic systems, and construction activities that contribute significantly to dust and vehicular emissions.
Provincial Health Directorate	Collection of health statistics related to air pollution impacts; support for public awareness and emergency health responses.

MoFE–Gandaki plays the coordinating role for air-quality governance and climate-sensitive atmospheric issues, working across sectoral ministries to ensure integration of air-quality objectives into provincial planning and development processes.

c) Local Governments (Municipalities and Rural Municipalities)

Local governments are the frontline institutions for air-quality management. Their responsibilities include:

- Regulation of construction activities and road dust control
- Prevention of open burning of waste and biomass
- Management of local traffic and promotion of clean transport
- Enforcement of environmental standards for small and medium enterprises
- Community-level forest-fire prevention and response
- Awareness programs on clean cooking, clean energy, and pollution health risks

Strengthening municipal technical capacity and enforcement authority is critical for effective air-quality management.

Policy and Legal Framework

Air quality management in Gandaki Province is guided by a combination of federal and provincial policies, laws, and regulatory instruments that together provide the institutional and legal foundation for protecting the atmospheric environment. Because air pollution sources are closely linked with energy use, transport systems, industrial activities, urban development, forest management, and climate variability, the policy and legal framework for air quality is necessarily cross-sectoral. At the federal level, national acts, regulations, and standards set the overall direction, technical benchmarks, and compliance requirements for pollution control and environmental protection. At the provincial level, these national provisions are operationalized and strengthened through provincial legislation and sectoral policies that respond to local environmental conditions and development priorities. This integrated policy and legal framework enables Gandaki Province to plan, regulate, monitor, and progressively improve air quality while aligning environmental protection with sustainable development and climate resilience objectives.

a) Federal Policy and Legal Instruments

Instrument	Relevance to Air Quality
Environment Protection Act, 2076 (2019)	Primary national legal framework for pollution control, environmental standards, and environmental governance.
Environment Protection Rules, 2077 (2020)	Implementation procedures for pollution control, environmental assessments, and compliance mechanisms.
National Ambient Air Quality Standards (NAAQS), 2012	Legal benchmark for acceptable levels of major air pollutants, forming the basis for air-quality assessment in Gandaki.
National Climate Change Policy, 2076 (2019)	Integrates climate mitigation and adaptation, linking atmospheric pollution with broader climate resilience.
National Adaptation Plan (2021–2050)	Long-term framework that recognizes climate-sensitive pollution risks such as heat stress, forest fires, and air stagnation events.
Disaster Risk Reduction and Management Act, 2074 (2017)	Legal basis for managing wildfire smoke, extreme weather events, and environmental emergencies.
Vehicle Emission and Fuel Quality Standards	Critical for controlling PM and NOx emissions from transport sectors.
Forest Act and related regulations	Provide authority for forest management and wildfire control, which strongly influence seasonal air pollution.

b) Provincial Policy and Legal Instruments

Instrument	Relevance to Air Quality
Gandaki Province Environment Protection Act, 2076	Provincial legal basis for environmental protection and pollution control; enables formulation of provincial directives and rules on air quality.

Instrument	Relevance to Air Quality
Provincial Climate Change Strategy / Action Planning Processes	Provide opportunities to integrate air-quality risks such as heat waves, wildfire smoke, and black carbon into climate resilience planning.
Provincial Sectoral Policies (Energy, Industry, Transport, Urban Development)	Enable cross-sector actions that reduce emissions through clean energy, cleaner production, and sustainable mobility.

Institutional Gaps and Coordination Needs

Although the legal framework is largely in place, effective air-quality governance in Gandaki Province faces several challenges:

- Limited air-quality monitoring coverage beyond Pokhara
- Weak integration between meteorological data (DHM) and pollution analysis
- Insufficient enforcement capacity at municipal level
- Fragmented responsibilities across transport, energy, forest, health, and environment sectors

A formal Provincial Air Quality Coordination Mechanism, led by MoFE–Gandaki and supported by sector ministries and municipalities, would strengthen:

1. Data sharing and early warning systems
2. Joint enforcement and compliance monitoring
3. Climate–air quality risk integration
4. Public health preparedness and communication

6.1.15 Key Recommendations: Air Quality

1. **Expand monitoring beyond Pokhara:** At least three additional permanent air quality stations should be installed in different ecological zones. Without this, provincial air quality claims will remain weak and speculative.

2. **Integrate DHM and air quality data**: Joint analysis of wind speed, temperature inversion, rainfall, and pollution will allow early warning of pollution episodes and improve SoE scientific credibility.

3. **Make transport the top priority**: Vehicle emissions are the most controllable pollution source. Expansion of electric vehicles, strict inspection systems, and clean public transport can directly reduce winter $PM_{2.5}$ peaks.

4. **Control dust at the source**: Construction sites, roads, and riverbed material handling must be regulated. These are major contributors to PM_{10} and $PM_{2.5}$ in growing towns.

5. **Link forest fire management with air quality policy**: Bipad Portal and fire detection systems should be used not only for disaster response but also for pollution forecasting and health warnings.

6. **Accelerate clean cooking energy**: Reducing biomass burning remains one of the most effective ways to cut winter pollution in valley settlements.

7. **Use air quality as a development indicator**: Tourism, health, and environmental reputation depend on clean air. Gandaki can brand itself as a "clean air province" if these measures are taken seriously.

6.2 Land Use, Soil Health and Agriculture

6.2.1 Background

Gandaki Province represents one of Nepal's most environmentally diverse regions, extending from the trans-Himalayan rain-shadow areas of Manang and Mustang in the north to the Inner-Terai plains of Nawalparasi

East (Nawalpur) in the south. This pronounced north–south elevation gradient creates sharp contrasts in climate, geology, land capability, soil formation processes, and agricultural potential within a relatively compact geographic area. As a result, land use and agricultural systems in the province are highly heterogeneous and spatially differentiated.

The Province is characterized by strong land–environment linkages with almost half of its territory about 41.6% covered by forests and shrubs (9,041.62km^2), but not the grassland (~1,748.77km^2). The forest area includes the major conservation areas such as Annapurna, Manaslu and the buffer zone of Chitwan National Park (FRTC, 2024). The current landuse classification of the landscape shows about 487,823 hectares (4878.237km^2) are classified as cultivable land. Out of the 487,823 ha land that is cultivable 351,597 ha is cultivated and the irrigable land is 272,630 ha, of which about 70,080 ha is irrigated (MoEWRWS, 2026).

Forest land is the dominant land-use type in Gandaki Province, covering a very large share of land in most mid-hill districts. According to the district-wise LULC data (***Figure 6-13***), forest area exceeds 800–1,200 sq. km in districts such as Tanahu (≈1,174 sq. km), Gorkha (≈1,268 sq. km), Syangja (≈861 sq. km), Kaski (≈885 sq. km), Lamjung (≈862 sq. km), and Myagdi (≈825 sq. km). In contrast, Manang and Mustang have very limited forest cover, with only about 78 sq. km in Manang and 65 sq. km in Mustang, reflecting their high-altitude, cold, and arid environments. This distribution shows that forest recovery and dominance are mainly a mid-hill phenomenon, likely linked to community forestry, natural regeneration on abandoned farmland, and reduced pressure from fuelwood extraction.

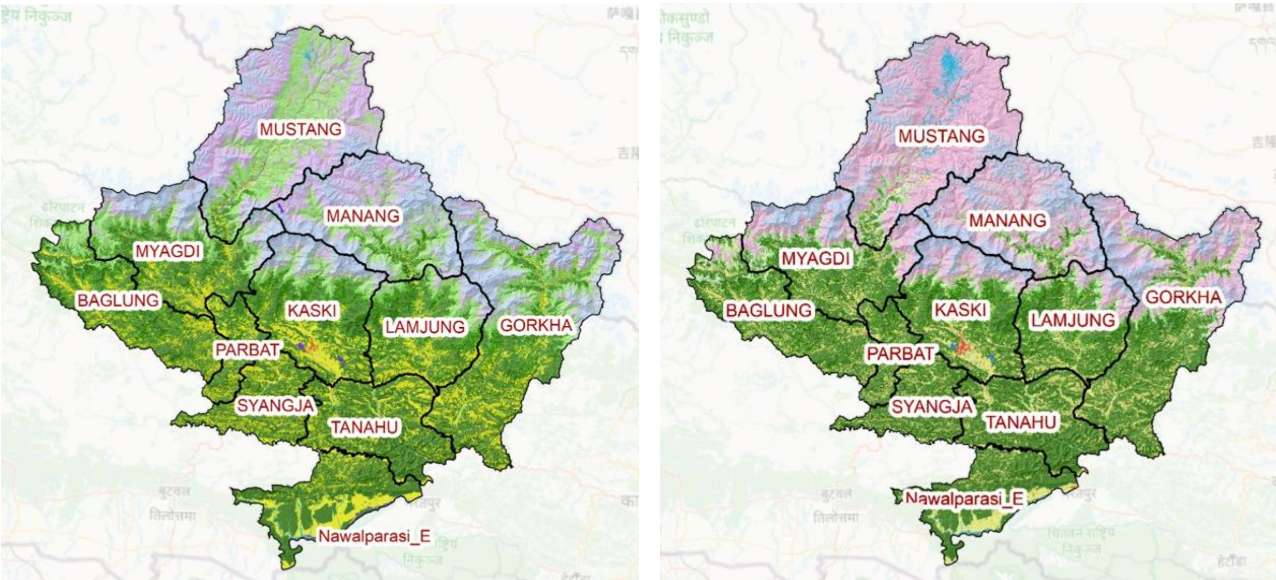


Figure 6-2. Landuse Map of Gandaki Province (left) 2010 Year and (right) 2022 Year

Grassland is highly concentrated in the northern high mountain districts, clearly separating Gandaki into two ecological zones. The LULC table shows that Manang and Mustang together contain several hundred square kilometres of grassland, while grassland areas in most mid-hill districts are comparatively small. This reflects the presence of alpine and sub-alpine pastures above the treeline, which are essential for grazing yaks, chauri, sheep, and goats. In contrast, districts such as Syangja, Tanahu, Kaski, and Parbat have very limited grassland, as land at these elevations is either forested or under agriculture. The data suggest that while grasslands remain stable in high-altitude areas, they are gradually shrinking or transforming into shrub and forest in the hills, partly due to declining livestock grazing and land abandonment.

Agricultural land shows a strong southward and valley-focused pattern across the province. The largest agricultural areas are found in Tanahu, Syangja, Kaski (valley areas), Gorkha, and East Nawalparasi, where terrain, soil, and irrigation conditions are more favorable. In contrast, Manang and Mustang have extremely limited agricultural land, restricted to narrow river valleys and irrigated pockets. The LULC data indicate that agricultural land occupies a much smaller share than forest land in almost all hill districts, highlighting a long-term trend of farmland contraction. This pattern is consistent with rural out-migration, labor shortages, and the conversion of marginal terraces into forest or shrubland, increasing pressure on remaining productive agricultural land to sustain food production in the province.

LULC data show that Gandaki Province is increasingly forest-dominated (***Figure 6-2***), with grasslands confined to high mountain districts and agricultural land shrinking in the hills, raising important questions for food security, rangeland management, and sustainable land-use planning.

Table 6-13. District-wise Landuse of Gandki Province (Unit in km2, Year 2022)[4]

Land Use Classes	Baglung	Gorkha	Kaski	Lamjung	Manang	Mustang	Myagdi	East Nawalparasi	Parbat	Syangja	Tanahu
Waterbodies	1.35	5.05	8.97	1.06	6.23	3.80	0.80	16.33	0.16	3.43	9.42
Glacier	0.00	394.52	157.59	39.81	524.46	294.32	278.12	0.00	0.00	0.00	0.00
Snow	0.81	162.27	98.79	37.28	249.87	231.57	122.92	0.00	0.00	0.00	0.00
Forest	1073.64	1267.96	885.13	861.77	77.58	65.42	825.26	704.42	349.08	861.32	1173.90
Riverbed	0.54	0.81	1.23	0.03	1.10	150.47	0.21	13.87	0.04	1.83	2.92
Built-up area	2.75	4.36	18.34	1.84	7.04	33.44	2.98	3.85	0.70	1.21	3.03
Agricultural Land	**367.06**	**411.91**	**298.49**	**218.97**	**24.31**	**36.54**	**223.77**	**284.38**	**120.65**	**279.40**	**346.22**
Bare Soil	0.00	0.01	0.10	0.00	0.10	4.81	0.00	0.31	0.00	0.00	0.05
Bare Rock	45.65	887.45	246.16	166.01	1107.74	2523.79	446.72	0.31	0.09	0.01	0.08
Grassland	165.45	394.49	159.62	183.19	242.05	257.33	294.35	26.61	4.60	7.99	13.09
Other Wooded Land	148.79	125.52	167.74	203.05	33.58	17.27	130.09	5.80	24.74	23.06	16.50
	1806.04	3654.35	2042.16	1713.01	2274.06	3618.76	2325.22	1055.88	500.06	1178.25	1565.21

Table 6-14.District-wise Landuse of Gandaki Province (Unit in km2, Year 2010)

Land Use Classes	Baglung	Gorkha	Kaski	Lamjung	Manang	Mustang	Myagdi	East Nawalparasi	Parbat	Syangja	Tanahu
Waterbodies	2.12	7.82	11.26	1.78	9.29	13.56	1.93	24.88	0.35	4.55	14.84
Glacier	0.00	394.71	157.62	39.82	524.95	292.47	278.04	0.00	0.00	0.00	0.00
Snow	0.00	194.81	92.19	21.00	202.61	162.55	121.67	0.00	0.00	0.00	0.00
Forest	1006.08	1137.94	826.14	793.78	89.34	70.52	790.67	657.83	300.15	740.25	1099.78
Riverbed	0.45	3.56	4.02	1.45	0.04	14.46	0.15	27.90	0.07	5.10	10.23
Built-up area	1.43	0.98	7.83	0.24	3.97	31.34	0.61	0.95	0.25	0.61	0.96
Agricultural Land	**371.66**	**453.29**	**356.84**	**279.66**	**10.69**	**32.34**	**222.80**	**318.07**	**164.41**	**389.34**	**396.14**
Bare Soil	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Bare Rock	3.75	427.59	108.42	69.31	714.38	1520.03	190.43	0.00	0.00	0.00	0.00
Grassland	246.89	848.35	303.11	281.69	677.32	1459.76	574.16	18.00	9.45	8.18	6.63
Other Wooded Land	173.58	185.12	174.66	224.20	41.36	23.33	144.89	8.20	25.35	30.16	36.29
	1805.96	3654.17	2042.09	1712.93	2273.96	3620.36	2325.35	1055.83	500.03	1178.19	1564.87

[4] *These are the landuse classification based on RS imagery analysis. These data are just to show the situation analysis but not been used to make decision rather to understand the trend. The landuse data such as cultivated land and forest land are considered from MOEWRES (2026).*

Agriculture remains central to Gandaki's economy and livelihoods. It contributes around one-quarter of provincial gross domestic product and provides full-time or seasonal work to more than half of the economically active population. The Province's economic growth is projected at 5.51% for the fiscal year 2024/25, with agriculture contributing 27.10% to the provincial GDP (NSO 2025) and approximately 57.6% of the economically active population is engaged in agriculture and livestock activities (GPPC 2024). The Gandaki Province Policy and Planning Commission (GPPPC) has prioritized agriculture as the #1 pillar in its Second Five-Year Plan (2024/25–2028/29), aligning it with Nepal's 16th national plan.

Beyond its economic contribution, agriculture underpins food security, sustains rural settlements, and shapes the province's cultural landscapes. At the same time, Gandaki is experiencing rapid socio-economic change driven by labour migration, demographic ageing, urban expansion (particularly around Pokhara Valley), infrastructure development, and increasing exposure to climate variability.

Soil systems in Gandaki are shaped by complex interactions between topography, climate, land use and long-standing agricultural practices. The province spans diverse agro-ecological zones, from hill and mountain districts to the eastern Terai, resulting in marked spatial variability in soil properties. Cropping patterns reflect these ecological gradients. In the hilly areas, there is expansion of orange and other fruit orchards, cereals cash crops and agro-tourism initiatives, accompanied by efforts to conserve and promote indigenous crops. In the high-hill zones**,** apple cultivation has expanded, supported by improved road connectivity that facilitates market access and reduces post-harvest losses

Paddy (Rice), Maize, Millet, and Wheat remain the staples. However, paddy cultivation area has seen a slight decline to approximately 94,182 hectares due to rapid urbanization around Pokhara and other valley hubs (MOALM, 2025). Province remains the lead producer of Mandarin Oranges in Nepal (notably in Syangja and Gorkha) (DOAD, 2025). Large cardamom, ginger, and coffee (specifically green bean coffee) are the primary high-value exports. The province accounts for roughly 34% of Nepal's total coffee cultivation area (NCPA/NSO 2024).

Climate change is intensifying structural constraints in Gandaki Province's agricultural systems, as rising temperatures and extreme rainfall increase soil erosion, nutrient loss and production risks. Although land use is shifting toward more commercial and climate-responsive agriculture, progress remains constrained by limited irrigation, and fragile hill environments. Realizing the province's strong ecological and economic potential will require climate-resilient crops, improved soil and water management, and farming practices adapted to diverse elevations to safeguard long-term productivity.

Forces like migration, climate change, soil health are reshaping the landuse and reported that the crop production is declining in many hill and mountain districts, while production is becoming more concentrated and input-intensive in accessible valleys and lowland areas. Soil health has therefore emerged as a critical limiting factor for sustainable agricultural development and environmental stability. This chapter assesses the **s**tate, trends, and interactions of land use, soil health, and agriculture in Gandaki Province, using district-wise data and a decadal perspective.

6.2.2 Land Use and Land-Use Change

Data sources and approach

Land use is assessed using a combination of (i) land-cover data from the National Land Cover Monitoring System (NLCMS) coordinated by the Forest Research and Training Centre (FRTC, 2024), and (ii) agricultural land-use proxies derived from district-wise cultivated area under major crops published by the Ministry of Agriculture and Livestock Development (MOAD, 2013; MOALD, 2021; MOALD, 2025). While land-cover data capture structural changes such as forest regeneration or expansion of built-up areas, cultivated area reflects land that is actively farmed and directly linked to soil management, fertilizer use, and agricultural production (NSO, 2024b).

District-wise land-use structure

Forest statistics indicate that mid-hill districts such as Parbat, Myagdi, Syangja, and Nawalparasi East have forest cover exceeding 50 percent of their total area, reflecting both long-standing community forestry and natural regeneration on abandoned agricultural land. In contrast, Manang and Mustang show very low forest cover, as land use is dominated by rangelands, barren land, and alpine terrain. Non-forest land in the mid-hills supports a mosaic of terraced agriculture, settlements, infrastructure, and river systems.

Cultivated land is heavily concentrated in the mid-hill districts. Syangja, Kaski, Baglung, Gorkha, Lamjung, Tanahun, and Parbat together account for more than three-quarters of Gandaki's total cultivated cereal area. High mountain districts contribute less than one percent, highlighting the structural limits of agriculture at high elevations.

Changes in Crop Land

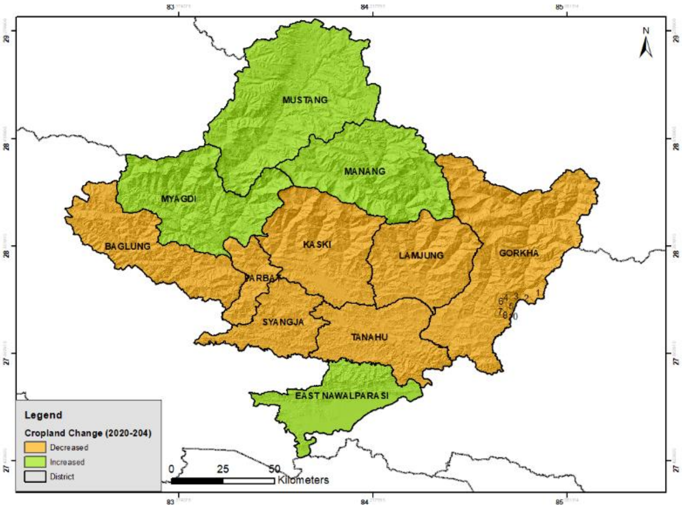
Evidence from agricultural statistics confirms that Gandaki Province has experienced a substantial contraction of cultivated agricultural land over the last decade, particularly in the mid-hill districts. A comparison of cultivated area between FY 2019/20 and FY 2023/24 shows that almost all districts recorded net declines in land under cultivation (***Table 6-15***).

Table 6-15. Change in Cultivated Agricultural Area by District (MOAD, 2013; MOALD, 2021; MOALD, 2025)

District	Area in Hector			
	2012/13	2019/20	2023/24	Change
Manang	845	643	2,759	2,116
Mustang	1,970	1,895	4,936	3,041
Gorkha	48,028	44,735	33,261	-11,474
Lamjung	40,616	33,032	29,053	-3,979
Tanahu	49,722	42,122	34,384	-7,738
Kaski	58,796	53,709	36,828	-16,881
Parbat	34,646	33,092	25,603	-7,489
Syangja	70,764	63,615	39,750	-23,865
Myagdi	21,176	18,795	37,854	19,059
Baglung	53,033	51,492	31,442	-20,050
Nawalparasi-East	NA	33,960	36,234	2,274

Between 2019/20 and 2023/24, the cultivated land area in Gandaki Province shows a clear and spatially uneven pattern of change, with most mid-hill districts experiencing a marked decline, while a few high-mountain and Terai-connected districts record increases (***Figure 6-3***). Districts such as Syangja, Baglung, Kaski, Gorkha, Tanahu, Lamjung, and Parbat show substantial reductions in cultivated land, indicating a widespread contraction of agricultural activity in the mid-hills. In contrast, Manang, Mustang, and Myagdi exhibit notable increases, and Nawalparasi-East (Nawalpur) shows a modest expansion, suggesting that agricultural land use is being sustained or expanded where commercial farming, irrigation, or market connectivity is stronger.

The pattern observed in the mid-hill districts is consistent with progressive abandonment of marginal and labor-intensive agricultural land, particularly rain-fed terraces. These areas are highly dependent on household labor, and once this labor base weakens, continued cultivation becomes difficult. The sharp declines in Syangja, Baglung, and Kaski among the largest migration-sending districts in the province suggest that demographic change is playing a central role in land-use outcomes. However, due to the absence of district-level datasets that directly link migration rates with cultivated land change for the same years, a formal statistical correlation cannot be established within this analysis.



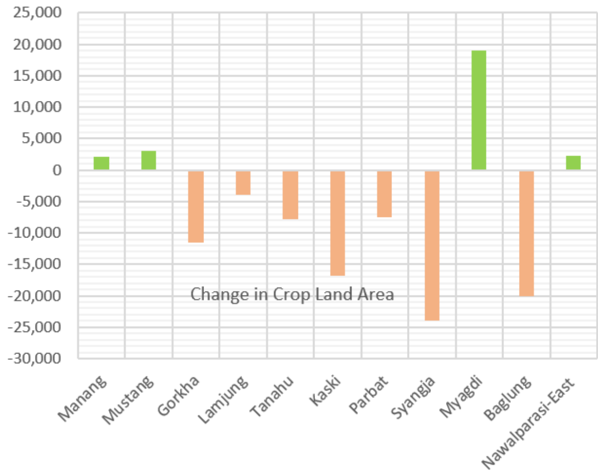


Figure 6-3. Change in Cropland Over 2019/20-2022/23 (left) Maps Indicating the Districts with Increased or Decreased Cropland and (right) Amount of Cropland Increased or Decreased in the Province

Despite the lack of quantified statistical relationships, out-migration emerges as a highly plausible and widely documented driver of agricultural land reduction in Gandaki Province. Sustained international and internal migration has reduced the availability of young and able-bodied labor, leaving agriculture increasingly managed by elderly household members. In many cases, remittance income substitutes subsistence production, leading households to deprioritize farming on less productive or physically demanding plots. This results in land being left fallow or gradually transitioning to shrubland and forest, a process that has been widely observed across Nepal's mid-hill regions.

Other structural factors reinforce this trend. Low agricultural profitability, rising input costs, limited mechanization in steep terrain, and increasing climate variability especially erratic rainfall and prolonged dry spells have further reduced incentives to maintain cultivation. In peri-urban districts such as Kaski and parts of Tanahu, conversion of agricultural land to settlements, roads, and infrastructure also contributes to declining cultivated area. Together, these drivers interact with migration dynamics to accelerate agricultural contraction rather than acting independently.

In contrast, the increase in cultivated land in high-mountain districts such as Manang and Mustang suggests a qualitative shift rather than a reversal of migration impacts. Here, agriculture is becoming more specialized and market-oriented, focusing on high-value crops such as apples, potatoes, and vegetables, supported by improved road access and niche markets. Similarly, Nawalpur's modest increase reflects the comparative advantage of flatter terrain, better irrigation, and more commercially viable farming systems.

Overall, the observed changes in cultivated land in Gandaki Province between 2019/20 and 2023/24 reflect a broader socio-economic and demographic transition. While no direct statistical linkage between out-migration and cultivated land change can be demonstrated with the available data, the spatial correspondence between major migration-sending districts and declining cultivated land strongly suggests that out-migration, combined with economic and environmental pressures, is a key underlying driver shaping current land-use trends. District-level interpretation points to three dominant trajectories: (i) cropland contraction and partial abandonment in remote hill and mountain districts; (ii) relatively stable but increasingly fragmented cropland in accessible mid-hill districts, with rising conversion pressure near roads and towns; and (iii) stable cropland with increasing cropping intensity in Nawalparasi East.

The landuse data is different in different source, for this reason, the cultivated land area data from (MoEWRWS, 2026) has been considered for the SOE and forest area form MOFE (2026).

6.2.3 Major Crop, Vegetable and Fruit Production

Agriculture in Gandaki Province is characterized by strong agro-ecological diversity, resulting in distinct patterns of major crop, vegetable, and fruit production across districts. The province spans high Himalayan, mid-hill, and Terai-influenced landscapes, which together support a mix of cereal-based subsistence farming, commercial vegetable cultivation, and high-value fruit production. Recent production trends indicate a gradual decline in traditional cereal crops in many mid-hill districts, alongside growing importance of vegetables and fruits, particularly in areas with better market access, irrigation, and road connectivity. This transition reflects changing livelihood strategies, labor availability, and profitability considerations, with agriculture increasingly shifting from subsistence-oriented cereal production toward more market-driven and specialized crop systems.

The tables (***Table 6-16*** and ***Table 6-17***) show that agricultural production in Gandaki Province is highly uneven across districts and crop types, and that this pattern has become more pronounced between 2019/20 and 2023/24. Overall, mid-hill districts dominate cereal production, while high-mountain and Terai-connected districts specialize in high-value crops, particularly fruits and vegetables. Paddy, wheat, and maize production remain concentrated in districts with relatively better irrigation and gentler terrain, such as Nawalparasi-East, Tanahu, Syangja, Baglung, and Gorkha. However, between 2019/20 and 2023/24, paddy production declined in several mid-hill districts, notably Gorkha, Lamjung, and Baglung, reflecting reduced cultivated land, labor shortages, and declining engagement in subsistence cereal farming. In contrast, Nawalpur shows a strong increase in paddy and maize production, underscoring the continued importance of Terai-type agriculture within Gandaki Province.

Table 6-16. District-wise Major Crop Production (2019/20, Unit in MT)

District	Paddy	Wheat	Maize	Oilseeds	Vegetables	Fruits
Manang	–	–	–	4	84	53
Mustang	–	–	–	29	145	204
Gorkha	51,260	10,240	936	441	2,533	2,540
Lamjung	37,000	738	383	1,107	3,806	4,477
Tanahu	34,662	4,200	56	720	10,595	9,220
Kaski	35,644	1,851	339	435	13,941	10,758
Parbat	20,330	1,290	440	364	1,273	997
Syangja	19,005	4,000	2,000	290	9,528	9,779
Myagdi	27,000	600	61	316	966	407
Baglung	62,370	325	204	974	2,691	1,616
Nawalparasi-East	11,978	42	1,816	225	14,685	96
Total	**299,249**	**23,286**	**6,235**	**4,905**	**60,247**	**40,147**

Table 6-17.: District-wise Major Crop Production (2023/240, Unit in MT)

District	Paddy	Wheat	Maize	Oilseeds	Vegetables	Fruits
Manang	–	–	–	4	84	53
Mustang	–	–	–	28	145	204
Gorkha	33,261	9,215	740	453	2,531	2,540
Lamjung	29,053	738	383	784	3,286	4,477
Tanahu	34,384	4,200	56	614	9,220	9,220
Kaski	36,828	1,851	339	438	13,941	10,758
Parbat	25,603	1,390	440	364	1,273	997
Syangja	39,750	4,000	2,000	290	9,528	9,779
Myagdi	37,854	600	61	316	966	407

District	Paddy	Wheat	Maize	Oilseeds	Vegetables	Fruits
Baglung	31,442	325	204	974	2,691	1,616
Nawalparasi-East	36,234	42	1,816	225	14,685	96
Total	**304,409**	**22,361**	**6,039**	**4,490**	**58,350**	**40,147**

Oilseed production remains comparatively low across most hill and mountain districts, with Nawalpur clearly dominating, indicating that oilseed cultivation remains limited to areas with larger land parcels and better market access. This suggests limited diversification into oilseeds in the mid-hills despite policy emphasis on crop diversification.

Vegetable production shows greater resilience than cereals across most districts. Districts such as Kaski, Tanahu, Syangja, and Nawalpur maintain high vegetable output in both years, indicating a shift toward more market-oriented and cash-based agriculture. Even in districts where cereal production declined, vegetable production often remained stable, suggesting that farmers are prioritizing crops with higher returns and shorter production cycles.

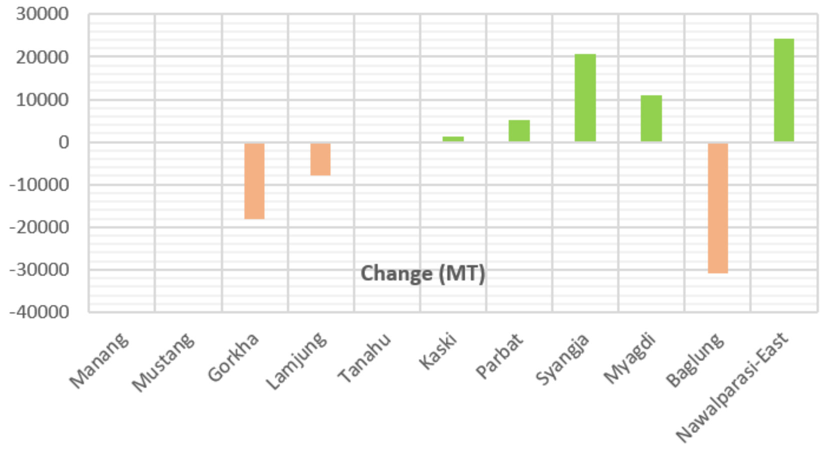


Figure 6-4. Net Change in Paddy Production in the Period of (2019/20-2023/24)

Fruit production displays a clear ecological specialization. Mustang and Myagdi stand out as major fruit-producing districts due to apple and temperate fruit cultivation, while Kaski and Tanahu show moderate but stable fruit production linked to peri-urban markets. Fruit production remains minimal in several cereal-dominated districts, reflecting climatic and market constraints rather than lack of agricultural activity.

Table 6-18. Oilseed, Vegetable and Fruit Production in Gandaki Province

Commodity	2019/20	2023/24	Change / Trend
Oilseeds	9,465	8,526	▼ Decrease
Vegetables	≈278,000	278,583	≈ Stable
Fruits	39,890	39,890	≈ Stable

Taken together, the tables suggest that agriculture in Gandaki Province is transitioning rather than uniformly declining. While traditional cereal-based farming is shrinking in many mid-hill districts, particularly where out-migration and labor shortages are high, production is increasingly concentrated in commercial vegetables, fruits, and irrigated lowland cereals, reshaping the province’s agricultural landscape.

6.2.4 Soil and Soil Health

Soils in Gandaki Province are shaped by steep slopes, fragile geology, and intense monsoon rainfall. The main soil health constraints include erosion and topsoil loss, declining soil organic matter, widespread soil acidity in hill districts, and nutrient imbalance associated with unbalanced fertilizer use. These constraints interact strongly with land-use change and agricultural intensification.

Soil Texture

Gandaki Province shows a wide mix of soil textures because of its dramatic elevation range from the lowland plains in the south to the high Himalaya in the north (

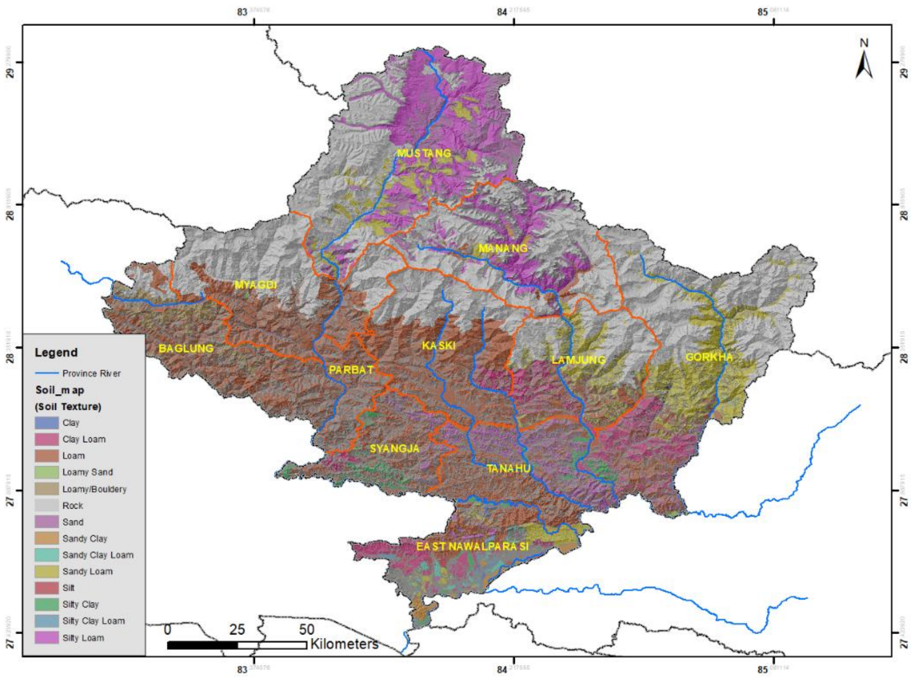


Figure *6-5*). Based on the soil texture map, loam and sandy loam soils cover much of the mid-hill districts such as Kaski, Syangja, Parbat, Myagdi, and Gorkha, making these areas generally suitable for terrace farming. Coarse and gravelly soils dominate the high mountain and Trans-Himalayan districts of Mustang and Manang, where soils are shallow and hold little moisture. In contrast, finer soils such as clay loam and silty clay loam occur mainly in river valleys and the southern lowlands of Nawalparasi (East), where soils are deeper and more fertile but also more prone to waterlogging during the monsoon.

Figure 6-5. Soil Texture Map of Gandaki Province (Sources: Department of Water Resources and Irrigation)

Soils in the Province are mostly young and continuously changing, shaped more by erosion and sediment movement than by long-term soil development. Steep slopes, active landslides, and intense monsoon rainfall transport soil materials downslope, while major rivers such as the Kali Gandaki and Marsyangdi deposit sand, silt, and clay along valleys and floodplains. In higher elevations, cold temperatures and freeze–thaw processes break rocks into coarse particles, limiting soil depth and organic matter. As a result, soil formation across the province is closely linked to natural processes like weathering, erosion, and deposition, making soils highly sensitive to deforestation, road construction, and unsustainable land use.

Soil texture determines how well soil can hold water, supply nutrients, drain excess moisture, and support root growth, all of which affect crop choice and productivity. In Gandaki's high mountain and Trans-Himalayan areas, where soils are mostly sandy, gravelly, and shallow, low water-holding capacity and poor nutrient retention limit crop options mainly to hardy crops, fodder, and orchard species such as apple, often under irrigation. In the mid-hill districts, the dominance of loam and sandy clay loam soils provides a good balance between drainage and moisture retention, making these areas suitable for cereals (maize, paddy in valleys), vegetables, and citrus fruits; however, these soils are highly prone to erosion on steep slopes if terraces and vegetation cover are not well maintained. In contrast, the southern lowlands and river valleys, where clay loam and silty clay loam soils are common, support higher yields of paddy, wheat, vegetables, and oilseeds due to better moisture and nutrient retention, though poor drainage can lead to waterlogging if not managed properly.

In general, variations in soil texture across Gandaki Province strongly shape cropping patterns, productivity levels, and land management needs, underscoring the importance of soil-specific agricultural planning and conservation practices.

Soil pH and nutrient status

District-wise soil testing data from Gandaki Province provide empirical evidence of soil health conditions and spatial variability across the province. The data, generated through provincial soil testing and mobile soil camps, capture soil reaction (pH) and the status of major nutrients nitrogen (N), phosphorus (P), and potassium (K) which are critical for crop productivity and long-term soil sustainability.

Table 6-19. Summary of Soil pH and Major Nutrient Status by District in Gandaki Province

District	Dominant soil pH condition	Nitrogen (N) status	Phosphorus (P) status	Potassium (K) status
Gorkha	Predominantly acidic	Low–Medium	Medium–High	Low
Kaski	Predominantly acidic	Low–Medium	Medium	Low–Medium
Lamjung	Predominantly acidic	Low	Medium	Low
Syangja	Mixed (acidic–neutral)	Low–Medium	Medium	Medium
Tanahun	Mixed (acidic–neutral)	Medium	Medium	Medium
Baglung	Predominantly acidic	Low–Medium	Medium	Low–Medium
Parbat	Predominantly acidic	Low	Medium	Low
Myagdi	Predominantly acidic	Low	Medium	Low
Nawalparasi East	Neutral to slightly basic	Medium	Medium–High	Medium–Low

District	Dominant soil pH condition	Nitrogen (N) status	Phosphorus (P) status	Potassium (K) status
Mustang	Neutral–alkaline (localized)	Low	Low–Medium	Low
Manang	Neutral–alkaline (localized)	Low	Low–Medium	Low

Source: Provincial Soil Testing and Fertility Assessment Data, Gandaki Province (Soil Camp Data, FY 2075/76).

The table (***Figure 6-6***) highlights several province-wide patterns:

- Soil acidity dominates the mid-hill districts, where high rainfall, leaching, and long-term fertilizer use without liming have lowered soil pH. Acidic soils reduce nutrient availability, particularly phosphorus, and limit crop response to fertilizer.
- Nitrogen deficiency is widespread, with most districts falling in the low to medium category. This reflects long-term nutrient mining under continuous cultivation and insufficient replenishment through organic matter or balanced fertilization.
- Phosphorus appears moderate to high in several districts, but in acidic soils much of this phosphorus is chemically fixed and not readily available to crops, creating hidden deficiencies.
- Potassium deficiency is emerging in several intensively cultivated districts, including Kaski, Lamjung, and Nawalparasi East, posing risks to crop stress tolerance and yield stability.

These soil health conditions reinforce the need for integrated soil fertility management, combining balanced N–P–K application, soil pH correction (liming) in acidic areas, restoration of organic matter, and erosion control particularly in districts experiencing both land contraction and production intensification.

State and Trends of Soil Nitrogen

The nitrogen status across Gandaki Province reflects structural nutrient depletion. Most districts are characterized by low to medium nitrogen levels, indicating that soils have been mined of nitrogen over time due to continuous cropping and inadequate replenishment of organic matter and N inputs. In Gorkha, the distribution of nitrogen status (828 low, 817 medium, 175 high) points to a low–medium dominant profile. Kaski shows a similar pattern (486 low, 437 medium, 53 high), again indicating nitrogen scarcity. Lamjung and Nawalparasi (East) are predominantly low in nitrogen, with only very small proportions of high-N soils. Baglung, Syangja and Parbat are relatively better, with medium nitrogen status prevailing, yet even in these districts, high nitrogen levels remain limited compared with the number of low and medium samples.

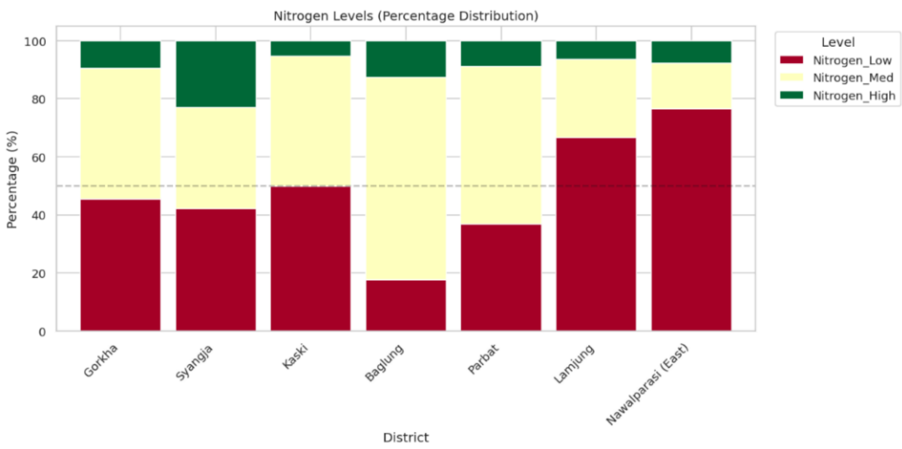


Figure 6-6. Soil Nitrogen (N) Sample Analysis and Trend

Taken together, these results show that nitrogen deficiency is systemic across the province. Current fertilizer practices and organic matter management are not sufficient to rebuild soil nitrogen pools, meaning that soils are being progressively depleted. This has direct consequences for crop productivity, plant vigor and resilience to climatic stress.

State and Trends of Soil Phosphorus

Phosphorus appears, at first glance, to be less constraining than nitrogen in many districts. The data show medium to high phosphorus levels in Gorkha, Syangja, Kaski and Baglunch as shown in the ***Figure 6-7***. In Parbat, phosphorus is mainly in the medium range, while Nawalparasi (East) shows a clear dominance of high phosphorus. Lamjung, however, stands out with a larger share of low phosphorus (38 low, 25 mediums, 15 high), highlighting localized P limitations.

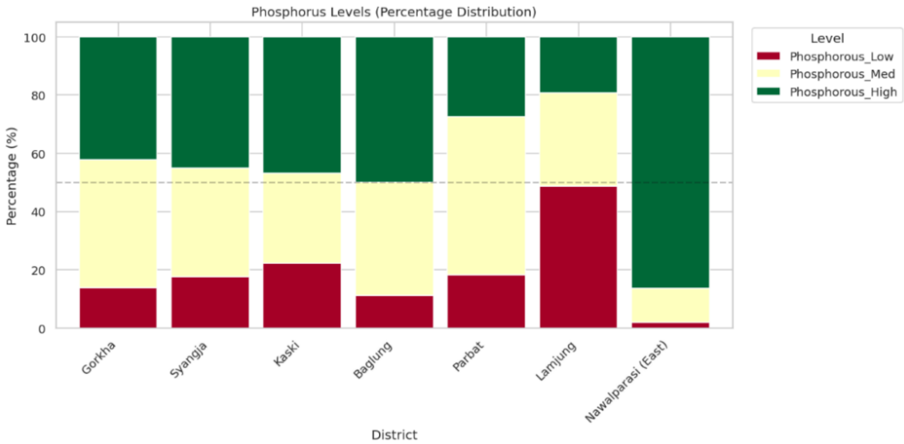


Figure 6-7. Soil Phosphorus (P) Sample Analysis and Trend

Despite these apparently favorable P levels, the strongly acidic soils in hill districts mean that a substantial portion of soil phosphorus is likely fixed in unavailable forms. Thus, the apparent adequacy of phosphorus does not always translate into effective plant uptake, particularly in Gorkha, Kaski and Lamjung, where soil acidity is severe. This interaction between pH and P availability is a critical dimension of soil fertility management in Gandaki Province.

State and Trends of Soil Potash

Potash (K) levels show greater spatial variability than nitrogen and phosphorus. In Gorkha and Syangja, medium K levels dominate, with a relatively balanced distribution between low, medium and high categories. Baglung also shows a medium-dominant profile.

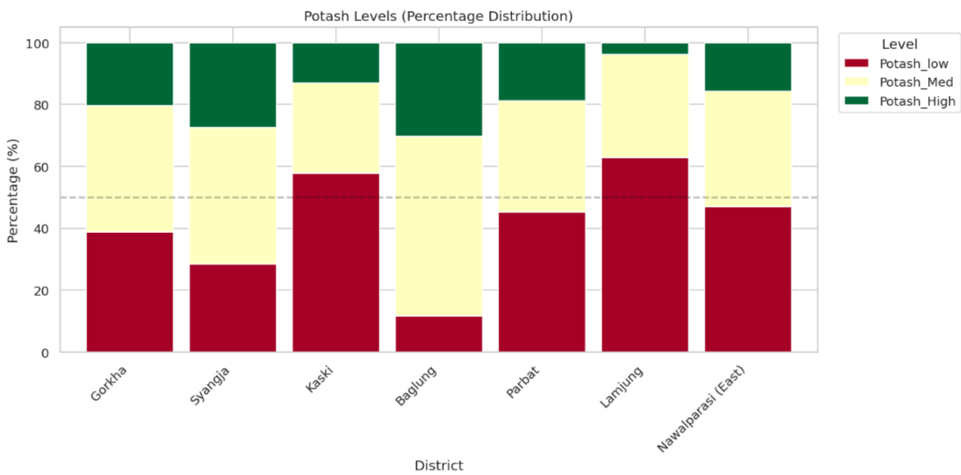


Figure 6-8. Soil Potash (K) Sample Analysis and Trend

By contrast, Kaski, Lamjung and Nawalparasi (East) exhibit notable potassium deficiencies. In Kaski, low K samples (558) exceed both medium (280) and high (127), indicating a low-K dominant status. Lamjung and Nawalparasi (East) also show a predominance of low K samples relative to medium and high. Parbat lies between these patterns with a low–medium dominant status. Given potassium's crucial role in crop resilience, water regulation, disease resistance and stress tolerance, these localized but significant K deficiencies pose risks for both productivity and climate resilience, particularly in intensively cultivated and high-value cropping areas.

Soil testing data from Gandaki Province show a clear spatial pattern. Hill districts such as Gorkha, Kaski, and Lamjung are dominated by acidic soils, while Syangja exhibits mixed pH conditions. Nawalparasi East is characterized largely by neutral to slightly basic soils due to alluvial parent material and lower rainfall intensity. Acidic soils reduce nutrient availability particularly phosphorus and lower fertilizer-use efficiency.

Nitrogen levels are predominantly low to medium across most districts, indicating long-term nutrient mining. Phosphorus levels appear moderate to high in several districts, but in acidic soils much of this phosphorus is chemically fixed and unavailable to crops. Potassium shows greater spatial variability, with emerging deficiencies in intensively cultivated districts such as Kaski, Lamjung, and Nawalparasi East.

6.2.5 Chemical Fertilizer Use and Trends

The use of chemical fertilizers in the Province has increased in recent years, reflecting a gradual shift toward more input-intensive agricultural practices, though the trend remains highly uneven across districts (MOALD, 2021; MOALD, 2025). Between 2019/20 and 2023/24, fertilizer use intensified mainly in districts with better market access, irrigation, and commercial farming systems, while remaining limited in much of the mid-hill and mountain areas. Terai-influenced and peri-urban districts show a clear rise in fertilizer application per unit of cultivated land, suggesting localized agricultural intensification on shrinking farmland. In contrast, high-mountain districts continue to rely on low-input systems due to structural constraints. Overall, the trend indicates that chemical fertilizer use in Gandaki Province is expanding selectively rather than uniformly, shaped by geography, accessibility, and changing livelihood strategies rather than by province-wide intensification. District-wise sales data further highlight the concentration of fertilizer use in a small number of districts.

Table 6-20. Cultivated Land, Sales of Chemical Fertilizers and Fertilizer Intensity by District in Gandaki Province (FY 2019/20)

District	Year 2019/20		
	Cultivated land (ha)[5]	Fertilizer total (Mt)	Fertilizer intensity (kg/ha)
Baglung	51,492	693	13.5
Gorkha	44,735	1,033	23.1
Kaski	53,709	1,234	23
Lamjung	33,032	220	6.7
Manang	643	13	20.2
Mustang	1,895	17	9
Myagdi	18,795	262	13.9
Nawalparasi East	33,960	2,062	60.7
Parbat	33,092	1,717	51.9
Syangja	63,615	1,220	19.2

[5] The agrioculture land area is different than the one mentioned in the PPPC (2024). These data have been considered to assess the sue of chemical fertilizer in the province.

Tanahu	42,122	2,342	55.6
Total	**377,090**	**10813**	**26.98**

Statistical Information on Nepalese Agriculture, MOALD (2019/20)

The table (***Table 6-20*** and ***Table 6-20***) shows that the use of chemical fertilizers in Gandaki Province is highly uneven across districts and has generally intensified between 2019/20 and 2023/24, though the magnitude and direction of change vary considerably.

Table 6-21. Cultivated Land, Sales of Chemical Fertilizers and Fertilizer Intensity by District in Gandaki Province (FY 2023/24

District	Year 2023/24		
	Cultivated land (ha)	**Fertilizer total (Mt)**	**Fertilizer intensity (kg/ha)**
Baglung	31,442	960.45	30.5
Gorkha	33,261	2,049.45	61.6
Kaski	36,828	2,140.40	58.1
Lamjung	29,053	1,352.15	46.5
Manang	2,759	9.15	3.3
Mustang	4,936	5.75	1.2
Myagdi	37,854	328.6	8.7
Nawalparasi East	36,234	4,490.10	123.9
Parbat	25,603	702.05	27.4
Syangja	39,750	2,039.15	51.3
Tanahu	34,384	2,696.30	78.4
Total	**312,104**	**16,774**	**44.63**

Statistical Information on Nepalese Agriculture, MOALD (2023/24)

A clear east–south gradient is evident. Nawalparasi-East (Nawalpur) stands out as the district with by far the highest fertilizer use and the strongest increase over time, rising from about 61 kg/ha to nearly 124 kg/ha. This reflects its relatively flat terrain, better irrigation coverage, cereal-dominated systems, and easier access to fertilizer supply chains. By 2023/24, fertilizer use in Nawalpur approaches levels typical of Nepal's Terai districts, indicating a more input-intensive farming system compared to the rest of Gandaki Province.

Several mid-hill districts Tanahu, Kaski, Gorkha, and Syangja also show substantial increases in fertilizer intensity. In these districts, fertilizer use roughly doubled over the period, despite declines in cultivated land area. This suggests a process of agricultural intensification on remaining farmland, where farmers are applying more fertilizer per hectare to sustain or increase yields, particularly for vegetables and irrigated cereals. Tanahu and Kaski, in particular, show relatively high fertilizer intensity by 2023/24, consistent with their growing role as commercial vegetable suppliers and their proximity to urban markets.

Table 6-22. District-wise Fertilizer Intensity (kg/ha) in Gandaki Province

District	Fertilizer intensity 2019/20 (kg/ha)[6]	Fertilizer intensity 2023/24 (kg/ha)	Net Change (kg/ha)
Baglung	13.5	30.5	17
Gorkha	23.1	61.6	38.5
Kaski	23	58.1	35.1
Lamjung	6.7	46.5	39.8

[6] The area of cultivated land is different then the one reported by PPPC (2024). The data from MOALD is to assess rthe use of chemical fertilize in the province.

District	Fertilizer intensity 2019/20 (kg/ha)[6]	Fertilizer intensity 2023/24 (kg/ha)	Net Change (kg/ha)
Manang	20.2	3.3	-16.9
Mustang	9	1.2	-7.8
Myagdi	13.9	8.7	-5.2
Nawalparasi East	60.7	123.9	63.2
Parbat	51.9	27.4	-24.5
Syangja	19.2	51.3	32.1
Tanahu	55.6	78.4	22.8
Total	**26.98**	**44.63**	**17.65**

Statistical Information on Nepalese Agriculture, MOALD (2023/24)

Other hill districts such as Lamjung and Baglung also record noticeable increases, though from a lower base. In these areas, fertilizer use appears to be expanding selectively, likely concentrated in accessible pockets and commercial plots, while large areas of marginal or labor-intensive land are being abandoned. Parbat and Myagdi show more mixed trends: Parbat's fertilizer intensity declines, while Myagdi's remains relatively low, indicating limited adoption of chemical inputs and continued reliance on low-input or semi-organic systems in many locations.

In contrast, high-mountain districts (Manang and Mustang) consistently exhibit very low fertilizer use, and intensity actually declines over the period. This reflects structural constraints such as small cultivated areas, high transport costs, limited market integration, and a stronger reliance on traditional practices and organic manure. In these districts, increased agricultural production observed in recent years is more likely linked to crop specialization (e.g., apples, potatoes) rather than greater use of chemical fertilizers.

The table (***Table 6-22***) suggests that chemical fertilizer use in Gandaki Province has increased over time, but in a highly localized and uneven manner. Growth in fertilizer use is concentrated in districts with better infrastructure, market access, and commercial agriculture, while much of the mid-hill and mountain region continues to operate under low-input conditions. Importantly, even where fertilizer intensity has increased, rates in most hill districts remain below agronomic recommendations, indicating that fertilizer use alone is unlikely to fully offset declining cultivated land, labor shortages, and other structural challenges facing agriculture in Gandaki Province.

6.2.6 Organic Inputs and Soil Management

Organic manure remains an important component of soil fertility management, particularly in hill and mountain areas. Gandaki Province hosts several registered organic fertilizer producers, mainly in Kaski, Gorkha, and Mustang. However, declining livestock numbers, labour shortages, and competing biomass uses limit the availability of organic inputs. As a result, the gap between nutrient removal and replenishment is widening in intensively cultivated areas.

6.2.7 Livestock Production

MOALD district statistics show Gandaki Province is increasingly oriented toward goats and poultry, while cattle and buffalo numbers have dropped sharply. Between 2019/20 and 2023/24, Gandaki's cattle fell from 481,865 to 302,175 (−37%) and buffalo from 677,490 to 430,146 (−37%), while goats increased from 1,533,629 to 1,778,326 (+16%). Poultry also grew overall (fowl: 6.79 million to 7.14 million) and ducks rose strongly (42,712 to 111,337), though duck numbers are heavily concentrated in a few districts. Following table () present the livestock and poultry statistics of the province.

Table 6-23. Cattle, Bufflo, Sheep and Goat in Gandaki Province, Unit in No. (Year 2019/20 and 2023/24)

District	2019/20	2023/24	2019/20	2023/24	2019/20	2023/24	2019/20	2023/24
	Cattle		Bufflo		Sheep		Goat	
Baglung	52,038	30,631	72,428	70,449	7,171	10,227	116,931	149,244
Gorkha	72,849	69,785	75,193	65,932	18,421	30,930	236,379	415,884
Kaski	44,489	37,245	118,819	45,275	15,029	12,875	126,575	184,592
Lamjung	19,046	14,813	60,118	36,450	15,732	13,320	129,073	143,251
Manang	3,018	1,567	0	0	5,060	1,892	3,079	5,823
Mustang	8,064	6,668	150	206	6,920	4,298	61,978	51,039
Myagdi	35,305	19,779	29,538	25,154	20,797	17,565	104,591	60,423
Nawalparasi East	78,181	37,198	70,599	43,950	3,678	1,366	118,389	167,779
Parbat	36,590	22,550	38,026	29,744	4,869	2,426	50,396	56,353
Syangja	35,677	12,704	86,872	59,397	2,212	783	218,214	156,159
Tanahu	96,608	49,235	125,747	53,589	893	694	368,024	387,779
Gandaki total	**481,865**	**302,175**	**677,490**	**430,146**	**100,782**	**96,376**	**1,533,629**	**1,778,326**

Table 6-24. Pigs, Fowls and Ducks in Gandaki Province, Unit in No. (2019/20 and 2023/24)

District	2019/20	2023/24	2019/20	2023/24	2019/20	2023/24*
	Pigs 2019/20		Fowl		Duck	
Baglung	9,400	8,185	384,038	460,350	1,549	3,850
Gorkha	11,533	12,371	579,496	942,351	370	2,231
Kaski	21,642	14,367	3,068,254	2,860,542	11,400	40,987
Lamjung	7,220	5,623	337,940	287,403	815	1,821
Manang	152	70	8,416	3,320	NA	64
Mustang	45	92	11,580	6,613	NA	60
Myagdi	1,389	2,850	210,030	113,700	1,736	1,435
Nawalparasi East	15,510	25,214	842,377	726,960	15,538	43,900
Parbat	9,010	2,165	288,110	272,265	9,003	4,793
Syangja	19,072	9,282	476,784	483,650	1,119	NA
Tanahu	67,180	47,163	578,582	982,953	1,182	12,196
Gandaki total	**162,153**	**127,382**	**6,785,607**	**7,140,107**	**42,712**	**111,337**

Yak, Nak, and Chauri husbandry remains an important traditional livelihood in the high mountain districts of Manang and Mustang, but recent data show a gradual decline in herd numbers, particularly in Mustang (***Table 6-25***). Between 2019/20 and 2023/24, the Yak and Chauri population in Manang remained relatively stable, with only a small decrease, suggesting that pastoral systems there are still being maintained despite difficult terrain and climatic conditions. In contrast, Mustang experienced a more noticeable decline, pointing to growing pressures on high-altitude livestock systems. These trends likely reflect a combination of factors, including out-migration of herders, rising labor shortages, changes in grazing practices, and increasing climate stress on alpine pastures. While yak and chauri continue to play a key role in food security, culture, and mountain ecosystems, the declining numbers highlight the need for improved rangeland management, veterinary support, and livelihood incentives to sustain high-altitude pastoralism in Gandaki Province.

Table 6-25. Population of Yak, Nak and Chauri in Gandaki's District

District	2019/20	2023/24	Change
Baglung	27	35	8
Gorkha	119	113	−6
Kaski	43	56	13
Lamjung	878	890	12
Manang	4,671	4,584	−87
Mustang	5,497	4,507	−990
Myagdi	375	360	−15
Nawalparasi East	3	2	−1
Parbat	861	842	−19
Syangja	7	8	1
Tanahu	40	45	5
Gandaki total	**12,521**	**11,442**	**−1,079**

6.2.8 Future Outlook

Landuse

Cropland land in the hill districts is observed to be contraction. Labour migration, demographic ageing, declining profitability of rain-fed farming, and increasing wildlife pressure are unlikely to reverse in the short to medium term. Mid-hill districts such as Lamjung, Gorkha, Baglung, Syangja, and Kaski are therefore expected to experience further decline or fragmentation of cultivated land, particularly on marginal terraces. Stabilization and intensification in accessible areas. In peri-urban valleys, major road corridors, and Nawalparasi East, cropland area is likely to remain relatively stable. However, cropping intensity is expected to increase through multiple cropping, irrigation expansion, and commercialization. At the same time, competition between agriculture, settlements, and infrastructure will intensify, increasing the risk of permanent loss of prime agricultural land.

Natural regeneration on abandoned terraces is likely to continue, contributing to increased forest and grassland cover. While this trend offers environmental benefits such as carbon sequestration and slope stabilisation, unmanaged regeneration may also increase wildfire risk, invasive species spread, and wildlife–crop conflict along forest–farm interfaces. Land use in Gandaki Province is expected to become increasingly polarised, with productive agriculture concentrated on a smaller land base and large areas transitioning toward forest- and shrub-dominated landscapes.

Soil Health

Soil health will be a decisive factor determining whether agricultural intensification in Gandaki Province is sustainable. Business-as-usual trajectory (high risk). If current practices continue without targeted intervention, soil acidity in hill districts is likely to intensify due to continued fertilizer use without pH correction. Nitrogen mining and declining soil organic matter will persist, while emerging potassium deficiency will become more widespread in high-production districts. Under this trajectory, fertilizer-use efficiency will decline, production costs will rise, and soils will become increasingly vulnerable to erosion and climate stress.

With systematic soil health management, including soil testing–based recommendations, balanced N–P–K application, liming of acidic soils, restoration of organic matter, and erosion control, soil productivity can be stabilised or improved. Healthier soils will enhance water retention, reduce nutrient losses, and improve resilience to rainfall variability and drought. Key soil-related risks in the future include hidden soil degradation that is not immediately reflected in yields, climate-driven acceleration of erosion and nutrient loss, and increasing spatial inequality in soil quality between districts.

Agriculture and Food Systems

Agriculture in Gandaki Province is expected to continue its structural transformation toward market-oriented and specialised systems. Horticulture, dairy, poultry, and mixed farming systems will expand further in accessible districts, driven by urban demand and market integration. In contrast, mountain districts will remain structurally constrained, with agriculture playing a smaller but locally important role in livelihoods and food security.

Production gains will increasingly rely on intensification rather than land expansion, raising per-hectare pressure on soil and water resources. Provincial food availability will therefore depend more on yield stability in core production areas and on inter-provincial trade and market functioning.

Climate Change as a Risk Multiplier

Climate change will amplify existing pressures on land, soil, and agriculture. More intense monsoon rainfall is expected to increase erosion and landslide risk on degraded terraces, while longer dry spells will heighten irrigation demand and moisture stress. Rising temperatures will alter crop suitability zones and increase pest and disease pressure. Without proactive soil and land management, climate change is likely to acceleratedegradation trends.

Risks and Opportunities

The future of land use, soil health, and agriculture in Gandaki Province presents both risks and opportunities. Key risks include progressive loss of soil fertility in intensification corridors, permanent conversion of prime agricultural land, growing environmental inequality between districts, and reduced resilience of food systems. At the same time, opportunities exist to guide regeneration of marginal land toward stable forest and agroforestry systems, to use soil health restoration as a cost-effective climate adaptation strategy, and to promote high-value, resource-efficient agriculture on suitable land.

The long-term sustainability of land use, soil health, and agriculture in Gandaki will depend on how effectively intensification is managed on a shrinking agricultural land base. Without targeted intervention, soil degradation and land-use polarisation will undermine productivity and environmental stability. With integrated land-use planning, systematic soil health restoration, and climate-smart agricultural practices, Gandaki Province can transform structural change into a pathway toward resilient, sustainable, and environmentally sound development.

6.2.9 DPSIR Analysis

Drivers

The main drivers shaping land use, soil health, agriculture, and livestock systems in Gandaki are demographic change, economic transition, climate variability, and policy priorities. Large-scale labour migration, especially from mid-hill districts such as Syangja, Kaski, Baglung, Gorkha, and Tanahu, has reduced the availability of farm labour and weakened traditional, labour-intensive farming systems. At the same time, urban expansion, particularly around Pokhara Valley and along major road corridors, has increased competition for land and accelerated conversion of agricultural land to settlements and infrastructure.

Climate change is acting as a long-term structural driver. More erratic rainfall, longer dry spells, and rising temperatures are increasing production risks, especially in rain-fed hill agriculture. Policy and market forces also play a role: provincial development plans increasingly promote commercial agriculture, horticulture, livestock and poultry, while community forestry policies have supported forest regeneration on abandoned land. Together, these drivers are pushing Gandaki away from extensive subsistence farming toward a more polarized land-use system, with intensive agriculture in accessible areas and land abandonment elsewhere.

Pressures

These drivers translate into several direct pressures on land and soil systems. One of the most visible pressures is the contraction of cultivated agricultural land, particularly in the mid-hills. Between 2019/20 and 2023/24, districts such as Syangja, Kaski, Baglung, Gorkha, Tanahu and Lamjung lost substantial areas of cropland, while only a few districts (Manang, Mustang, Myagdi and Nawalparasi East) showed expansion. This reflects abandonment of marginal terraces, declining labour availability, and lower profitability of rain-fed cereals.

At the same time, pressure is increasing on the remaining agricultural land. Fertilizer use per hectare has risen sharply in accessible districts such as Nawalparasi East, Tanahu, Kaski and Gorkha, indicating intensification on a shrinking land base. This creates pressure on soil nutrients and soil structure. Livestock systems are also under pressure: cattle and buffalo numbers have declined by more than one-third in the province, reducing availability of farmyard manure, while grazing pressure on alpine grasslands is changing as yak and chauri numbers decline in Mustang.

State

The current state of land use in Gandaki Province is characterised by forest dominance, shrinking agricultural land, and spatially concentrated grasslands**.** Forests now cover nearly half of the province, exceeding 50 percent of land area in most mid-hill districts, while Manang and Mustang remain dominated by grassland, bare land and rock due to altitude and climate. Agricultural land occupies a much smaller share of total land and is increasingly confined to valleys, lowlands, and irrigated pockets.

Soil health conditions reflect both natural constraints and management pressures. Soil acidity dominates mid-hill districts, nitrogen levels are generally low to medium across the province, phosphorus availability is constrained by acidity, and potassium deficiency is emerging in intensively cultivated districts. Soil erosion remains a persistent problem due to steep slopes, intense monsoon rainfall, and inadequate conservation measures on terraces.

Livestock systems are in transition. Goats and poultry are expanding, while cattle, buffalo, sheep, and yak-based systems are declining or stagnating, especially in remote and labour-scarce areas. This shift has implications for nutrient cycling, soil organic matter, and land management practices.

Impacts

These changes are already producing visible impacts on both livelihoods and the environment. The loss of cultivated land and declining soil fertility threaten local food production in hill districts, increasing dependence on food imports and markets. Intensification in limited areas raises the risk of hidden soil degradation**,** where yields are maintained in the short term but soil health declines over time.

Forest expansion through natural regeneration has positive impacts such as carbon sequestration, slope stabilisation, and biodiversity recovery, but it also brings new challenges, including increased human–wildlife conflict, wildfire risk, and loss of open grazing land**.** In high mountain areas, declining yak and chauri numbers affect not only livelihoods but also rangeland dynamics and cultural landscapes.

The province is experiencing a growing spatial inequality, productive, market-connected areas intensify and diversify, while remote hill and mountain areas face land abandonment and declining agricultural activity.

Responses

Current responses include community forestry, promotion of commercial crops, soil testing programs, fertilizer subsidies, and livestock support schemes. These have helped stabilise forest cover and encouraged agricultural diversification in some areas. However, responses remain fragmented and uneven**.** Soil health management is still largely input-focused, with limited attention to soil organic matter restoration, pH correction, and erosion control at scale. Livestock policies have not fully addressed the decline of manure-based systems or the sustainability of high-altitude pastoralism.

There is a clear need for integrated responses that link land-use planning, soil health restoration, climate adaptation, and livelihood support. This includes protecting prime agricultural land, promoting climate-resilient and soil-friendly farming practices, managing forest–farm interfaces, supporting rangeland management in mountain districts, and aligning agricultural intensification with long-term soil sustainability.

In Gandaki Province, demographic change, climate stress and economic transition are driving land abandonment in the hills and intensification in accessible areas. These pressures are reshaping land use, degrading soil health in intensification zones, and altering livestock systems. While forest recovery offers environmental benefits, unmanaged land-use change and declining soil fertility pose growing risks to food security and rural livelihoods. Integrated land, soil, and agricultural management is essential to ensure that current transitions lead to long-term environmental and economic sustainability.

Table 6-26. DPSIR Synthesis for Land Use, Soil Health and Agriculture in Gandaki Province

DPSIR Element	Synthesis Insight
Drivers	Land use, soil health, and agricultural change in Gandaki Province are driven by interacting socio-economic and environmental forces, including population out-migration, labour shortages, urban expansion, market-oriented agricultural transformation, infrastructure development, and climate change. These drivers operate unevenly across districts, accelerating land abandonment in mid-hills while intensifying production in accessible valleys and lowland areas.
Pressures	These drivers translate into multiple pressures on land and soil systems, such as conversion of agricultural land to non-agricultural uses, abandonment of terraces, increasing fertilizer intensity on shrinking farmland, reduced organic matter inputs due to declining livestock, overgrazing in some rangelands, and soil erosion on steep slopes intensified by heavy monsoon rainfall.
State	The current state is characterized by a net decline in cultivated land, widespread soil acidity and nutrient deficiencies (especially nitrogen and emerging potassium), declining soil organic matter in intensively farmed areas, and uneven irrigation coverage. While forest and shrubland are expanding through natural regeneration on abandoned land, agricultural productivity is becoming increasingly concentrated in a smaller, more intensively managed area.
Impacts	These state changes have far-reaching impacts, including reduced long-term soil fertility, declining resilience of farming systems to climate variability, increased dependence on external food supplies, loss of traditional agricultural landscapes, rising human–wildlife conflict at forest–farm interfaces, sedimentation of rivers, and heightened disaster risk from erosion and landslides. Social impacts are most pronounced in remote hill and mountain communities.
Responses	Existing responses include fertilizer subsidies, irrigation development, soil testing programs, promotion of high-value crops, and forest regeneration through reduced land pressure. However, responses remain fragmented and insufficiently integrated across land-use planning, soil management, agriculture, forestry, and climate adaptation. Stronger emphasis is needed on integrated land-use planning, soil-test-based nutrient management, terrace and slope conservation, revitalization of crop–livestock linkages, and climate-resilient farming systems.

6.2.10 Baseline and Sate Indicators

Baseline and state indicators provide a structured snapshot of how land use, soil health, and agriculture in Gandaki Province have changed over time and where they currently stand. By comparing historical baselines (around 2010–11) with the most recent available data (around 2022), these indicators capture both long-term structural shifts such as declining cultivated land and expanding forest cover and emerging pressures, including soil acidity, nutrient depletion, and increasing fertilizer intensity. Together, they reveal a province that is becoming more forest-dominated, more spatially polarized in agricultural production, and increasingly dependent on intensification of a shrinking agricultural land base. These indicators form the empirical foundation for assessing sustainability risks and guiding future land, soil, and agricultural management responses.

Table 6-27. Land Use, Soil Health and Agriculture Indicators for Gandaki Province

Indicator	Baseline	State	Key Districts Affected	Synthesis
Total cultivated agricultural land area	≈377,090 ha (2020)	≈351,597 ha (MoEWRWS, 2026)	Decline prominent in Lamjung, Gorkha, Kaski, Parbat, Syangja, Baglung, Myagdi	Cultivated land has declined by ~14%, driven mainly by abandonment in mid-hill districts and urban expansion around Pokhara Valley.
Share of agricultural land in provincial area	17% (2020)	≈16% (2026)	Province-wide	Agriculture is losing spatial dominance, increasing pressure on remaining productive land.
Abandoned agricultural land	No systematically recorded (pre-2010)	Substantial and widespread (2022)	Lamjung, Gorkha, Parbat, Syangja, Myagdi, Baglung	Land abandonment has become a defining rural change, reshaping landscapes and accelerating forest regeneration.
Forest and shrubland expansion on former farmland	Limited regeneration (2010)	Increasing natural regeneration (MoFE, 2024)	Lamjung, Gorkha, Parbat, Myagdi, Baglung	Regeneration improves forest cover but alters traditional farming systems and forest–farm interfaces.
Soils with acidic pH (<5.5)	~40–50% of samples (2010)	>60% of samples (Soil Lab, 2019)	Kaski, Tanahun, Syangja, Lamjung, Gorkha	Soil acidity is widespread in mid-hill districts, constraining nutrient availability and crop productivity.
Soil organic matter (SOM)	Medium (2–3%) (2010)	Low to medium (<2.5%) (Soil Lab, 2019)	Tanahun, Kaski, Nawalpur East (intensive zones)	Declining SOM reflects intensive cultivation and reduced manure input, weakening soil health.
Nitrogen-deficient soils	No systematically recording	>70% of samples (2022)	Province-wide; severe in Lamjung, Gorkha, Syangja	Nitrogen deficiency remains the most widespread soil fertility constraint across Gandaki.
Phosphorus imbalance (deficiency/excess)	Mostly adequate (2010)	Mixed status (2022)	Excess in Nawalpur East, deficiency in mid-hills	Uneven fertilizer use is emerging, raising risks of inefficiency and nutrient runoff.
Potassium-deficient soils	No systematic recording	20–30% of samples (Soil Lab, 2019)	Kaski, Tanahun, Syangja, Baglung	Increasing potassium deficiency signals long-term nutrient mining.
Chemical fertilizer consumption	≈10,813 MT (MOALD, 2025)	≈16,774 MT (MOALD, 2025)	Highest in Nawalpur East, Kaski, Tanahun, Gorkha	Fertilizer use is increasing while cultivated land shrinks, raising per-hectare pressure.
Average fertilizer application rate	≈26.98 kg/ha (MOALD, 2025)	≈44.63 kg/ha (MOALD, 2025)	Intensive districts: Nawalpur-East, Kaski, Tanahun, Gorkha	Rising input intensity improves yields but increases soil and water risks if unmanaged.
Cattle and buffalo population	≈1.05 million head (MOAD, 2013)	≈0.82 million head (MOALD, 2025)	Decline in Lamjung, Gorkha, Myagdi, Baglung	Reduction in large livestock weakens manure availability and nutrient recycling.
Goat population	≈0.72 million head (MOAD, 2013)	≈1.78 million head (MOALD, 2025)	Growth in Baglung, Myagdi, Gorkha	Shift toward goats alters grazing pressure and nutrient flows.

Indicator	Baseline	State	Key Districts Affected	Synthesis
Population of Yak, Nak and Chauri	≈ 12,521 (2019)(MOALD, 2025)	≈11,442 (MOALD, 2025)	Decline all the district including Mustang, Manang except a few no of increasement in Lamjung and Kaski	Reducing large number in Manang and Mustang
Cropping pattern (cereal share of cropped area)	≈70% (MOAD, 2013)	≈55–60% (MOALD, 2025)	Diversification in Kaski, Tanahun, Nawalpur East	Shift toward vegetables and fruits increases income but input and climate sensitivity.
Irrigated agricultural land	≈no systematically recorded data available (2010/11)	≈25.7% (MoEWRWS, 2026)	Better coverage in Nawalpur East, Kaski; low in Myagdi, Baglung	Irrigation expansion has improved resilience but remains uneven across districts.

Note:
District references are based on soil test reports, agricultural statistics, and district-level synthesis in the Land Use, Soil Health and Agriculture chapter. Percentages for soil indicators refer to the proportion of tested samples rather than total land area.

6.2.11 Observed Trend, Risk and Target Action

The observed trends in land use, soil health, and agriculture point to a clear transition underway in Gandaki one marked by cropland contraction in the hills, intensification in accessible valleys and lowlands, and growing stress on soil systems. While some changes, such as forest regeneration and crop diversification, offer environmental and economic opportunities, they also introduce new risks, including hidden soil degradation, rising inequality between districts, increased human–wildlife conflict, and long-term threats to food security. This section links observed trends to their associated risks and identifies targeted actions that can help steer current transitions toward sustainable outcomes. The focus is not on reversing structural change, but on managing it protecting productive land, restoring soil health, and aligning agricultural intensification with environmental limits and climate resilience.

Table 6-28. Observed Trends, Risks and Targeted Actions for Land Use, Soil Health and Agriculture in Gandaki Province

Observed Trends	Key Risks	Targeted Actions
Contraction of cultivated agricultural land in mid-hill districts, with widespread abandonment of marginal and labour-intensive terraces	Declining local food production, increased dependence on food imports, and loss of productive agricultural landscapes	Protect prime agricultural land through land-use planning, discourage unplanned conversion, and support consolidation and viable use of remaining farmland
Expansion of forest and shrubland through natural regeneration, particularly on abandoned agricultural land	Increased human–wildlife conflict, higher wildfire risk, and loss of open grazing land	Actively manage forest–farm interfaces through buffer planting, agroforestry, controlled grazing, and community-based fire management
Spatial polarization of agriculture, with intensification in accessible valleys and decline in remote hill and mountain areas	Growing inequality between districts, marginalisation of remote farming communities, and uneven development outcomes	Promote location-specific agricultural strategies, supporting commercial agriculture in suitable areas while sustaining low-input systems in marginal regions
Rising fertilizer intensity on shrinking agricultural land, especially in Nawalparasi East, Tanahu, Kaski, and Gorkha	Hidden soil degradation, nutrient imbalance, declining fertilizer-use efficiency, and long-term productivity loss	Implement soil-test-based nutrient management, balanced N–P–K application, and monitoring of fertilizer intensity to prevent overuse

Observed Trends	Key Risks	Targeted Actions
Widespread soil acidity in mid-hill districts, with low nitrogen and emerging potassium deficiencies	Reduced nutrient availability, lower crop response to inputs, and increased vulnerability to climate stress	Scale up liming programs, restore soil organic matter, and promote integrated soil fertility management
Persistent soil erosion on steep slopes, driven by intense monsoon rainfall and inadequate conservation	Loss of topsoil, declining soil depth, sedimentation of rivers, and increased landslide risk	Strengthen terrace maintenance, erosion control measures, and slope stabilization through vegetation and bioengineering
Shift in livestock systems, with declining cattle, buffalo, and yak populations and expansion of goats and poultry	Reduced availability of farmyard manure, weakened nutrient cycling, and pressure on rangelands	Support integrated crop–livestock systems, manure management, and sustainable rangeland management, especially in high-mountain districts
Transition from cereal-based subsistence farming toward vegetables and fruits, particularly in accessible districts	Increased dependence on market inputs and exposure to price and climate shocks	Promote climate-resilient crops, diversification, and value chains that balance productivity with soil and water sustainability
Climate variability and warming acting as risk multipliers	Accelerated erosion, moisture stress, pest outbreaks, and yield instability	Integrate climate adaptation into land-use planning, soil management, and agricultural extension services

6.3 Climate Change and Disaster Risk Reduction

6.3.1 Background

Gandaki Province is increasingly shaped by climate change, which is altering both the intensity and the spatial expression of natural hazards (PPPC, 2025). The province's pronounced physiographic diversity from the trans-Himalayan districts of Mustang and Manang to the highly rainfall-intensive mid-hills and densely populated river valleys creates multiple climate regimes within a relatively small geographic area. As a result, changes in temperature and precipitation are translating into differentiated but interconnected disaster risks across the province.

Observed climate data indicate a clear warming trend across all elevation zones, with stronger warming at higher altitudes and rising night-time temperatures in hill and valley areas (Adhikari and Mathema, 2023; DHM, 2024b). In high mountain districts, even small increases in temperature have significant implications, including shifts from snowfall to rainfall, accelerated glacier retreat, and changes in seasonal runoff timing. In lower elevations and urbanizing valleys, higher maximum temperatures and warmer nights are increasing heat stress, evapotranspiration, and water demand, while also compounding health and livelihood risks.

Changes in precipitation are equally consequential. While long-term trends in total annual rainfall remain mixed, the dominant signal is increasing variability and intensification of rainfall events, particularly during the monsoon season, which already contributes the majority of annual precipitation in Gandaki Province. Recent evidence points to rainfall becoming more concentrated within shorter periods, increasing peak runoff, sediment transport, and slope instability. At the same time, the length of dry spells between rainfall events is increasing in many areas, including traditionally wet districts, creating a dual challenge of flood risk during the monsoon and water stress during the dry season.

These temperature and precipitation changes are reshaping the province's disaster risk profile. Floods, flash floods, and landslides are becoming more frequent and damaging in the middle hills and river valleys, where steep terrain, high rainfall intensity, expanding infrastructure, and population concentration intersect. In the trans-Himalayan north, warming temperatures are amplifying cryosphere-related hazards, including glacial lake instability and downstream cascade risks, while also intensifying long-term water scarcity. Across much of the province, prolonged dry spells are affecting spring-fed water systems, agriculture, and hydropower reliability, even in areas with high annual rainfall.

In this context, climate change acts not as a single hazard but as a risk multiplier, increasing the likelihood, intensity, and compound nature of disasters. Disaster Risk Reduction in Gandaki Province, therefore cannot be separated from Climate Change Adaptation. Effective risk management requires integrating observed changes in temperature and precipitation into planning, infrastructure design, land-use decisions, and early warning systems, while recognizing that upstream climate processes often generate downstream impacts across district boundaries.

Climate change and disaster risk are among the most significant determinants of environmental sustainability and human well-being in Gandaki Province. The province's exceptional physiographic diversity from the trans-Himalayan rain-shadow districts of Mustang and Manang to the very wet mid-hill districts such as Kaski, Parbat, and Syangja creates highly differentiated climate regimes and risk profiles. At the same time, population concentration, agricultural dependence, and expanding infrastructure in hazard-prone locations are increasing exposure to climate-related disasters.

This section presents a consolidated assessment of Climate Change (CC) and Disaster Risk Reduction (DRR) for the SoE of Gandaki Province, applying the DPSIR framework. The narrative integrates recent district-level climate baselines (temperature and precipitation), rainfall variability and extremes (CDD/CWD), land-use and agricultural exposure, and population dynamics drawn from the attached SoE analyses and datasets.

6.3.2 Rainfall Variability and Trend

Gandaki's rainfall regime is shaped by steep elevation gradients and strong monsoon control, so spatial variability is the first-order feature. Even within the wider Gandaki/Narayani system, observed mean annual precipitation ranges from ~150 mm in the Trans-Himalaya rain-shadow to ~5,400 mm in the wet mid-hills respectively Mustang and Kaski districts. Seasonally, the system remains monsoon-dominant (***Figure 6-9***), but the emerging signal is less about a simple increase/decrease in annual totals and more about shifts in seasonality and event structure especially more erratic rainfall, higher-intensity short-duration events, and longer dry spells between wet spells.

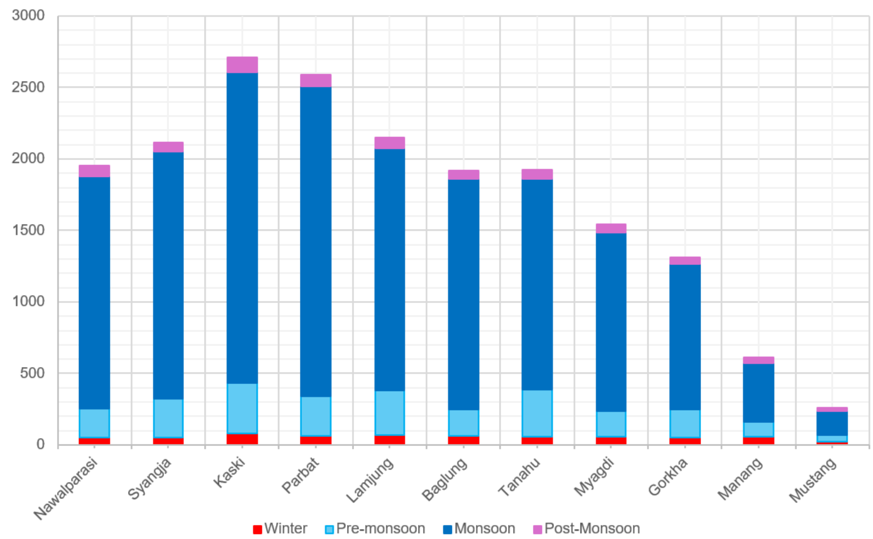


Figure 6-9. District-wise Season Rainfall Pattern of Gandaki Province (long-term mean)

The province is divided into four physiographic regions: 1) High Mountain, 2) Middle Mountain, 3) Hill and 4) Siwalik/Terai. Rainfall variability has been analyzed based on the rain-gauge data in a particular region (**Figure *6-10***). The High Mountain region receives a low amount of rain, but there is an increasing trend, while the hilly region receives a high amount of rainfall among all.

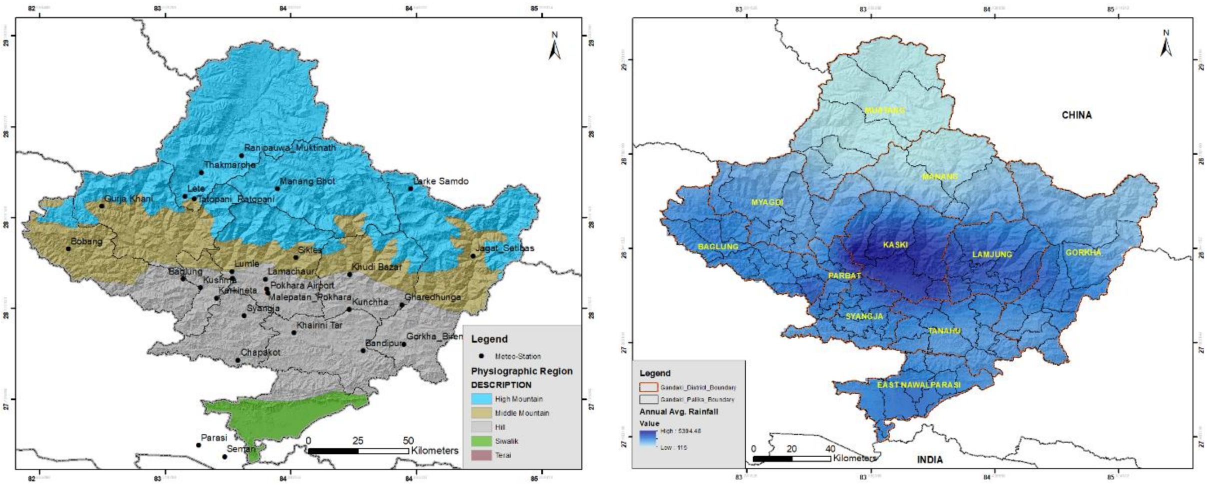
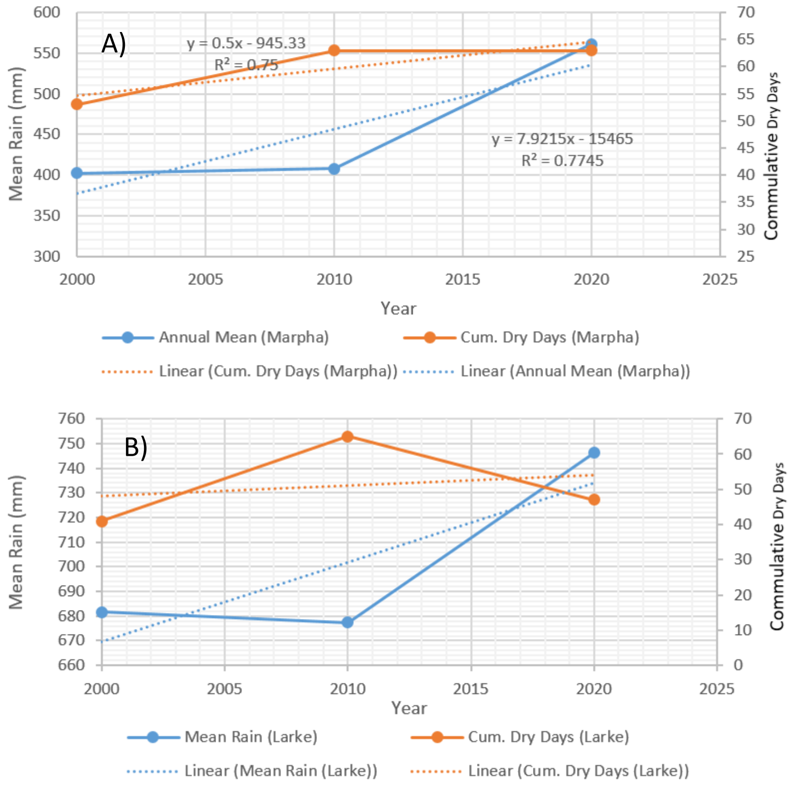


Figure 6-10. (left) Physiographic Region and Distribution of Rain-gauges; (right) Long Terms Annual Mean Rainfall (in mm)

Review of rainfall amount and dry/wet days of the province indicated rainfall in the high Mountain region increases with the increasing number of dry days, meaning that the rain is more intense. Similar to the High Mountain region the rainfall trend and cumulative dry days are similar in the Mid Mountain, Hill and Siwali/Terai regions (**Figure *6-11***).



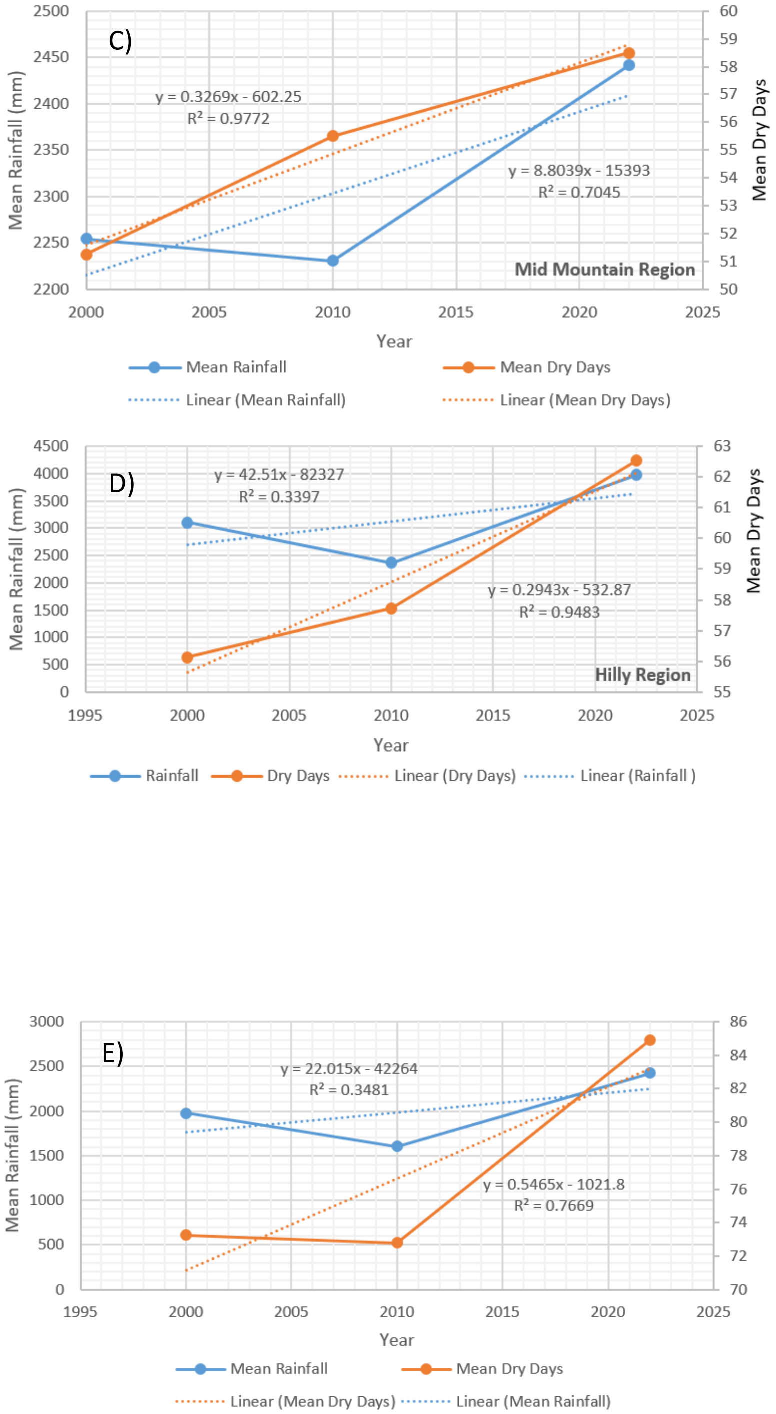


Figure 6-11. Long-term Rainfall Trend and Cumulative Dry Pays of Gandaki Province: (A & B) High Mountain Region, (C) Mid-Mountain Region, (D) Hilly Region and (E) Siwalik/Terai Region

Trends in AnnualRrainfall Totals are "mixed" (station-to-station)

Station specific review and analysis of long terms rainfall of Gandaki Province [2000–2022: Marpha (Mustang), Samdo-Larke (Gorkha), Lumle (Kaski), Khudibazar (Lamjung), Dumkauli (Nawalparasi)] finds non-uniform and insignificant trends in annual precipitation. In high altitude region such as in Mustang, Manang and high mountain region of Gorkha districts, indicates the increasing trend of rainfall.

- Marpha: significant increase of +2.42 mm/year

- Lumle: significant decrease of −15.68 mm/year (largest decline among the stations)
- Manang, Khudibazar, Dumkauli: not uniform

This "mixed total" pattern frames rainfall changes in Gandaki as increasing variability and intensity rather than a uniform province-wide rise/fall in annual totals.

The stronger and more consistent signal: rising variability and "hydrological polarization"

Rainfall-extremes analysis (CDD/CWD based clustering across stations) shows a near-universal increase in consecutive dry days (CDD), with the highest provincial average trends around +0.31 days/year (~3.1 days/decade) even in traditionally wet zones. At the same time, consecutive wet days (CWD) are flat to decreasing in many areas, indicating wet periods becoming more fragmented. Taken together, the pattern is a "polarization" of rainfall:

- longer and/or more frequent dry spells, and
- rainfall arriving in more concentrated wet bursts, which increases flash-flood/landslide triggering thresholds while also raising drought stress in the shoulder and dry seasons

This aligns with the perception of the local community that the rainfall change is increasingly expressed through short-duration high-intensity events and longer dry spells, not just changing annual totals.

Recent Decadal Evidence: "Wet Pockets" Intensifying in 2020s (but not everywhere)

The decadal rainfall analysis (1980s–2020s) suggests that several mid-hill stations have experienced very large increases in the 2020s, even where long-term trend tests may show mixed results:

- Pokhara Airport: ~3,514 mm (2010s) → 4,922 mm (2020s)
- Bhadaure Deurali: ~4,211 mm (2010s) → 6,899 mm (2020s)
- Syangja: ~2,773 mm (2010s) → 3,772 mm (2020s)

At the same time, some stations show different behavior (including volatility and dips in earlier decades), reinforcing that local topography + circulation interactions produce strong sub-regional differences. DHM (2023) Nepal Climate Summary 2023 also shows how extreme these wet pockets can be: Lumle (Kaski) recorded 4,625.9 mm total precipitation in 2023, among the highest in the country.

Rainy Days vs Gntensity: fewer rainy days but heavier bursts

According to Adhikari & Mathema (2023) assessment reports that the number of rainy days (daily precipitation >2.5 mm) shows:

- Marpha: increasing by +0.5 days/year
- Khudibazar: decreasing by −0.5 days/year (significant)
- Lumle: decreasing by −0.25 days/year
- Others generally decreasing (not always significant)

This indicates that "both flood and drought": rainfall may occur on fewer days but in more intense events, while dry spells lengthen between storms consistent with CDD/CWD.

Rainfall Variability:

In Gandaki Province, rainfall is not the same for everyone, and the data clearly show that some communities live with much more uncertainty than others. In places like Lumle, Pokhara Airport and Syangja, rainfall is not only very high but also quite stable. For example, Lumle receives about 5,450 mm of rain in a year and its variability is very low (CV 10.4%). Pokhara Airport gets around 3,894 mm with a CV of 16.9%, and Syangja receives about 2,910 mm with a CV of 19.1%. This means people in these areas can generally depend on regular rainfall for farming, water supply and daily life.

But the situation is very different in the northern mountain areas. Manang Bhot receives only about 397 mm of rain per year, and its variability is extremely high (CV 49.0%). Larke Samdo, even though it gets a bit more rain (about 967 mm), is also highly unstable with a CV of 51.5%. This tells us that in some years there is reasonable rain, but in other years there is very little, making life and farming very uncertain. Ranipauwa (Muktinath) is even drier, with only about 245 mm of average annual rainfall and a high variability (CV 39.3%). The table below presents station/location specific long term mean rainfall, recorded maximum annual rainfall amount and other statistics to derive rainfall variability (***Table 6-29***).

Table 6-29. Long-term (2000-2024) Annual Mean Rainfall, Recorded Maximum Rainfall Amount and Variability Statistics

Station/Location	Mean annual rainfall (mm)	Std dev (mm)	Min (mm)	Max (mm)	CV (%)	Range (mm)	Variability Class
Larke Samdo	966.5	498.2	408.8	2485.6	51.5	2076.8	High
Manang Bhot	397.3	194.8	100.2	1056.7	49	956.5	High
Ranipauwa (Muktinath)	245.4	96.5	109.6	483.4	39.3	373.8	Moderate
Bandipur	1786.5	571.9	522.2	2999.1	32	2476.9	Moderate
Bhadaure Deurali	4394.9	1350.4	2607.4	8937.2	30.7	6329.8	Moderate
Malepatan (Pokhara)	3732.4	1073.4	184	5752.7	28.8	5568.7	Moderate
Kushma	2470	657.8	52.8	3670.7	26.6	3617.9	Moderate
Parasi	1868	483.3	1045	2984.3	25.9	1939.3	Moderate
Semari	1928.1	471.2	1035.4	2923.2	24.4	1887.8	Low to Moderate
Jagat (Setibas)	1505.9	348.3	1019.4	2221.7	23.1	1202.3	Low to Moderate
Chapakot	1917	438.1	1081.3	2959.4	22.9	1878.1	Low to Moderate
Bobang	2326.3	524.3	1197.5	3418.5	22.5	2221	Low to Moderate
Gorkha (Birenchowk)	1685.3	368.2	728.1	2278.1	21.8	1550	Low to Moderate
Baglung	1996.6	435	1023.7	2922.4	21.8	1898.7	Low to Moderate
Thakmarpha	424.4	90.6	287.6	697.2	21.3	409.6	Low to Moderate
Gurja Khani	1811.6	384.7	861.1	2505.9	21.2	1644.8	Low to Moderate
Kunchha	2554.6	514.7	1714.4	3661.7	20.1	1947.3	Low to Moderate
Karkineta	2504.8	490.3	1306	3404.4	19.6	2098.4	Low to Moderate
Tatopani (Ratopani)	1610.1	307.5	658.5	2137.7	19.1	1479.2	Low to Moderate
Syangja	2910.4	555.2	2070.6	4333.3	19.1	2262.7	Low to Moderate
Khairini Tar	2364.3	444.8	1684.9	3609.4	18.8	1924.5	Low to Moderate
Khudi Bazar	3337.4	592.7	2070.3	4658.6	17.8	2588.3	Low to Moderate
Pokhara Airport	3893.5	658.7	2966.8	5454.3	16.9	2487.5	Low to Moderate
Lete	1405.9	205.6	1058.6	1856.4	14.6	797.8	Very Low (Highly Stable)

Station/Location	Mean annual rainfall (mm)	Std dev (mm)	Min (mm)	Max (mm)	CV (%)	Range (mm)	Variability Class
Gharedhunga	2982.9	433.4	1951.4	3959.8	14.5	2008.4	Very Low (Highly Stable)
Lamachaur	4305.6	606.5	3114.2	5354.4	14.1	2240.2	Very Low (Highly Stable)
Sikles	3822	523	2617.4	4885.2	13.7	2267.8	Very Low (Highly Stable)
Lumle	5451.7	568.8	4294.7	6556.7	10.4	2262	Very Low (Highly Stable)

Data Sources: DHM 2024

The data show a very clear pattern of rainfall variability in the province. The southern and central areas are wet and reliable, while the northern high mountain and trans-Himalayan areas are dry and highly unpredictable. This means vulnerability is not only about how much rain an area gets, but also about how stable that rain is. People in Manang, Larke and Muktinath are facing a double challenge: less rain and more uncertainty, which makes their livelihoods much more fragile compared to places like Lumle, Pokhara or Syangja.

Projections suggest for Gandaki Province- wetter monsoon, drier winter

Future-climate evidence in the attached publications points toward monsoon intensification with dry-season drying (Lamichhane et al., 2025):

- A CMIP6-based multi-model ensemble projection for the Gandaki River Basin indicates annual precipitation increases of ~7–32% (near future) and ~18–45% (far future) under SSP245, and ~6–35% (near future) and ~42–110% (far future) under SSP585, relative to 1980–2014
- The same study projects precipitation decreasing from November–March and increasing from April–October, i.e., a tendency toward drier winters and wetter wet seasons (Assessing future precipitation)

DHM's (2024) update similarly emphasizes that winter is anticipated to become drier while the wet season becomes wetter, increasing the likelihood of extremes. It also shows intensification of heavy precipitation indicators for the Gandaki basin in projections.

6.3.3 Temperature Variability

Gandaki spans low river valleys, middle hills, and the High Himalaya within a short north–south distance. Because of this, temperature is not just a background climate variable it shapes water demand, crop calendars, forest moisture, snow and ice processes, and the type of hazards communities face. In recent decades, the province has moved into a warmer regime, but the warming is not uniform: daytime temperatures rise almost everywhere, while night-time patterns differ between valleys and high mountain districts.

Baseline temperature variability across districts

Long-term normal (2000-2020) shows very large thermal contrasts across the province (***Figure 6-12***). Warm valley and lowland districts record annual mean maximum temperatures around 30–31°C, while the northern high mountain districts remain cold through the year. For example, Kaski is around 30.7°C for the annual mean maximum temperature, while Manang is around 4.2°C; for annual minimum temperature, warm valleys such as Kaski are around 18.8°C whereas Manang is around −4.6°C. Seasonally, pre-monsoon is the hottest period for maximum temperature (e.g., Kaski about 34.2°C, Nawalparasi about 32.7°C), and winter brings the coldest minima, especially in Manang (about −9.3°C) and Mustang (about −8.9°C).

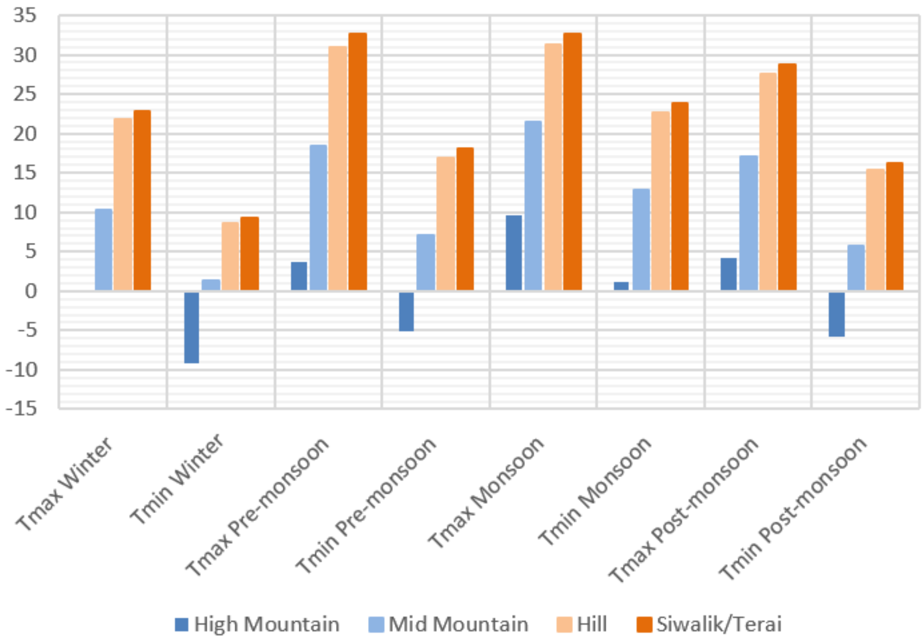


Figure 6-12. Long Term Seasonal Mean Temperature (Tmax and Tmin) in Physiographic Region

The diurnal temperature range (day–night difference) is another useful indicator. Using the same DHM normal (DHM, 2024b), annual DTR spans roughly from about 7.5°C in Gorkha to about 12.1°C in Nawalparasi, with several hill/valley districts around 11–12°C (for example, Kaski around 11.9°C and Tanahu around 11.8°C). This matters because shifts in DTR often signal whether warming is occurring more in daytime heat or in night-time heat retention, which affects crops, human health, and ecosystem stress.

Observed long-term trends (1971–2014) – clear warming in maximum temperature

Observed district trend analysis shows that annual maximum temperature has increased across all eleven districts. The strongest annual maximum temperature trend among the Gandaki districts is in Manang (about +0.092°C/year) and Mustang (about +0.080°C/year). In the middle hills, trends remain clearly positive, such as Gorkha (about +0.076°C/year), Tanahu (about +0.072°C/year), and Parbat (about +0.059°C/year). Even the lower-elevation district of Nawalparasi-East shows a positive annual maximum temperature trend (about +0.026°C/year).

Minimum temperature trends are more spatially mixed. Valley and lower-elevation districts show increasing minimum temperature, such as Syangja (about +0.047°C/year), Tanahu (about +0.042°C/year), Kaski (about +0.018°C/year), and Nawalparasi-East (about +0.015°C/year). In contrast, high mountain districts show decreasing annual minimum temperature, particularly Manang (about −0.030°C/year) and Mustang (about −0.014°C/year). This implies that in the high mountains, hotter days are increasingly paired with colder nights an important feature for frost risk, snow processes, and alpine ecosystem stress.

Station evidence and elevation dependence

Station-based evidence supports the same picture: maximum temperature is increasing at representative stations, and the increase can be strong at high altitude (Adhikari and Mathema, 2023). A station analysis cited in the temperature variability notes reports increasing annual maximum temperature across representative Gandaki stations (Jomsom, Chame, Lumle, Khudibazar, and Dumkauli), with the largest increase at the high-altitude station Chame (about +0.14°C/year). The same synthesis notes that annual minimum temperature can decrease at high altitude (Chame about −0.12°C/year), while lowland stations such as Dumkauli show increasing minimum temperature (about +0.02°C/year).

Physiographic Region and Temperature Trend:

A region-wise (Siwalik, Hill, Mid Mountain, and High Mountain) description of observed (annual mean) changes in maximum (Tmax) and minimum (Tmin) temperatures in Gandaki Province is discussed below. The trends are interpreted using both the graphical results and the station-based dataset summarized into physiographic regions, and are discussed in the context of national climate findings reported by the DHM.

Siwalik Region

The Siwalik region shows the strongest warming signal among all physiographic zones of Gandaki Province. The annual mean maximum temperature (Tmax) is increasing at a very rapid rate of about 0.95 °C per decade, while the minimum temperature (Tmin) is rising at around 0.25 °C per decade. This indicates that both daytime heat and night-time warmth are intensifying in this region. The station data from Damauli clearly supports this pattern. In the early part of the record, annual mean Tmax values were generally around 30.5–31.0 °C, whereas in recent years they frequently exceed 32.5 °C. Similarly, Tmin has increased from around 18.5 °C in the 1990s to more than 19.0 °C in recent years. This confirms a sustained warming of the thermal environment.

Such strong warming is consistent with the broader national picture described by DHM, which reports a significant and positive trend in maximum temperature across Nepal. However, the magnitude of warming observed in the Siwalik region is higher than national averages, suggesting that local factors such as land-use change, urban expansion, reduced vegetation cover, or station surroundings may be amplifying the temperature signal.

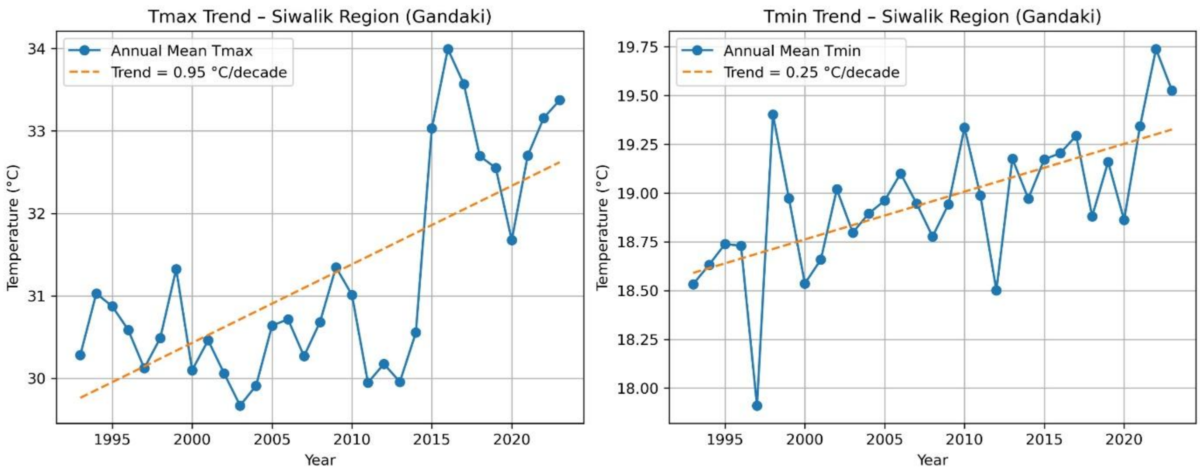


Figure 6-13. Long-term Annual (mean) Temperature Trend of Siwalik Region

From a practical perspective, this rapid increase in temperature has serious implications. The Siwalik belt is likely to face increasing heat stress, higher irrigation demand, greater evaporation losses, and heightened risks to human health and livestock. Cropping systems that are already sensitive to heat will become more vulnerable, particularly during the pre-monsoon and early monsoon seasons.

Hill Region

The Hill region shows a steady and balanced warming in both maximum and minimum temperatures. According to the figures, Tmax is increasing at a rate of about 0.24 °C per decade, and Tmin is increasing by about 0.22 °C per decade. This indicates a general warming of the climate, affecting both daytime and night-time conditions. The combined station data from Chapakot, Lumle, Malepatan (Pokhara), Pokhara Airport, and Syangja confirm this trend. Early-period mean Tmax values were close to 25.7 °C, while recent averages approach 26.3 °C. Tmin has increased from roughly 14.7 °C to around 15.2 °C. Although the year-to-year variability is large, the long-term direction of change is clearly upward.

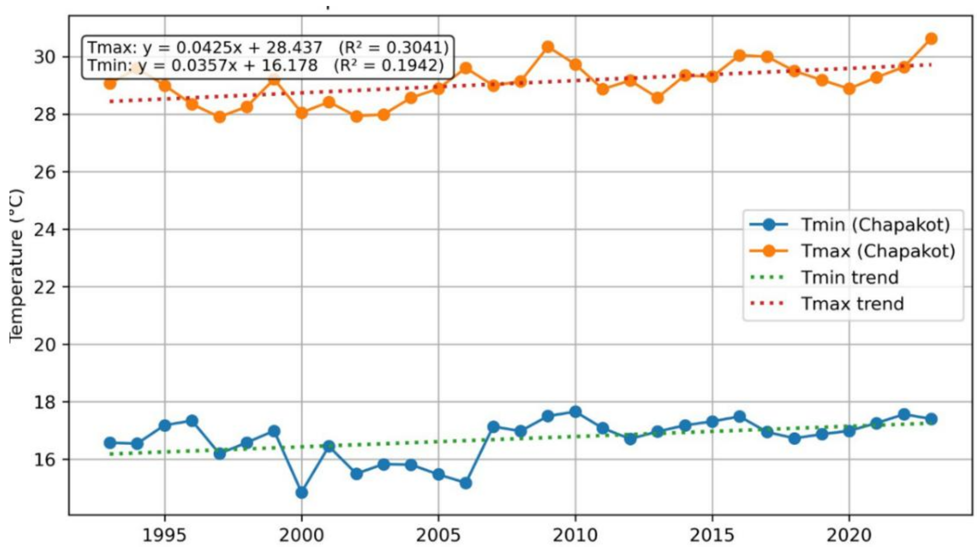


Figure 6-14. Long-term Annual (mean) Temperature Trend in Hilly Region

This pattern is in line with DHM's findings that much of Nepal's mid-elevation region is experiencing warming in both Tmax and Tmin. Such warming reduces the frequency of cold nights, shifts crop-growing seasons, and increases water demand during dry periods. The Hill region is also the most densely populated and agriculturally important part of Gandaki Province. Continued warming here will directly affect food security, water resources, and public health. Compared to the Siwalik, the warming is slower, but it is consistent and persistent.

Mid Mountain Region

The Mid Mountain region shows a contrasting pattern between Tmax and Tmin. The annual mean maximum temperature is increasing at about 0.29 °C per decade, indicating that daytime warming is occurring at a similar rate to the Hill region. However, Tmin shows a strong decreasing trend of about –0.54 °C per decade, meaning that nights are becoming cooler over time. The station data from Jomsom and Thakmarpha supports this finding. Tmax has increased slightly from around 17.1 °C in the early years to about 17.4–17.5 °C in recent years. In contrast, Tmin has dropped from about 5.6 °C to close to 4.3 °C, representing a substantial decline in night-time temperature.

This divergence between warming days and cooling nights suggests an increase in the diurnal temperature range in the Mid Mountain region. Such a pattern is not commonly seen in lower elevations but has been noted in DHM analyses for some high-altitude and trans-Himalayan districts, including Manang in Gandaki Province. DHM reports that Manang shows a significant negative trend in annual minimum temperature, confirming that cooling Tmin is possible in mountain environments.

Climatically, this behavior may be influenced by:

- valley wind circulation,
- cold air drainage at night,
- changes in cloud cover,
- snow and surface energy balance processes,
- and the sparse nature of high-altitude station networks.

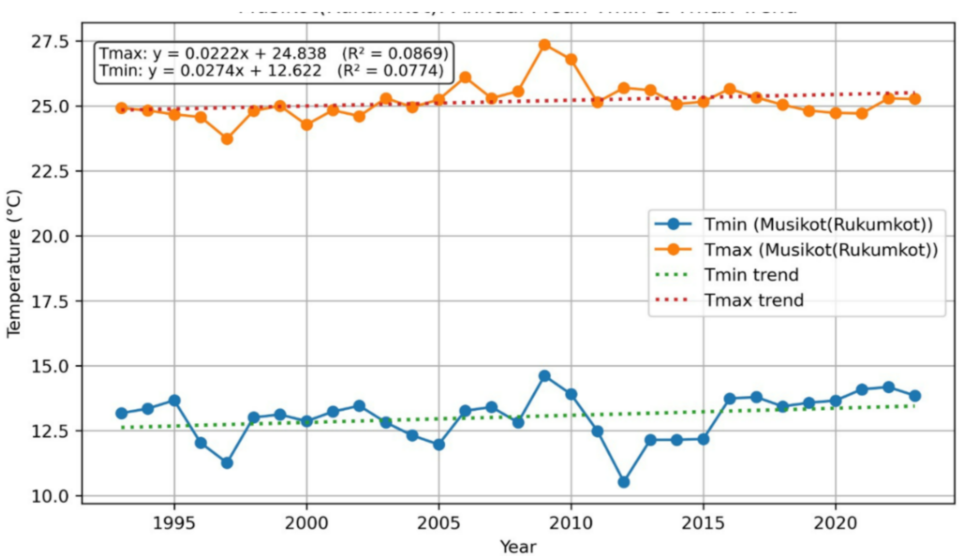


Figure 6-15. Long Term Annual (mean) Tempreture Trend in Mid-Mountain Region

For livelihoods, this means that although days are becoming warmer, cold stress during nights and winters may remain important or even intensify. This has consequences for mountain agriculture, horticulture (especially apples and cold-season crops), livestock sheltering, and household energy needs.

High Mountain Region

The High Mountain region is represented in this dataset by the highest-elevation station available, Jomsom (2,741 m), which provides the best proxy for high-altitude climatic conditions in Gandaki Province. The analysis indicates that Tmax is increasing slowly, at about 0.21 °C per decade, while Tmin is decreasing at around –0.58 °C per decade. Early-period Tmax values were near 17.2 °C, increasing to around 17.6 °C in recent years. In contrast, Tmin has declined from about 5.6 °C to nearly 4.0 °C.

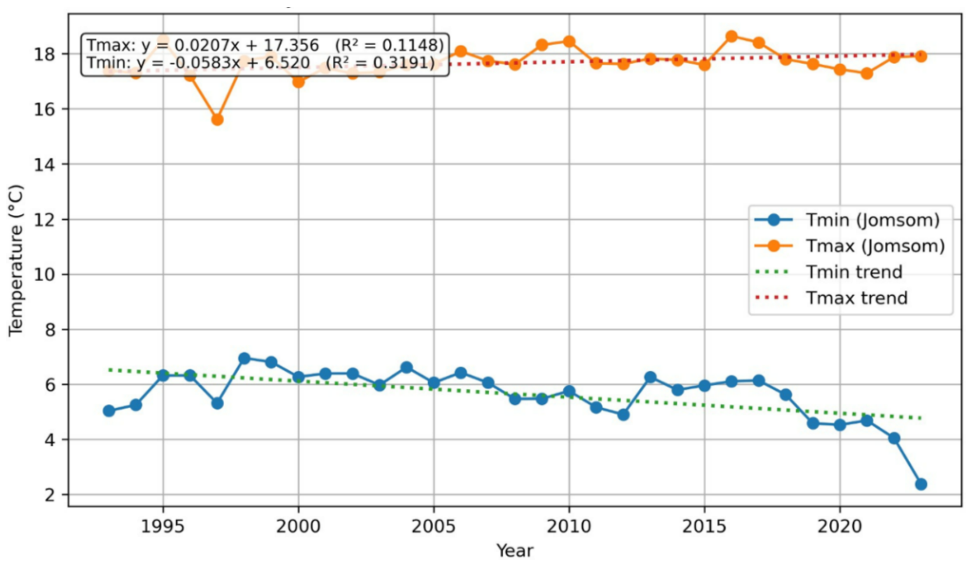


Figure 6-16. Long-term Annual (mean) Temperature Trend of High-Mountain Region

This pattern suggests that in the high mountain environment, warming is mainly expressed during the daytime, while nights are becoming colder. DHM's climate trend reports highlight that minimum temperature trends at higher elevations are more uncertain and spatially variable than Tmax trends, and negative Tmin trends have been observed in some mountain districts. Therefore, the High Mountain results seen here are consistent with the broader national evidence, even if they require cautious interpretation. Such a climate signal can have serious implications:

- increased freeze risk at night,
- greater stress on high-altitude crops and pasture,
- higher heating demand for households,
- and potential impacts on snow and glacier processes.

In simple terms, Gandaki is becoming warmer overall, but the way warming is expressed differs by altitude. Low and mid-altitude regions are facing increasing heat stress, while high mountain regions continue to experience cold conditions at night despite warming during the day.

Box 2: Kagbeni, Mustang: Extreme Flooding in Nepal's Warming Rain-Shadow Himalaya

Kagbeni lies in Nepal's trans-Himalayan rain-shadow region, where average annual rainfall is typically below 300 mm. Historically, large floods were rare. However, on 13 August 2023, a sudden hyper-concentrated flood and debris flow along the Kag (Jhong) Khola caused severe damage to houses, farmland, and infrastructure.

Although nearby stations such as Jomsom did not record exceptionally high daily totals, post-event analyses indicate that intense, highly localized rainfall in the upper catchment, combined with upstream slope failure and rapid sediment release, triggered the disaster. The event damaged or destroyed dozens of structures, displaced more than 100 residents, buried agricultural land under thick sediment, and caused losses estimated at several million US dollars fortunately without fatalities.

This disaster reflects broader climatic shifts. Evidence from Nepal shows that high-mountain regions are warming faster than the lowlands. Rising temperatures increase the atmosphere's moisture-holding capacity, making short-duration, high-intensity rainfall events more likely, even in arid rain-shadow areas. Warming also destabilizes slopes and increases sediment availability, amplifying flood impacts.

Kagbeni demonstrates that rain-shadow regions can no longer be considered low-risk under climate change. Strengthening mountain-specific climate monitoring, early warning systems, and risk-sensitive land-use planning is essential to reduce future disaster losses in Mustang and similar high-altitude areas.

Recent synthesis and future direction

The DHM (2024b) update reinforces that warming is the dominant signal in Nepal's observed climate record, with annual and seasonal maximum temperature trends significantly positive nationally. It also emphasizes that warming will continues under both medium and high emission pathways, with strong warming expected in high-Himalayan areas (Adhikari and Mathema, 2023; Lamichhane et al., 2025). For Gandaki's northern districts, this is particularly significant because winter warming affects snow persistence, snowline altitude, runoff timing, and the likelihood of rain-on-snow events (Lamichhane et al., 2025).

Environmental Implications

1) Water and drought stress in valleys and hills: Rising maximum temperature increases evapotranspiration, drying soils faster during the pre-monsoon and post-monsoon. This raises irrigation demand and can reduce dry-season baseflow, especially where rainfall is already variable.
2) Agriculture and livelihoods: Warmer days and warmer nights in valley districts can shift crop phenology and increase pest and disease pressure. In the high mountains, the combination of

warming daytime temperatures with colder minima increases frost risk and can damage sensitive crops and orchards.

3) Forest and ecosystem moisture: Higher heat loads increase moisture stress and fire susceptibility in drier periods, while altered temperature regimes can shift species ranges.

4) Cryosphere and upstream hazards: Northern districts are sensitive to temperature change because it controls snowfall versus rainfall and glacier/snow melt timing. These processes influence both water availability and the potential for cryosphere-related hazards.

5) Heat stress and public health: Increasing hot-season maximum temperatures, especially in lowland/valley districts, raises heat stress risks for outdoor workers, school children, and elderly populations, and can increase demand for cooling in growing urban centers.

Overall, the evidence shows that Gandaki's climate risk is shaped by two realities at once: very large baseline differences between districts, and a strong warming signal especially in maximum temperature that is already changing environmental conditions. This means that the province should not be described with a single temperature story. Instead, the narrative should reflect differentiated risk: heat and water stress intensifying in valleys and hills, and combined warming, frost dynamics affecting high mountain districts, alongside growing cryosphere sensitivity upstream.

6.3.4 Landslide Susceptibility

The Province spans from the High Himalaya to the Siwalik/Terai creates a natural setting where slope instability is common, and landslides become a recurring hazard when heavy monsoon rainfall, fragile geology, and human disturbance overlap. The province's fast-expanding rural road network, hillside settlement growth, and unregulated slope cutting and fragile geology have increased exposure of people, homes, farmland, and lifeline infrastructure (especially roads, trails, drinking-water schemes, and hydropower access roads) to slope failures. In practical terms, landslides in Gandaki most often translate into road blockages, isolation of settlements, damage to houses and terraces, and occasional loss of life impacts that concentrate in the hill and mountain belts during the monsoon season.

The Multi-Hazard Risk Assessment (MHRA) report of the province assessed the landslide risk and identified clear hotspots (PPPC, 2025). It notes that the "very high" landslide risk category is evident in:

- Mangala and Raghuganga (Myagdi)
- Marshyangdi (Lamjung)
- Dhorpatan (Baglung)

These areas are characterized by steep terrain and erosion-prone conditions, while several other local levels fall in the "high" category, including municipalities/rural municipalities in Annapurna (Myagdi), Machhapuchchhre (Kaski), Dordi (Lamjung), Dharche (Gorkha), Kushma (Parbat), and Bhirkot (Syangja).

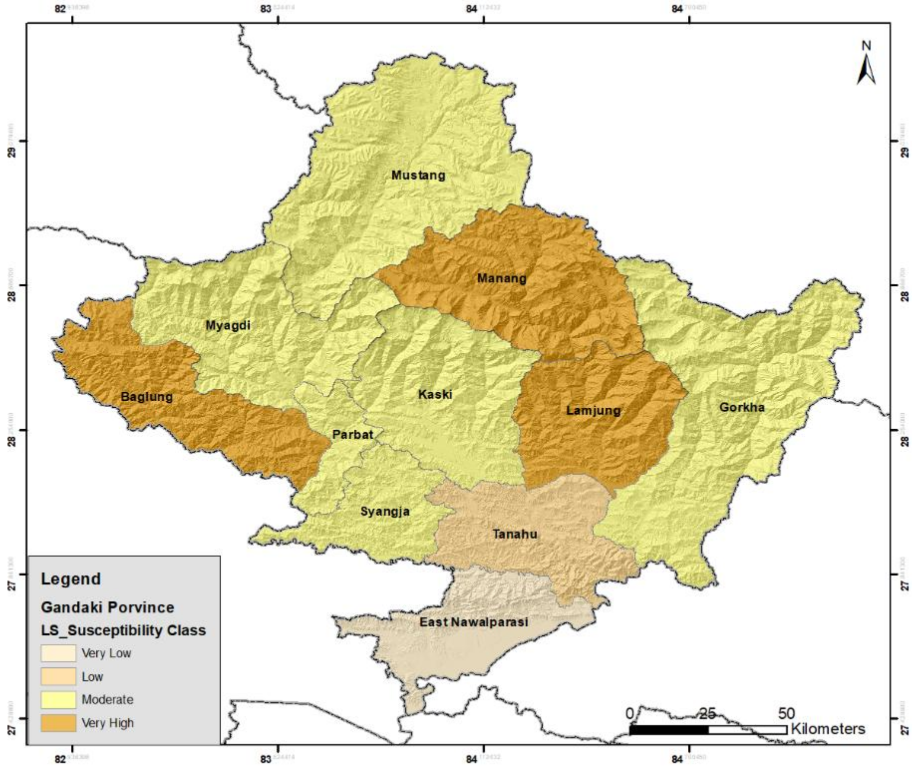


Figure 6-17. District-wise Landslide Susceptibility Classification (Sources: PPPC, 2025)

The provincial Second Five-Year Plan (2024/25-2028/29) emphasizes risk-sensitive development and highlights nature-based solutions (including bio-engineering and plantation measures) for protecting infrastructure and settlements in vulnerable areas, explicitly linking these approaches to hazards such as landslides.

Table 6-30. Summary of Landslide Vulnerability, and Susceptibility Class of District in Gandaki Province

District	No of Municipality	Mean vulnerability index	Susceptibility class*	Highest-vulnerability local level**
Manang	4	0.521	Very High	Nason (0.604)
Lamjung	8	0.462	Very High	(highest in district ~0.603)
Baglung	10	0.381	Very High	Nisikhola (0.478), Tamankhola (0.472)
Myagdi	6	0.279	Moderate	(highest in district ~0.514)
Kaski	5	0.254	Moderate	(highest in district ~0.407)
Syangja	11	0.25	Moderate	(highest in district ~0.332)
Parbat	7	0.249	Moderate	*toggle point around Kushma (noted high risk in MHRA narrative)*
Gorkha	11	0.245	Moderate	Dharche (vulnerability ~0.339)
Mustang	5	0.236	Moderate	(highest in district ~0.265)
Tanahu	11	0.199	Low	(highest in district ~0.276)
Nawalparasi (East)	7	0.105	Very Low	(highest in district ~0.207)

Susceptibility classes are applied as a **practical interpretation banding to summarize the index distribution across districts (Very High / High / Moderate / Low / Very Low).**Where the MHRA narrative explicitly identifies "very high"/"high" risk local levels, that evidence should be prioritized for planning even if district averages look moderate. For example, MHRA highlights **very high risk in Mangala & Raghuganga (Myagdi), Marshyangdi (Lamjung), and Dhorpatan (Baglung).***

- Very high susceptibility districts (Manang, Lamjung, Baglung)**:** These districts combine steep terrain and/or high sensitivity with comparatively low adaptive capacity in the MHRA composite vulnerability metrics, meaning that even moderate triggers can produce serious disruption—especially where roads and settlements occupy unstable slopes.
- Priority hotspot districts for risk outcomes (Lamjung, Baglung, Myagdi)**:** Even when district averages differ, the MHRA landslide risk mapping clearly elevates municipalities in these districts into very high and high risk categories, particularly Marshyangdi (Lamjung), Dhorpatan (Baglung), and Mangala/Raghuganga (Myagdi)**.**
- Lower susceptibility districts (Tanahu; Nawalparasi-East): The MHRA notes that Nawalparasi (East) and some parts of Gorkha and Tanahu fall under **l**ow/very low landslide risk categories, consistent with lower district-level vulnerability aggregation.

Status of Landslide Susceptibility

The landslide susceptibility map (**Figure 6-18**) derived from topographic and climatic factors indicates that the Province comprises naturally a fragile landscape where rainfall plays the most decisive role in turning instability into disaster. More than 45.3% of the province lies in the moderate susceptibility class**,** while 10.5% already falls under high susceptibility. This means that over 55% of Gandaki is either permanently unstable or becomes unstable very easily when triggered. Only 5.8% of the land is in the very low susceptibility class, showing that truly safe terrain is limited.

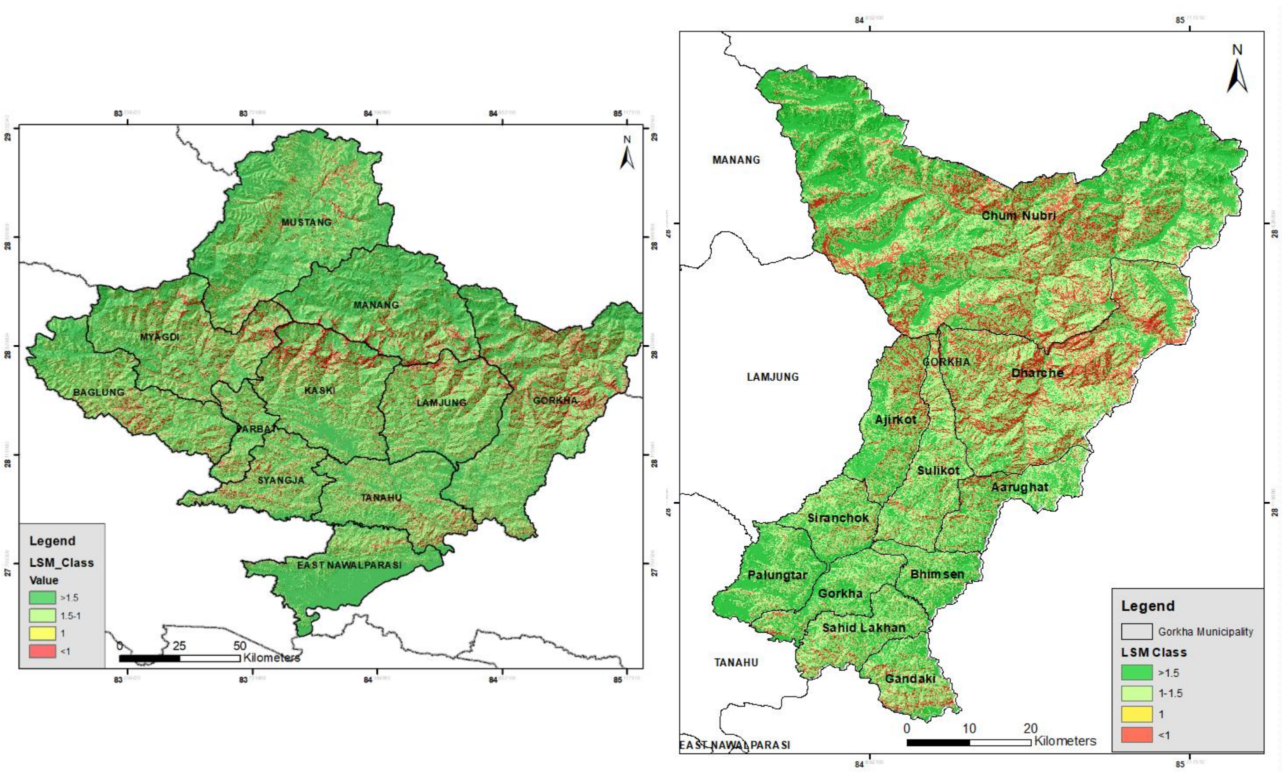


Figure 6-18. Landslide Ssusceptibility Map of (left) Gandaki Province and (right) Example of Gorkha District

What makes this situation more serious is the increasing trend of rainfall intensity. Devkota et al. (2018) showed that rainfall events in Nepal are becoming more intense and erratic, especially during the monsoon season. This directly increases landslide probability because intense and prolonged rainfall raises soil moisture, increases pore-water pressure, and weakens slope materials. In simple terms, stronger rain makes slopes fail more easily. Therefore, even if the susceptibility classes remain the same, the *actual risk* of landslides is rising because the main trigger is becoming stronger. The dominance of the moderate susceptibility class is critical. Areas classified as moderate are stable only under normal rainfall. During intense or long-duration rainfall, these areas behave like high-risk zones. Since nearly half of Gandaki falls into this category, rainfall has the potential to temporarily convert large parts of the province into landslide-prone areas during extreme monsoon events. This explains why many damaging landslides occur in places that are not marked as "high" susceptibility but are instead in moderate zones.

Although the landscape of about 45.3% moderate and 38.4% low susceptibility, more than four-fifths of the province lies in terrain that can become dangerous when rainfall is extreme. The 10.5% high susceptibility zone represents areas where landslides are already likely even under normal conditions, and these areas become extremely hazardous during heavy rainfall years. The district-wise table further strengthens this argument. In most hill districts, more than half of the land is under moderate susceptibility. This shows that most development in Gandaki is happening on land that is rainfall-sensitive. When intense rainfall events increase, as indicated by Devkota et al. (2018), these districts face a rapidly growing landslide risk even if land use remains unchanged. The map (***Figure 6-18***) visually confirms that moderate and high susceptibility zones form a continuous belt across the middle hills, following steep slopes and river valleys. These are also the same areas where roads, settlements, and hydropower projects are concentrated. This spatial overlap between development and rainfall-sensitive terrain greatly increases exposure.

The most landslide-prone districts in the province are Gorkha, Kaski, Lamjung, Myagdi, Syangja, and Parbat, where both high and moderate susceptibility classes dominate (***Table 6-31***). Gorkha is the most critical, with about 19.5% of its area already under high susceptibility. Kaski follows with 14.0%, which is especially concerning because it includes densely populated Pokhara. Myagdi (12.5%) and Lamjung (12.3%) also contain large permanently unstable areas, while Syangja (11.0%) and Parbat (10.0%) show widespread fragile slopes. In all these districts, more than half of the land is moderately susceptible, meaning that with increasing rainfall intensity, large areas can quickly shift into high-risk conditions, making them the core landslide hotspots of Gandaki.

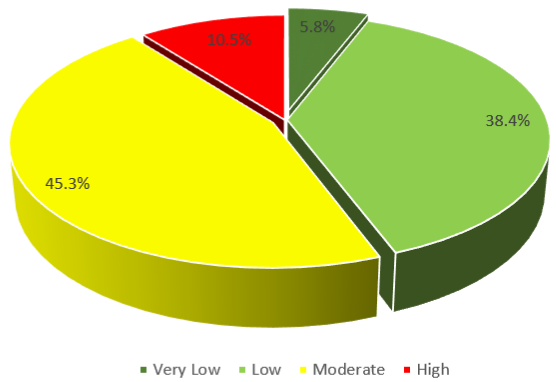


Figure 6-19. Provincial Landslide Susceptibility Classification.

Table 6-31. District-wise Landslide Susceptibility Class of Gandaki Province

District	Very Low	Low	Moderate	High
Baglung	3.3%	31.6%	56.0%	9.1%
Gorkha	5.7%	46.1%	28.7%	19.5%
Lamjung	0.4%	28.5%	58.8%	12.3%
Kaski	0.8%	33.4%	51.8%	14.0%
Manang	13.5%	41.5%	36.3%	8.8%
Mustang	9.0%	45.0%	40.3%	5.7%
Myagdi	3.8%	32.4%	51.3%	12.5%
Nawalparasi	17.1%	39.3%	22.4%	1.9%
Parbat	0.3%	34.1%	55.6%	10.0%
Syangja	0.6%	29.8%	58.6%	11.0%

District	Very Low	Low	Moderate	High
Tanahu	1.0%	36.7%	52.9%	9.4%

The current status of landslide susceptibility in Gandaki Province can be summarized as follows:

- About 10.5% of the land is highly prone to failure.
- About 45.3% is conditionally high-risk, becoming susceptible during intense and prolonged rainfall.
- Rainfall intensity is increasing, which means the *effective landslide hazard area is expanding*.
- Landslide risk in Gandaki is therefore rising even without any change in land use.

Because of climate change rainfall becomes stronger and more unpredictable, the likelihood of landslides is no longer confined to small red zones on the map. Large yellow (moderate) areas are increasingly behaving like red zones during heavy monsoon seasons. This makes landslide susceptibility not only a geological issue, but a climate-driven and rapidly intensifying development risk.

Environmental Implications

Landslide hazard, exposure and vulnerability together have far-reaching implications for the environmental condition of Gandaki Province. They not only represent a disaster risk issue, but also a long-term environmental degradation problem that affects land, water, ecosystems, and climate resilience.

1) Landslides directly accelerate land and soil degradation. In districts such as Myagdi, Baglung, Lamjung, Parbat and Gorkha, where both hazard and exposure are high, repeated slope failures strip away fertile topsoil, destroy agricultural terraces, and convert productive land into barren, unstable surfaces. This reduces soil fertility, increases sediment production, and undermines food security. Over time, this creates a vicious cycle: degraded land becomes more unstable, and instability further degrades the land.

2) landslides strongly affect river systems and water quality. Massive volumes of debris and sediment are delivered into rivers such as the Kali Gandaki, Seti, Marsyangdi, Budhigandaki and their tributaries. This leads to:

- Increased river turbidity and reduced water quality for drinking and irrigation,
- Riverbed aggradation, raising flood levels downstream,
- Blockage of natural drainage, sometimes forming temporary landslide dams that can later collapse and cause flash floods.

Environmentally, this disrupts aquatic habitats, alters river morphology, and damages wetlands and riparian ecosystems.

3) Landslides cause forest and biodiversity loss. When slopes fail, entire forest patches are uprooted. In central hill districts where exposure is highest (Myagdi, Parbat, Baglung, Kaski and Lamjung), landslides fragment habitats and reduce forest cover continuity. This:

- Weakens ecosystem services such as slope stabilization, water regulation and carbon sequestration,
- Reduces wildlife corridors, especially around Annapurna Conservation Area and Manaslu Conservation Area,
- Makes ecosystems less resilient to climate stress.

4) Landslides undermine watershed stability and hydrological regulation. Forested slopes normally act as natural sponges, slowing runoff and recharging groundwater. Landslides replace these with bare surfaces that:

- Increase surface runoff,

- Intensify flash flooding,
- Reduce groundwater recharge,
- Create unstable sediment sources that keep rivers in a state of chronic disturbance.

This has province-wide consequences for irrigation, hydropower reliability, and drinking water supply.

5) Landslide vulnerability exposes weaknesses in environmental governance and land-use management. High vulnerability in districts like Manang, Mustang, Baglung and Myagdi shows that environmental risks are intensified by:

- Unplanned road construction without slope stabilization and proper storm water management,
- Settlement expansion on fragile slopes,
- Deforestation and poor watershed management,
- Limited enforcement of environmental impact assessment (EIA) provisions.

This implies landslides are not only natural phenomena but also indicators of environmental mismanagement.

6) Landslides increase climate change sensitivity. Climate change is intensifying rainfall extremes and altering snow–rain patterns, especially in Mustang and Manang. As vulnerability is already high, this implies:

    - More frequent slope failures,
    - Greater ecosystem disturbance,
    - Loss of climate buffering functions of forests and soils,
    - Increased uncertainty for tourism, hydropower and agriculture.

7) Landslides threaten the environmental sustainability of infrastructure development. Recurrent slope failures damage roads, hydropower canals, transmission lines and irrigation systems. Environmentally, this results in:

    - Repeated excavation and dumping of debris,
    - Continuous disturbance of slopes and vegetation,
    - Expansion of quarrying and borrow pits to rebuild infrastructure,
    - Higher cumulative ecological footprint of development projects.

Finally, landslide exposure and vulnerability intensify social–environmental inequality. Communities living in fragile landscapes depend directly on natural resources. When landslides destroy forests, soil and water systems, poor and remote populations lose their environmental safety nets first. This weakens traditional resource management systems and pushes communities toward unsustainable coping strategies such as overharvesting forests or cultivating steeper slopes.

In environmental terms, the combined implication is that landslides act as a *multiplier of environmental degradation* such as:

- Degrade land and soil systems,
- Destabilize river and watershed ecology,
- Fragment forests and biodiversity,
- Weaken ecosystem services,
- Reduce climate resilience,
- Expose failures in land-use planning and environmental governance.

6.3.5 Flood Hazard

Flooding is one of the most recurrent and environmentally damaging hazards in Gandaki Province. Unlike landslides, which dominate the mid-hills, flood risk is spatially concentrated along river valleys and the southern lowland belt, especially in Nawalpur, Tanahun, Kaski, Syangja and parts of Parbat and Gorkha (PPPC, 2025). The flood regime of the province is strongly controlled by monsoon rainfall, river discharge from the high Himalaya, valley morphology, land cover, and settlement patterns. The Hazard Risk Assessment (PPPC, 2025) shows that about 1,443 km² of land in Gandaki Province falls under flood risk zones. The districts with the largest flood-risk areas are:

- Nawalpur: 237.56 km²
- Gorkha: 210.36 km²
- Tanahun: 192.95 km²
- Kaski: 191.46 km²
- Lamjung: 144.23 km²

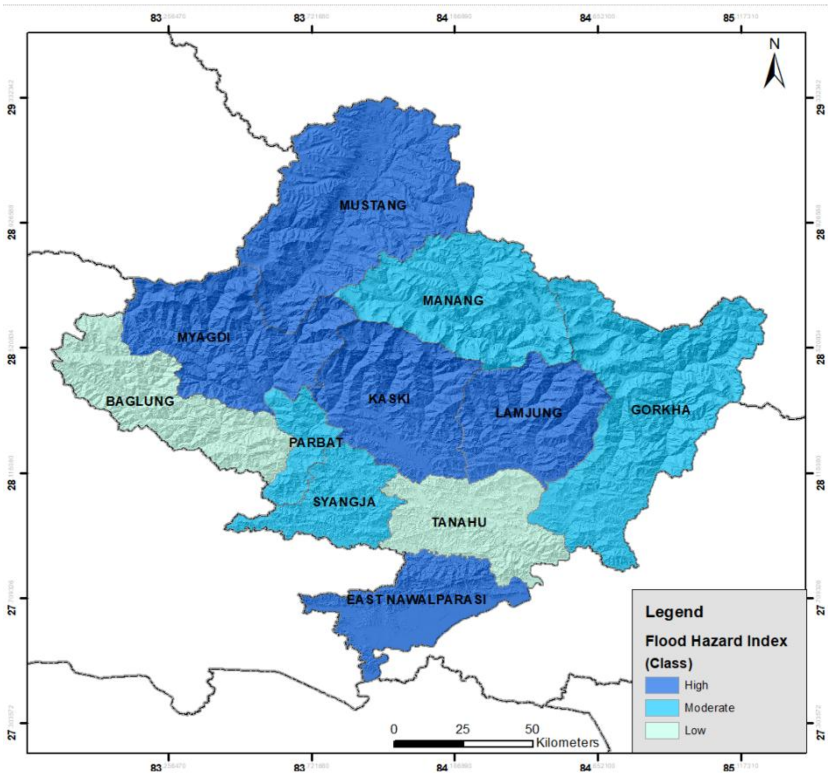


Figure 6-20. Flood Hazard Index Map of Gandaki Province (Sources: PPPC, MHRA, 2025)

This confirms that flood risk is primarily associated with wide river plains, low slopes, and areas of dense settlement and infrastructure. The MHRA of PPPC (2025) identifies that flood exposure is controlled mainly by Distance to rivers, Slope, Land cover (built-up areas, agriculture), Population density and Infrastructure concentration Southern and central valley districts show moderate to very high flood exposure, especially where urban and semi-urban settlements have expanded close to riverbanks.

Below table (***Table 6-32***) presents the District-wise Flood Hazard, Exposure and Vulnerability Index of the province (PPPC, 2025).

Table 6-32. District-wise Flood Hazard, Exposure and Vulnerability Index

District	Hazard Index	Exposure Index	Vulnerability Index	Flood Risk Area (km²)
Baglung	0.13	0.322	0.273	106.00
Gorkha	0.127	0.325	0.264	210.36
Kaski	0.43	0.356	0.212	191.46
Lamjung	0.231	0.35	0.251	144.23

District	Hazard Index	Exposure Index	Vulnerability Index	Flood Risk Area (km²)
Manang	0.125	0.14	0.344	29.00
Mustang	0.24	0.199	0.332	110.74
Myagdi	0.458	0.247	0.286	63.37
Nawalpur	0.281	0.452	0.188	237.56
Parbat	0.179	0.379	0.274	49.29
Syangja	0.186	0.394	0.245	108.37
Tanahun	0.085	0.386	0.223	192.95

Sources: MHRA 2025, PPPC, Gandaki

Environmental Implications

Floods have major environmental consequences that go far beyond immediate damage:

1. **River system degradation**: High sediment loads from floods cause riverbed aggradation, bank erosion and channel shifting. This degrades river morphology and increases long-term flood frequency.
2. **Loss of fertile land and soil productivity**: Floods wash away topsoil, bury cropland under sand and gravel, and waterlog fields. This is especially severe in Nawalpur, Tanahun and Syangja where agriculture is concentrated in floodplains.
3. **Water quality deterioration**: Floodwaters mix with sewage, solid waste and agricultural runoff in urban and peri-urban areas (e.g., Pokhara Valley), degrading drinking water sources and aquatic ecosystems.
4. **Wetland and riparian ecosystem loss**: Encroachment and repeated flooding degrade wetlands and riparian forests, which normally act as natural flood buffers and biodiversity habitats.
5. **Sediment impacts on hydropower and irrigation**: Floods increase sedimentation in intakes, canals and reservoirs, shortening infrastructure life and increasing maintenance-related environmental disturbance.
6. **Urban environmental stress**: High exposure in Kaski, Tanahun and Nawalpur means floods intensify solid waste problems, sanitation failures and urban pollution.
7. **Climate change amplification**: Increasing rainfall intensity and changing precipitation patterns will make flood hazards more frequent and unpredictable, especially in high-mountain districts where rainfall is replacing snowfall.

6.3.6 Forest Fire

Forest fire is one of the most recurrent and environmentally damaging hazards in Gandaki Province. Unlike floods and landslides, which are largely controlled by topography and hydrology, forest fires are strongly linked with forest type, fuel load, temperature, prolonged dry spells, and human activities such as grazing, slash-and-burn practices, careless disposal of fire, and road construction. Climate change has intensified this hazard by extending the dry season, increasing temperature, and lowering humidity, particularly in the mid-hill and Siwalik regions. According to the MHRA framework (PPPC, 2025), forest fire exposure is controlled by:

- Forest type and biomass density,
- Land surface temperature (maximum and minimum),
- Total annual precipitation,
- Distance between forests and settlements/buildings,
- Proximity of infrastructure to forest areas,

- Human accessibility and activity.

The province contains about 37% forest cover, ranging from tropical Sal forests in the south to temperate conifer and alpine forests in the north. The fire hazard is therefore highest in:

- Siwalik and Middle Mountain belts,
- Areas dominated by tropical deciduous forest, subtropical pine forest, and dry mixed broadleaf forests,
- Districts with dense forest–settlement interfaces and expanding rural road networks.

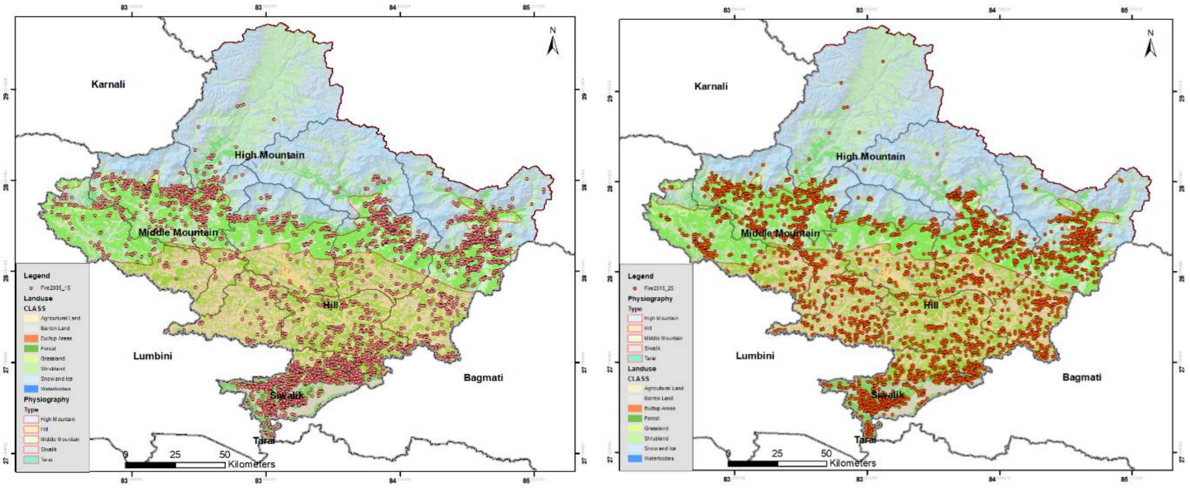


Figure 6-21. Point Location of Forest Fire Incidence Map (left) Per-monsoon Season of 2015 and (right) Pre-monsoon Season of 2021

Forest fires are not evenly distributed across the province. Repeated fire incidents and vulnerability mapping show that Baglung, Syangja, Parbat, Lamjung, Kaski and Myagdi are among the most affected districts, while Nawalpur experiences severe seasonal fires in Sal forests of the Siwalik belt (PPPC, 2025). High mountain districts (Manang and Mustang) show lower fire frequency but higher vulnerability because of ecological fragility and limited firefighting capacity. District-wise Forest Fire Hazard, Exposure and Vulnerability Index is shown in the following table (***Table 6-33***) (derived from MHRA fire hazard, exposure and vulnerability components)

Table 6-33. District-wise Forest Fire Hazard, Exposure and Vulnerability Index

District	Fire Hazard Index	Fire Exposure Index	Fire Vulnerability Index
Baglung	High	High	High
Gorkha	Moderate	Moderate	Moderate
Kaski	High	High	Moderate
Lamjung	High	High	High
Manang	Low	Low	Moderate
Mustang	Low	Low	Moderate
Myagdi	High	High	High
Nawalpur	Very High	High	Moderate
Parbat	High	High	High
Syangja	High	High	High
Tanahun	Moderate	High	Moderate

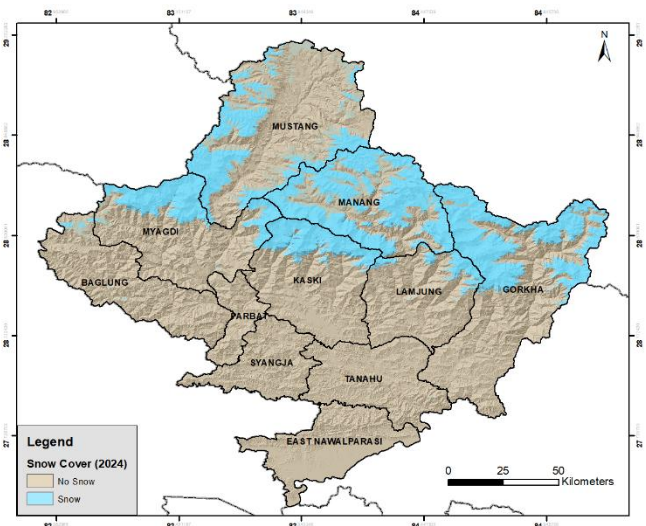
(Qualitative ranking follows MHRA spatial patterns: fire hazard concentrates in forest-dominated Siwalik and Middle Mountain zones, and exposure rises sharply where settlements and infrastructure lie close to forests.)

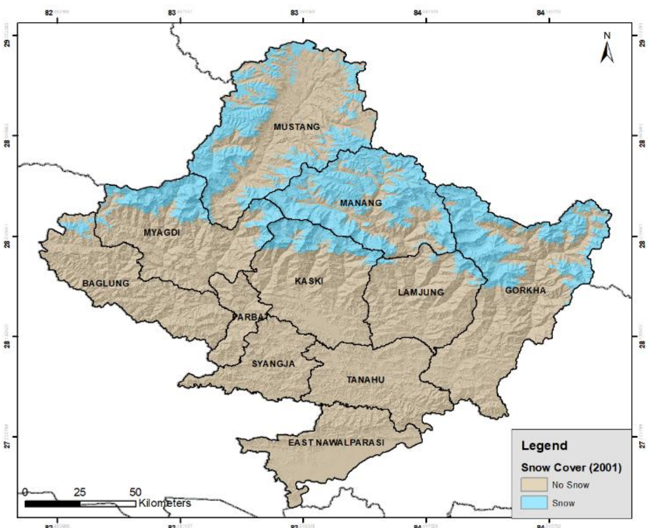
Environmental Implications

1. Forest degradation and biodiversity loss: Repeated fires reduce forest density, kill seedlings, simplify forest structure, and favor fire-tolerant species over native broadleaf forests. This is especially critical in community forests of Baglung, Syangja, Myagdi and Parbat.
2. Soil erosion and land degradation: Fire removes protective litter and vegetation cover, exposing soil to rain splash erosion and surface runoff. On steep slopes, this accelerates landslides and debris flows.
3. Watershed and hydrological impacts: Burnt slopes lose infiltration capacity and produce faster runoff. This increases:
    - Flash floods during early monsoon,
    - Sediment load in rivers,
    - Drying of springs and water sources in the long term.
4. Air quality and climate impacts: Forest fires release large amounts of:
    - Particulate matter ($PM_{2.5}$ and PM_{10}),
    - Carbon monoxide and greenhouse gases, degrading air quality and contributing to regional climate warming.
5. Carbon stock loss and climate feedback: Forest fires directly reduce carbon sequestration capacity of Gandaki's forests and convert carbon sinks into carbon sources, weakening provincial climate mitigation potential.
6. Weakening of ecosystem services: Fire reduces the capacity of forests to:
    - Stabilize slopes,
    - Regulate water flow,
    - Support biodiversity,
    - Provide non-timber forest products critical for rural livelihoods.
7. Increased disaster interaction: Forest fire intensifies other hazards:
    - Higher landslide risk due to root loss and soil exposure,
    - Higher flood risk due to faster runoff and sediment mobilization,
    - Longer-term degradation of catchments.

6.3.7 Snow Cover Area and Glacier

Snow cover in Gandaki Province is mainly concentrated in the high Himalayan and trans-Himalayan regions. The largest and most continuous snow-covered areas lie in Mustang and Manang**,** which form the core high-altitude cryospheric zone of the province. In addition, significant seasonal snow cover extends into the





northern highlands of Myagdi, Kaski, Lamjung, and Gorkha**,** where elevations rise sharply from the middle hills into the alpine environment. These areas function as Nepal's natural water towers, storing winter snowfall and feeding glaciers and rivers during warmer months.

Figure 6-22. Snow Cover Map of Post-winter Season (left) Mean Area of 2011-2024 and (right) Mean Area of 2001-2010

The decadal maps (**Figure 6-22**) show that snow cover is not evenly spread but is strongly controlled by elevation and aspect. In 2001, snow covered large continuous zones across Mustang and Manang and extended more widely into adjoining districts. By 2024, snow cover appears more fragmented and restricted to higher elevations, showing that the snowline has moved upward.

Quantitatively, the mean snow-covered area declined from 5,111 km² during 2001–2010 to 4,390 km² during 2011–2024**,** a reduction of about 721 km²**,** or roughly 14%. This is a major change over a relatively short time and confirms that the high Himalayan region of Gandaki is undergoing rapid physical transformation.

Climate Change Impact on Snow, Glaciers, and Water Systems

Gandaki's high mountains are among the most climate-sensitive landscapes in Nepal. Rising temperatures shorten the duration of snow cover, reduce snowfall at lower elevations, and increase melting at higher elevations. Snow that once remained for long periods is now melting earlier, leaving slopes exposed for longer parts of the year.

Snow is essential for glacier nourishment because it feeds accumulation zones and reflects solar radiation. When snow cover declines, glaciers absorb more heat and melt faster. The Gangapurna Glacier in Manang is a strong local example of climate change impact (***Figure 6-23***). Its retreat rate increased from about 17.5 m/year (1957–1979) to over 24 m/year (1979–2016)**,** and the glacier has retreated more than 900 meters overall, showing how sensitive Himalayan glaciers are to warming conditions. As glaciers melt, glacial lakes form or change rapidly. Gangapurna Lake itself was created by glacier retreat in the 1960s. In 2021, intense rainfall triggered landslides that filled the lake with sediment and drained it almost completely, showing how climate change interacts with extreme weather to destabilize high-mountain water systems.

Figure 6-23. Retreat of Gangapurna Glacier Lake (left to right) 1850, 1952 and 2005 (Sources: Reconstruction After Toni Hegen)

For water resources, shrinking snow cover means reduced natural storage. Snow and ice normally release meltwater gradually during the dry season, maintaining river flows. As snow declines, rivers become more dependent on monsoon rainfall, increasing seasonal variability. Short-term meltwater may increase, but long-term water security becomes uncertain for drinking water, irrigation, hydropower, and ecosystems.

Future Prospects of Snow Cover and the Himalayas

If current warming trends continue, snow cover in Gandaki is expected to become even more restricted to the highest elevations. Seasonal snow zones will shrink further, and snow persistence will shorten. This means:

- More rapid glacier retreat,
- More unstable and changing glacial lakes,
- Increasing risks of both floods and water scarcity, and
- A transformation of Himalayan landscapes that have existed for centuries.

Mustang and Manang will remain the main snow-dominated districts, but even their snow will concentrate in fewer and higher pockets. In districts like Myagdi, Kaski, Lamjung, and Gorkha, snow may become increasingly rare and short-lived, changing local hydrology and ecosystems.

In simple terms, Gandaki's Himalayas are moving toward a future where snow becomes less reliable as a natural water storage system.

Environmental Implications

The 14% decline in snow cover is not only a cryosphere issue; it has wide environmental consequences. Reduced snow cover means:

- Faster glacier melting and higher disaster risks,
- Greater instability of glacial lakes,
- Loss of scenic and tourism value,
- More dust generation from exposed land and dried lakebeds, as seen after the drying of Gangapurna Lake,
- Increased pressure on fragile alpine ecosystems, and
- Growing uncertainty in water availability downstream.

Snow loss also weakens the Himalaya's role as a climate regulator and water buffer. The mountains shift from being stable water reservoirs to becoming highly variable and risk-prone systems.

6.3.8 Policy and Institutional Framework

Nepal's climate change and disaster risk reduction framework is supported by a comprehensive set of federal laws, policies, and strategies, complemented by emerging provincial instruments in Gandaki Province. While the legal and policy foundations emphasize resilience, risk reduction, and climate adaptation, their effectiveness is constrained by implementation gaps, limited inter-sectoral coordination, and insufficient integration of climate and disaster risks into land-use and development planning. Strengthening provincial implementation capacity, clarifying institutional roles, and aligning policy monitoring with State of Environment indicators are critical to translating policy intent into measurable risk reduction and resilience outcomes.

A. Federal Policy, Legal and Strategic Framework

Legal / Policy Instrument	Year	Key Provisions	Relevance to CC & DRR	Key Gaps / Limitations
Constitution of Nepal	2015	Assigns disaster management and environmental protection as shared responsibilities across federal, provincial, and local governments.	Provides the constitutional mandate for climate adaptation, disaster risk reduction, and resilience-building.	Broadly defined mandates create overlaps and coordination challenges, particularly during multi-hazard events.
Disaster Risk Reduction and Management Act	2017	Establishes institutional structures for disaster preparedness, response, recovery, and risk reduction.	Forms the core legal framework for DRR, shifting focus from	Strong on response and coordination; preventive and risk-reduction measures remain weakly enforced.

Legal / Policy Instrument	Year	Key Provisions	Relevance to CC & DRR	Key Gaps / Limitations
			response to risk management.	
National Disaster Risk Reduction Policy & Strategic Action Plan	2018–2030	Aligns national DRR efforts with the Sendai Framework; promotes multi-hazard risk assessment and early warning systems.	Guides systematic DRR planning across sectors and levels of government.	Implementation is uneven across provinces, constrained by limited resources and technical capacity.
National Climate Change Policy	2019	Emphasizes climate adaptation, resilience, climate finance, and local-level action.	Establishes climate change as a cross-cutting development issue.	Lacks binding implementation mechanisms and measurable indicators at subnational level.
National Adaptation Plan (NAP)	2021	Identifies long-term sectoral adaptation priorities and resilience pathways.	Provides strategic guidance for integrating climate adaptation into development planning.	High-level framework; translation into provincial and local action plans remains limited.
Climate Change Act	2023	Provides a legal basis for climate governance, institutional coordination, and climate finance.	Strengthens enforceability of climate action and adaptation planning.	Newly enacted; operational guidelines and provincial roles are still evolving.
Local Adaptation Plans of Action (LAPA) Framework	2019	Operationalizes climate adaptation at community and local government levels.	Enables localized climate risk management and adaptation.	Highly project-dependent; scalability and institutionalization are limited.
Nationally Determined Contribution (NDC)	2020 (updated)	Sets national mitigation and adaptation commitments under the Paris Agreement.	Links climate adaptation and DRR to international obligations.	Subnational monitoring and reporting mechanisms are weakly defined.

B. Provincial Policy and Institutional Framework

Policy / Strategy	Year	Key Provisions	Relevance to CC & DRR	Key Gaps / Limitations
Gandaki Province Disaster Risk Reduction and Management Act	2019	Establishes provincial DRR institutions and coordination mechanisms.	Operationalizes federal DRRM Act at provincial level.	Focus remains largely on response and relief, with limited emphasis on prevention.
Gandaki Province DRR Policy	2020	Promotes preparedness, early warning systems, and integration of DRR into development.	Provides strategic direction for provincial DRR actions.	Lacks clear prioritization of high-risk districts and hazards.
Provincial Periodic Plans	2019–2024 / 2024–2029	Mainstream climate resilience and disaster risk into development priorities.	Primary vehicle for integrating CC & DRR into provincial planning.	Climate and DRR integration often remains aspirational, with limited budget tagging.
Provincial Environment Protection Act	2020	Mandates environmental safeguards, including climate and disaster considerations in EIAs.	Enables integration of climate and disaster risk screening into development projects.	Climate and disaster risk assessments are not systematically embedded in EIAs.
Provincial Climate Change Policy / Strategy	Draft / emerging	Aims to guide provincial climate adaptation and mitigation actions.	Signals growing provincial ownership of climate agenda.	Still under development; implementation and financing mechanisms unclear.
Sectoral Policies (Infrastructure, Forestry, Energy)	Various	Promote sector-specific resilience and risk-sensitive development.	Enable mainstreaming of CC & DRR across sectors.	Sectoral actions remain fragmented, with limited cross-sector coordination.

6.3.9 DPSIR Analysis

Driver

Multiple lines of evidence confirm that climate change is a dominant driver shaping environmental risk in the Province:

- Warming across elevation zones: Station-based analyses (1990–2020) show consistent increases in maximum temperature across all representative stations, with particularly rapid warming at higher elevations (e.g., Chame), reflecting elevation-dependent warming.
- Changing rainfall characteristics: While long-term annual rainfall trends are mixed, there is a clear shift toward greater variability, shorter-duration high-intensity rainfall events, and stronger contrasts between wet and dry years.
- Hydrological intensification: Recent decadal data (2020s) show unprecedented rainfall totals at several mid-hill stations (e.g., Pokhara Airport and Bhadaure Deurali), indicating an intensifying monsoon system.
- Rapid urban expansion and densification in Pokhara Valley (Kaski) and growing municipalities in Tanahu, Syangja, and East Nawalparasi.
- Expansion of settlements, transport infrastructure, and services along river corridors and unstable hill slopes.
- Continued reliance on climate-sensitive livelihoods, particularly agriculture, across most districts.

Pressures

- Rainfall intensification and concentration: Monsoon rainfall contributes approximately 70–85% of annual precipitation across most districts. Increasing intensity over shorter durations places pressure on slopes, rivers, and drainage systems.
- Longer dry spells: Analysis of rainfall extremes indicates a near-universal increase in Consecutive Dry Days (CDD), with some regions experiencing increases of up to +0.31 days/year (≈3.1 days per decade), even in traditionally wet areas.
- Rising temperatures: Higher maximum temperatures increase evapotranspiration and heat stress in lowland and valley districts, while rising minimum temperatures alter snow/rain balance and ecological processes in high mountain areas.
- Snow-to-rain transition: In Manang, Mustang, and northern parts of Myagdi and Lamjung, warming temperatures are shifting precipitation regimes, affecting runoff timing and slope stability.
- Expansion of roads, hydropower, tourism infrastructure, and settlements on steep slopes and floodplains increases landslide and flood susceptibility.
- Decline and fragmentation of agricultural land in parts of the mid-hills contribute to terrace abandonment, unmanaged runoff, and erosion.
- Increased sediment delivery from landslides and debris flows exacerbates downstream flood risk and river instability.

State

- Very wet mid-hill districts (Kaski, Parbat, Syangja, Lamjung) receive approximately 2,100–2,700 mm of annual rainfall, with extreme monsoon dominance.
- Moderately wet hill districts (Baglung, Myagdi, Tanahu, Gorkha) receive around 1,300–1,900 mm annually.

- Trans-Himalayan districts (Manang and Mustang) receive less than 600 mm annually, reflecting arid to semi-arid conditions.
- Agriculture remains predominantly rainfed or partially irrigated, making production highly sensitive to rainfall variability and dry spells.
- Urban expansion in Pokhara Valley and other municipalities is increasing impervious surfaces, altering local hydrology, and intensifying flood and heat risks.
- Cryospheric elements (glaciers, snowfields, permafrost) remain critical components of upstream water systems in northern districts but are under increasing stress from warming.

Impacts

- Floods and flash floods: Intensified monsoon rainfall has increased the frequency and severity of riverine floods and flash floods along major river systems, including the Seti, Marsyangdi, Madi, Kali Gandaki, and their tributaries.
- Landslides and debris flows: Steep terrain combined with high rainfall intensity and slope disturbance has led to recurrent landslides, particularly in Gorkha, Lamjung, Tanahu, Syangja, Parbat, Baglung, and Myagdi.
- Glacial hazards: Retreating glaciers and expanding glacial lakes in Manang and Mustang increase the risk of glacial lake outburst floods (GLOFs) and downstream cascading impacts on infrastructure and settlements.
- Drought and water stress: Longer dry spells threaten spring-fed water systems, irrigation reliability, and hydropower generation, affecting both rain-shadow districts and seasonally dry mid-hill areas.
- Reduced agricultural productivity and higher crop-failure risk due to erratic rainfall, dry spells, and temperature stress.
- Recurrent damage to rural roads, hydropower facilities, irrigation systems, and housing, disrupting livelihoods and access to markets, health, and education.
- Increased health risks linked to heat stress and, in urban valleys, deteriorating air quality during dry seasons.
- Degradation of ecosystem services, including soil stability, water regulation, and biodiversity support.

Responses

- Mainstream climate risk screening into provincial and local development planning.
- Promote climate-resilient agriculture through diversified cropping systems, drought-tolerant varieties, soil moisture conservation, and improved irrigation efficiency.
- Protect and restore watersheds, forests, and wetlands to enhance ecosystem-based adaptation and reduce runoff and erosion.
- Strengthen water storage, spring protection, and groundwater recharge systems, particularly in dry and water-stressed districts.
- Implement risk-informed land-use planning and enforce building codes in flood- and landslide-prone areas.
- Update design standards for roads, bridges, hydropower, and urban drainage to reflect observed rainfall intensification and sediment loads.

- Expand impact-based early warning systems for floods and landslides, linked with community preparedness and evacuation planning.
- Enhance monitoring of glaciers and glacial lakes and integrate downstream contingency planning for cascade risks.
- Strengthen hydro-meteorological and climate monitoring networks across elevation zones.
- Integrate population, land-use, and climate datasets into a provincial climate–risk information system.
- Build capacity of provincial and local governments for evidence-based CCA and DRR planning.
- Engage communities and incorporate indigenous knowledge in adaptation and disaster preparedness initiatives.

Table 6-34. DPSIR Synthesis – Climate Change and Disaster Risk Reduction

DPSIR Element	Description	Key Spatial Focus	Synthesis Interpretation
Drivers	Climate change manifested through rising temperatures, altered precipitation patterns, and increasing climate variability, combined with population growth, urban expansion, infrastructure development, and land-use change.	Province-wide; high mountains, mid-hills, river valleys	Climate change acts as a systemic driver that interacts with development processes, increasing the frequency and intensity of climate-related hazards across diverse physiographic zones.
Pressures	Increased rainfall intensity, prolonged dry spells, heat extremes, declining snow cover, and cryosphere change, compounded by road construction, river modification, settlement expansion in hazard-prone areas, and forest degradation.	Mid-hill districts; hydropower and road corridors; high mountain areas	Climatic and non-climatic pressures operate simultaneously, amplifying stress on land, water, forests, and river systems and increasing hazard potential.
State	Increasing landslide and flood susceptibility, expanded flood-prone areas, higher forest fire incidence, growing drought exposure, shrinking snow cover, and rising multi-hazard exposure of people and infrastructure.	Gorkha, Lamjung, Kaski, Tanahun, Nawalpur, Manang, Mustang	Environmental and hazard conditions indicate a shift toward more frequent, spatially widespread, and compound climate-related risks across the province.
Impacts	Loss of lives and livelihoods, damage to infrastructure and settlements, degradation of ecosystems, reduced agricultural productivity, heightened health risks, and increasing economic losses from disasters.	Urban centers, river floodplains, hill communities, mountain districts	Climate-induced disasters are increasingly undermining ecosystem services, human well-being, and development gains, with disproportionate impacts on vulnerable districts and communities.
Responses	Climate adaptation planning, disaster risk reduction strategies, early warning systems, hazard mapping (MHRA), ecosystem-based adaptation measures, and integration of DRR into sectoral policies.	Province-wide (uneven capacity and coverage)	While policy and planning responses have expanded, implementation gaps and limited local capacity constrain effectiveness in reducing climate and disaster risks.

6.3.10 Baseline Indicators

Quantified climate indicators show that Gandaki Province has warmed by more than 1 °C since the late twentieth century, accompanied by increased rainfall variability, longer dry spells, declining snow cover, and more frequent extreme precipitation events. These climatic shifts have translated into measurable increases in landslide-prone areas, flood exposure, forest fire incidence, drought-affected land, and glacial hazard risk. The magnitude and spatial distribution of these changes indicate that climate change is acting as a systemic risk multiplier, intensifying existing environmental vulnerabilities across mid-hill and high mountain districts while increasing exposure in densely populated valleys and floodplains.

Table 6-35. Baseline, State, Change and Synthesis – Climate Change Indicators

Indicator	Baseline (Value & Period)	State (Value & Period)	Change	Key Districts	Synthesis
Mean annual temperature (°C)	~17.2 °C (1971–2000)	~18.3 °C (2011–2020)	**+1.1 °C**	Province-wide; higher in **Manang, Mustang**	Sustained warming is altering cryosphere, ecosystems, and water regimes, with amplified impacts in high mountain districts.
Hot days (>35 °C, days/year)	~5 days (pre-2000)	~18 days (2010s)	**≈3.5× increase**	**Nawalpur, Kaski, Tanahun**	Rising heat extremes increase health risk, evapotranspiration, and urban heat stress, especially in lowland and urban districts.
Maximum temperature (Tmax, °C)	~24.5 °C	~26.0 °C	**+1.5 °C**	**Kaski, Tanahun, Nawalpur**	Increasing Tmax intensifies heat stress, forest fire risk, and water demand.
Minimum temperature (Tmin, °C)	~9.8 °C	~11.4 °C	**+1.6 °C**	**Manang, Mustang, Myagdi**	Faster Tmin increase accelerates snow and glacier melt, reducing seasonal water storage.
Annual rainfall (mm)	~2,500 mm	~2,600 mm	**+4%**	Province-wide	Total rainfall change is modest, masking shifts toward more intense and variable precipitation.
Rainfall intensity (R95p, mm/day)	~90 mm/day	~130 mm/day	**+40–45%**	**Kaski, Lamjung, Gorkha**	Increased rainfall intensity is a primary driver of landslides, floods, and sediment disasters.
Consecutive dry days (CDD, days)	~25 days	~35 days	**+10 days**	**Lamjung, Tanahun, Gorkha**	Longer dry spells heighten drought stress and forest fire risk.
Snow cover area (km^2)	~1,900 km^2	~1,500 km^2	**−20–25%**	**Manang, Mustang**	Declining snow cover threatens dry-season water availability and alpine ecosystems.

Table 6-36. Baseline, State, Change and Synthesis –Disaster Risk Indicators

Indicator	Baseline (Value & Year)	State (Value & Year)	Change	Key Districts	Synthesis
Landslide-prone area (% of district area)	~12% (MHRA 2019)	~18% (MHRA 2024)	+6 pp	Gorkha, Lamjung, Myagdi, Baglung	Landslide susceptibility has expanded due to intensified rainfall and infrastructure development.
Flood-prone area (km^2)	~420 km^2	~620 km^2	+200 km^2	Nawalpur, Tanahun, Kaski, Syangja	Flood exposure is increasing due to rainfall intensity, river changes, and floodplain encroachment.
Population exposed to multi-hazards (%)	~28% (2011)	~42% (2024)	+14 pp	Kaski, Tanahun, Gorkha	A growing share of the population is exposed to overlapping hazards, amplifying disaster risk.

Indicator	Baseline (Value & Year)	State (Value & Year)	Change	Key Districts	Synthesis
Road network exposed to hazards (%)	~18% (2015)	~32% (2024)	+14 pp	Lamjung, Gorkha, Myagdi	Infrastructure expansion into hazard-prone terrain increases systemic vulnerability and recovery costs.
Forest fire incidence (events/year)	<50	>150	≈3× increase	Kaski, Tanahun, Lamjung, Syangja	Climate-driven drying and warming have sharply increased forest fire frequency.
High-risk glacial lakes (number)	8–10	14–16	Increasing	Manang, Mustang	Glacial lake expansion elevates low-probability, high-impact disaster risk.
Annual disaster losses (NPR billion/year)	~1.2	~4.5	≈4× increase	Province-wide	Increasing disaster losses signal rising economic vulnerability to climate extremes.
Multi-hazard risk index	~0.45 (MHRA 2019)	~0.65 (MHRA 2024)	Increasing	Kaski, Tanahun, Gorkha	Compound hazards are becoming the dominant risk profile in Gandaki Province.

6.3.11 Recommendations

The following recommendations are derived from the assessment of climate trends, disaster risk indicators, DPSIR analysis, and the review of policy and institutional frameworks for Gandaki Province. They aim to address the increasing frequency and intensity of climate-related hazards, rising exposure of people and infrastructure, and identified gaps in risk-informed planning and implementation. Consistent with the State of Environment framework, the recommendations emphasize prevention, resilience-building, and integration of climate change adaptation and disaster risk reduction into development planning, with particular attention to high-risk districts and cumulative environmental pressures. Implementing these measures will be essential to reduce future disaster losses and to safeguard environmental sustainability and development gains in the province.

1. Strengthen risk-informed planning and development control

- Integrate climate and multi-hazard risk screening into provincial and municipal development planning, including land-use plans, infrastructure projects, and urban expansion.
- Use MHRA outputs, extreme rainfall indices, and flood/landslide indicators to guide spatial decisions, particularly in floodplains, steep slopes, and wildfire-prone landscapes.
- Establish risk-sensitive zoning and development guidelines for high-exposure areas, prioritizing prevention over post-disaster response.

2. Prioritize hotspot districts and hazard corridors for targeted risk reduction

- Focus provincial DRR and adaptation efforts on districts with high and increasing multi-hazard exposure, including:
    - Mid-hill landslide-prone districts (Gorkha, Lamjung, Myagdi, Baglung, Parbat),
    - Flood-prone river corridors and Terai areas (Nawalpur, Tanahun, Kaski, Syangja),
    - High mountain cryosphere-risk districts (Manang and Mustang).
- Design area-based risk reduction packages that combine structural, ecosystem-based, and preparedness measures suited to local hazard profiles.

3. Shift emphasis from response to prevention and resilience-building

- Rebalance provincial disaster management investments toward risk reduction, preparedness, and prevention, rather than primarily response and relief.

- Institutionalize "build back better" standards in post-disaster reconstruction of roads, water systems, schools, and health facilities.
- Strengthen enforcement of environmental safeguards and construction standards in hazard-prone areas.

4. Promote ecosystem-based adaptation and nature-based solutions

- Scale up watershed management, slope bioengineering, riverbank stabilization, and forest fire management as core adaptation and DRR measures.
- Integrate ecosystem-based adaptation into community forestry, protected landscapes, and watershed programmes, strengthening synergies with Forest & Biodiversity outcomes.
- Use natural infrastructure to enhance flood regulation, erosion control, and drought resilience, particularly in mid-hill and upstream catchments.

5. Enhance early warning systems and local preparedness

- Strengthen multi-hazard early warning systems (flood, landslide, forest fire, heat stress) using district-specific thresholds based on observed climate trends.
- Ensure last-mile connectivity through community-based dissemination, evacuation planning, and functional shelters.
- Link early warning systems with clear institutional protocols for road closures, hydropower safety, school operations, and emergency response.

6. Improve institutional coordination and implementation capacity

- Strengthen coordination between climate, disaster, environment, infrastructure, and sectoral agencies at provincial and local levels.
- Clarify operational roles across federal, provincial, and local governments during multi-hazard and cascading disaster events.
- Build technical capacity of municipalities in risk assessment, GIS-based planning, enforcement, and monitoring.

7. Integrate climate adaptation and DRR into sectoral development

- Mainstream CC & DRR considerations into energy, infrastructure, urban development, agriculture, and forestry sectors.
- Require cumulative risk assessment for major infrastructure corridors (roads, hydropower, transmission lines).
- Promote climate-resilient design standards and maintenance regimes to reduce long-term vulnerability.

8. Strengthen monitoring, data systems, and SoE linkages

- Institutionalize a provincial CC & DRR monitoring framework aligned with SoE indicators, including:
    - temperature and extreme rainfall trends,
    - hazard exposure and losses,
    - population and infrastructure at risk.
- Ensure regular updating of hazard and climate data through coordination with DHM, MHRA, and provincial agencies.
- Use monitoring outputs to inform adaptive planning and policy revision.

9. Improve financing and accountability for CC & DRR

- Introduce climate and DRR budget tagging within provincial plans to track investments and outcomes.
- Align provincial priorities with federal climate finance mechanisms and international support, focusing on prevention and resilience.

- Strengthen accountability mechanisms to ensure that CC & DRR investments lead to measurable risk reduction.

Climate change is acting as a systemic risk multiplier in Gandaki Province, intensifying existing environmental and disaster vulnerabilities across physiographic zones. Addressing these challenges requires a shift toward risk-informed development, targeted investment in hazard hotspots, ecosystem-based adaptation, and strengthened institutional coordination. By aligning climate adaptation and disaster risk reduction with State of Environment indicators and development planning, Gandaki Province can reduce future disaster losses while enhancing long-term environmental resilience.

Table 6-37. Observed Trends, Risks, and Targeted Actions

Observed Trends	Key Risks	Targeted Actions
Rising mean, maximum, and minimum temperatures, with faster warming in high mountain districts.	Accelerated snow and glacier melt, increased heat stress, and heightened forest fire risk.	Integrate **temperature and heat-risk indicators** into sectoral planning; promote climate-resilient design standards and fire risk management in vulnerable districts.
Increasing rainfall variability and intensity, despite modest changes in total annual rainfall.	Higher frequency of landslides, flash floods, and sediment-related disasters, especially in mid-hill districts.	Apply **risk-informed land-use planning**, strengthen drainage and slope stabilization, and regulate development on steep and unstable slopes.
Longer dry spells (increasing CDD) during pre-monsoon and post-monsoon periods.	Increased drought stress, water scarcity, and forest fire incidence.	Promote **ecosystem-based adaptation**, water conservation measures, and community-based forest fire management.
Declining snow cover and expanding glacial lakes in high mountain areas.	Increased risk of GLOFs and reduced dry-season water regulation.	Strengthen **cryosphere monitoring**, GLOF risk assessment, and preparedness planning in Manang and Mustang districts.
Expansion of flood-prone areas and floodplain settlements, particularly along major river corridors.	Rising exposure of people, infrastructure, and livelihoods to flooding.	Enforce **floodplain zoning**, improve river corridor management, and integrate flood risk into urban and infrastructure planning.
Increasing landslide-prone areas linked to climate extremes and infrastructure expansion.	Disruption of transport networks, damage to settlements, and repeated disaster losses.	Prioritize **slope bioengineering, road drainage improvements**, and cumulative risk assessment for infrastructure corridors.
Rising frequency and intensity of forest fires in recent years.	Forest degradation, biodiversity loss, air pollution, and threats to settlements.	Scale **early warning systems, fuel management, and community-based fire control**, linking DRR with forest management.
Growing population and infrastructure exposure to multiple hazards.	Compound and cascading disaster risks, increasing recovery costs and inequities.	Strengthen **multi-hazard early warning systems**, preparedness planning, and targeted risk-reduction investments in hotspot districts.
Increasing disaster-related economic losses despite policy advances.	Erosion of development gains and growing fiscal burden on provincial and local governments.	Shift focus toward **prevention, risk reduction, and resilience financing**, supported by budget tagging and monitoring.

6.4 Industry and Energy

6.4.1 Background

Industry and energy are central to Gandaki Province's socio-economic transformation and environmental sustainability. The province hosts Nepal's most important tourism hub (Pokhara Valley, Annapurna and

Manaslu Conservation Area, Upper Mustang among others), major hydropower corridors (Kaligandaki, Marsyangdi, Modi, Seti, Madi and their tributaries), and rapidly expanding market and construction activities. Together, these drive economic growth, employment generation, infrastructure development, and improved living standards. At the same time, they exert significant pressure on air quality, forests, rivers, land stability, and waste management systems.

The industrial structure of Gandaki is characterized by:

- A dominance of service-oriented industries, especially wholesale/retail trade, accommodation and food services, education, and health;
- A widespread presence of small and medium manufacturing units, such as agro-processing, furniture, metal workshops, construction materials, and handicrafts;
- Rapid growth of the construction sector, linked to urban expansion, road networks, hydropower projects, and tourism infrastructure.

Energy demand in the province is shaped by:

- Household dependence on traditional biomass and LPG, with gradual electrification;
- Increasing electricity consumption in commercial and industrial sectors;
- Heavy reliance on petroleum fuels in transport and construction machinery;
- Large and growing investment in hydropower generation, positioning Gandaki as an energy-producing province of national importance.

This dual role of industry and energy as drivers of development and as sources of environmental pressure makes them a critical thematic sector for the province.

6.4.2 Industrial Profile of Gandaki Province

The Economic Census 2018 (NPC, 2019) provides the most comprehensive picture of the industrial structure and employment in Gandaki Province. The province had a total of 100,684 establishments engaging 332,472 persons, indicating an economy dominated by micro and small enterprises rather than large-scale industries. The district-wise distribution shows a strong spatial concentration, with Kaski alone accounting for a major share of both establishments and employment, reflecting the central economic role of Pokhara Metropolitan City. Nawalpur and Tanahun also emerge as important economic centers along national highways, while mountain districts such as Manang and Mustang have very small industrial bases, highlighting their limited industrial development and greater dependence on tourism and service activities.

The data indicates a highly enterprise-driven economy dominated by micro and small establishments.
District distribution shows strong spatial concentration (***Table 6-38***):

Table 6-38. District-wise no of Industries Established and Persons Employed (Sources: (NPC, 2019))

District	No of Establishments	Persons Engaged
Kaski	30,745	111,818
Nawalparasi East (Nawalpur)	12,745	38,396
Tanahun	12,433	36,686
Gorkha	10,972	30,423
Baglung	8,923	30,372
Syangja	7,410	20,946
Lamjung	6,411	29,395
Myagdi	5,063	16,652

District	No of Establishments	Persons Engaged
Parbat	4,720	12,983
Mustang	775	3,106
Manang	487	1,695

Overall, the industrial structure of the Province shows a strong spatial concentration and clear functional differentiation among districts. Kaski alone accounts for nearly one-third of the total industrial establishments and employment in the province, reflecting the dominant economic role of Pokhara Metropolitan City as the main center for tourism, trade, services, and urban-based industries. In contrast, Nawalpur and Tanahun are emerging as important economic corridors along national highways, where improved connectivity is supporting the growth of trade, manufacturing, logistics, and construction-related activities. Meanwhile, the mountain districts of Manang and Mustang have relatively small industrial bases in terms of number of establishments, but their environmental sensitivity is significantly higher due to fragile alpine ecosystems and heavy dependence on tourism. Even limited industrial and service activities in these areas can therefore generate disproportionate environmental pressures, particularly related to waste management, fuel use, and landscape degradation.

Types of Industries by District

Industries are classified using Nepal Standard Industrial Classification (NSIC) sectors (NPC, 2074). In environmental terms, five groups are most relevant:

1. Manufacturing
2. Construction + utilities/mining
3. Wholesale & retail trade
4. Accommodation & food services
5. Transport, storage and ICT

District-wise industrial composition is shown below Table (***Table 6-39***):

Table 6-39. District-wise Industries Type According to NICS and Key Character and Environmental Implication

District	Manufacturing	Construction + Utilities	Wholesale & Retail Trade	Accommodation & Food Services	Key Industrial Character	Major Environmental Implications
Kaski	2,896	163	16,197	6,073	Strong service-based economy driven by tourism, commerce, and urban construction	High municipal solid waste, hotel/restaurant wastewater, transport emissions, construction dust, quarry pressure
Nawalpur	1,539	115	7,219	1,766	Emerging industrial and logistics hub with manufacturing and agro-processing	Industrial effluents, solid waste, air pollution from transport and factories
Tanahun	1,133	–	6,454	1,900	Mixed economy with trade, tourism services, and moderate manufacturing	Waste generation, pressure on water resources, construction-related impacts
Gorkha	Small-scale	Limited	Dominant	Limited	Trade- and agriculture-linked small industries, hydropower corridor influence	Unmanaged waste, construction impacts, localized air and water pollution
Baglung	Small-scale	Limited	Dominant	Limited	Trade and small manufacturing economy	Riverbed material extraction, waste management issues, road construction impacts

District	Manufacturing	Construction + Utilities	Wholesale & Retail Trade	Accommodation & Food Services	Key Industrial Character	Major Environmental Implications
Syangja	Small-scale	Limited	Dominant	Limited	Agriculture-linked trade and small industries	Waste disposal, water quality issues, construction pressure
Lamjung	Small-scale	Limited	Dominant	Limited	Trade-based economy with hydropower and construction linkages	River and slope disturbance, waste generation
Myagdi	Small-scale	Limited	Dominant	Limited	Trade and construction-linked local industries	Quarrying impacts, air and water pollution risks
Parbat	Small-scale	Limited	Dominant	Limited	Trade and small manufacturing with hydropower corridor influence	Waste management challenges, construction dust, river pressure
Manang	Very small	Very limited	Limited	Dominant	Tourism-driven service economy in fragile alpine environment	Solid waste accumulation, wastewater disposal, fuel use pressure
Mustang	Very small	Very limited	Limited	Dominant	Tourism-driven economy with sensitive ecosystems	Waste disposal challenges, landscape degradation, energy use impacts

Sources: Economic Survey of Gandaki Province, 2018

6.4.3 Energy Sources and Consumption Pattern

Energy use in Gandaki Province reflects a mixed transition system where traditional biomass, commercial fuels and modern renewable energy coexist. The structure of energy consumption is shaped by geography, settlement patterns, income levels, access to electricity, and the nature of industrial activities.

The main energy sources used in the province are:

- Traditional biomass: fuelwood, agricultural residues and animal dung,
- Commercial energy**:** electricity, diesel, petrol, LPG and limited coal,
- Modern renewable energy**:** micro-hydro, solar home systems, institutional solar PV, biogas and improved cookstoves.

According to the WECS (2024), Gandaki Province consumed about 46,462 TJ of energy in 2022, making it one of the major provincial energy consumers in Nepal.

Sector-wise Energy Consumption Structure

Energy demand in Gandaki is distributed across five main sectors:

a) Residential (Households)
b) Industry
c) Transport
d) Commercial and Services
e) Agriculture

The table below (***Table 6-40***) presents the sectoral energy consumption in each district. The structure shows two strong features:

- Households still dominate total energy use because of biomass dependence,
- Industry and transport dominate commercial energy use and emissions.

Table 6-40. Sectoral Energy Consumption in Gandaki Porvince (Sources, WECS, 2024)

Sector	Energy (TJ)	Share of total
Residential	19,337.10	**41.60%**

Industry	18,035.52	**38.80%**
Commercial	4,063.84	8.70%
Transport	3,158.61	6.80%
Agriculture	1,147.90	2.50%
Construction & mining	719.12	1.50%
Total	**46,462.08**	**100%**

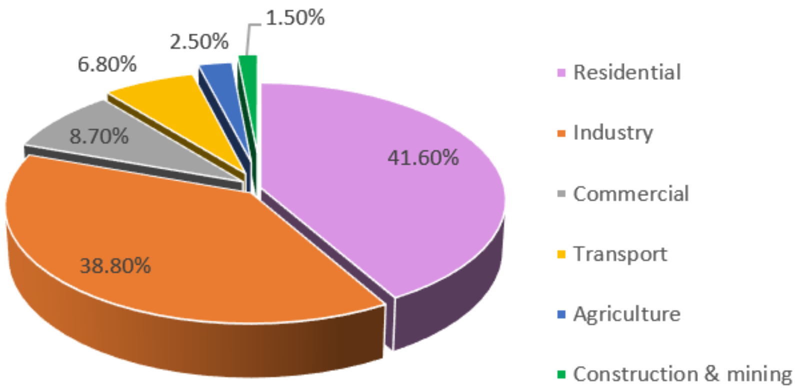


Figure 6-24. A Glace of Sectoral Energy Consumption Pattern in Gandaki Province

a) Household energy use

Residential energy consumption in Gandaki is largely driven by cooking and heating needs. Main household fuels:

- Fuelwood (dominant in rural and hill districts),
- LPG (dominant in urban areas and towns),
- Electricity (rapidly increasing for lighting, appliances, and cooking in urban households).

Household energy according to the National Population and Housing Census (NPHC) 2021 shows that Gandaki Province is in a 'dual transition' - LPG has become the single most common cooking fuel, but fuelwood still remains dominant in many hill districts (***Table 6-41***).

Table 6-41. Usual Cooking Fuel by District (% of households), Gandaki Province (CBS 2021)

District	Wood/Firewood (%)	LPG (%)	Electricity (%)	Biogas (%)	Other fuels* (%)
Gorkha	63.9	34.1	0.2	1.6	0.3
Manang	68.4	29.3	0.1	1.9	0.3
Mustang	33.5	54.1	0.1	9.0	3.2
Myagdi	73.5	25.7	0.1	0.6	0.1
Kaski	16.1	83.2	0.2	0.4	0.1
Lamjung	52.1	45.8	0.3	1.7	0.1
Tanahun	44.6	53.8	0.2	1.2	0.1
Nawalparasi (East)	35.3	62.8	0.3	1.5	0.1
Syangja	65.7	32.9	0.2	1.2	0.1
Parbat	72.1	27.5	0.1	0.2	0.1
Baglung	78.1	21.6	0.1	0.1	0.1

District	Wood/Firewood (%)	LPG (%)	Electricity (%)	Biogas (%)	Other fuels* (%)
PROVINCE AVG	47.1	51.5	0.2	1.0	0.1

Note: "Other fuels" groups cow dung, kerosene and other minor fuels reported in the census.

- *Province average: LPG 51.5% and fuelwood 47.1% together account for almost all household cooking.*
- *Pokhara/Kaski has the clearest clean-fuel transition: the vast majority of households use LPG as their usual cooking fuel.*
- *Fuelwood remains the main cooking fuel in several mid-hill districts, indicating continued pressure on forests and persistent indoor air pollution risks.*
- *Mountain districts show distinct patterns and still rely on a mix of LPG, biomass and small shares of alternative fuels.*

Lighting access is close to universal. NPHC 2021 of CBS (2021a) reports that 97.6% of households in Gandaki use electricity as their usual source of lighting; solar is the main alternative (1.9%), especially in the high mountain districts.

Table 6-42. Usual Source of Lighting by District (% of households), Gandaki Province (NPHC 2021)

District	Electricity (%)	Solar (%)	Kerosene (%)	Biogas (%)	Other (%)
Gorkha	96.7	2.7	0.3	0.0	0.3
Manang	86.4	13.4	0.2	0.0	0.0
Mustang	77.1	22.4	0.2	0.0	0.3
Myagdi	95.1	3.4	0.5	0.0	0.9
Kaski	99.4	0.5	0.1	0.0	0.1
Lamjung	98.8	0.7	0.2	0.0	0.2
Tanahun	97.2	2.2	0.3	0.0	0.2
Nawalparasi (East)	95.5	4.0	0.2	0.0	0.2
Syangja	99.1	0.7	0.2	0.0	0.1
Parbat	99.0	0.6	0.2	0.0	0.2
Baglung	97.1	1.9	0.3	0.0	0.7
PROVINCE AVG	97.6	1.9	0.2	0.0	0.2

Solar lighting is most prominent in Mustang and Manang, while electricity lighting exceeds 95% in most other districts, reflecting successful grid expansion and reliability improvements.

b) Commercial use of energy: Industries, transport, service sector

Commercial energy use in Gandaki Province is driven mainly by industries, transport, and the service sector, reflecting the province's growing urban economy, tourism activities, and infrastructure development. Industries consume a large share of commercial energy, particularly diesel and other thermal fuels, for manufacturing, agro-processing, construction materials, and backup power, with electricity playing a gradually increasing role. The transport sector is almost entirely dependent on petroleum fuels, especially diesel and petrol, due to road transport, tourism mobility, and movement of construction materials and goods. The service sector, including hotels, restaurants, trade, and commercial establishments, relies on a combination of electricity for lighting, appliances, and services, and LPG and fuelwood for cooking and heating. Together, these three sectors show that while electricity use is expanding, Gandaki's commercial economy still remains strongly dependent on fossil fuels, especially for transport and industrial activities, highlighting the need for cleaner energy options, efficiency improvements, and electrification of commercial services.

Table below (***Table 6-43***) summarizes district-wise electricity sales (in TJ) for FY 2077/78 (WECS, 2024). Kaski accounts for the largest share driven by residential and service-sector demand while Nawalpur records the highest industrial electricity sales, reflecting its role as an emerging industrial corridor.

Table 6-43. Summary of District-wise Electricity Sales (in TJ) for FY 2077/78

District	Agriculture (TJ)	Commercial (TJ)	Industry (TJ)	Residential (TJ)	Transport (TJ)	Total (TJ)
Baglung	–	17.1	3.9	44.29	–	65.29
Gorkha	0.66	34.36	6.72	64.41	0.11	106.27
Kaski	0.54	291.76	121.28	570.43	–	984.01
Lamjung	–	97.85	0.22	0.77	–	98.85
Manang	–	–	–	–	–	–
Mustang	–	–	–	–	–	–
Myagdi	0.12	24.35	2.48	26.66	–	53.62
Nawalpur	6.18	49.77	382.16	221.94	–	660.05
Parbat	0.03	25.4	4.54	30.09	0.05	60.1
Syangja	0.02	24.88	4.31	38.35	–	67.56
Tanahun	0.91	40.74	41.51	99.83	–	182.99
Total	**8.46**	**606.22**	**567.13**	**1,096.78**	**0.16**	**2,278.74**

Source: WECS provincial compilation using NEA electricity sales (NEA, 2022). Units: terajoules (TJ).

Petroleum Product Consumption Pattern

The table below (***Table 6-44***) presents district-wise petroleum product sales in FY 2077/78 (kL) in the province (WECS, 2024). Kaski dominates petrol (MS) and is the only district reporting aviation turbine fuel (ATF) sales, while Tanahun and Syangja show substantial diesel demand linked to highway transport and wider economic activity.

Table 6-44. District-wise Petroleum Product Sales in Gandaki Province

District	Petrol (MS) kL	Diesel kL	Kerosene (SKO) kL	ATF kL	Total (kL)*
Baglung	1,468	4,967	101	–	6,536
Gorkha	1,504	6,376	–	–	7,880
Kaski	23,903	38,374	1,307	1,326	64,910
Lamjung	991	4,667	–	–	5,658
Mustang	–	72	–	–	72
Myagdi	794	4,620	–	–	5,414
Parbat	1,357	6,818	–	–	8,175
Syangja	3,353	11,785	326	–	15,464
Tanahun	7,816	30,589	16	–	38,421
Total	**41,186**	**108,267**	**1,750**	**1,326**	**152,529**

*Source: Nepal Oil Corporation (NOC, 2022) as compiled in WECS provincial report. LPG is not reported reliably by district due to cross-district depot distribution; therefore, totals here cover liquid fuels only (*MS + Diesel + SKO + ATF). Units: kilolitres (kL).*

6.4.4 Renewable Energy and Clean Energy Access

Gandaki Province is moving toward a more diversified renewable energy mix. Alongside large grid-connected hydropower, the province has a strong footprint of distributed renewable energy technologies (RETs) especially micro-hydro, solar PV systems, biogas, and improved cookstoves that support rural electrification, clean cooking, and productive energy use. The province-level energy assessment notes that "modern and new renewable energy" forms a measurable share of the energy system, while household-level renewable supply is dominated by biogas and solar. According to WECS and AEPC (WECS, 2024) data show widespread deployment of:

- Solar home systems,
- Institutional solar PV,
- Micro-hydro projects,
- Improved cookstoves,
- Biogas plants.

A clear trend is that RET ownership varies by geography and livelihood: hill districts have relatively higher micro-hydro and improved water mills, mountain districts rely more on solar and institutional solar systems, and the Terai district (Nawalpur) shows strong uptake of solar irrigation/water pumping **(*Table 6-45*)**. In addition, Mustang is nationally recognized as a priority district for wind energy development, with licensed wind projects listed for Jomsom/Tangbe areas. Districts like Baglung, Gorkha, Myagdi and Lamjung show strong adoption of micro-hydro and solar systems for rural electrification.

Table 6-45. Summary of Renewable Energy Technologies Adopted in Gandaki Province (Sources AEPC 2024)

District	Micro-hydro projects (No.)	Micro-hydro capacity (kW)	HHs benefited (micro-hydro)	Improved Water Mills (No.)	Solar Home Systems (No.)	Institutional Solar PV (No.)	Institutional Solar PV (Wp)	Solar Irrigation (No.)	Solar Water Pumping (No.)	Domestic Biogas (No.)	Mud ICS (No.)	Metallic ICS (No.)
Baglung	145	3,646	33,931	40	4,074	25	92,000	–	3	999	26,465	509
Gorkha	57	1,016	10,521	57	5,989	53	67,370	–	–	9,035	8,865	12,372
Kaski	9	248	1,876	55	1,792	12	24,000	1	2	19,100	2,855	1,594
Lamjung	24	439	3,819	12	5,402	20	41,500	1	–	12,083	4,947	1,886
Manang	12	299	1,688	5	135	–	–	–	–	–	16	68
Mustang	–	–	–	5	1,333	31	27,510	–	–	14	–	3
Myagdi	38	562	5,475	23	4,851	48	64,145	–	1	1,078	11,290	1,456
Nawalpur	44	302	4,307	–	5,056	9	25,500	41	1	6,025	1,847	292
Parbat	13	194	1,923	5	4,504	2	4,500	–	–	989	16,792	388
Syangja	7	157	1,464	1	4,059	20	39,000	2	5	9,871	19,739	805
Tanahun	22	272	2,355	1	11,177	3	6,000	5	15	20,561	13,986	3,328
Grand Total	**371**	**7,135**	**67,359**	**204**	**48,372**	**223**	**391,525**	**50**	**27**	**79,755**	**106,802**	**22,701**

6.4.5 Trend of Industry and Energy Use Over the Past Two Decades

Although district-level time series are limited, national and provincial energy datasets allow a strong trend narrative.

Energy Transition Trend

The energy transition in Gandaki Province is not only a qualitative observation; it is clearly supported by available data. The use of electricity has expanded rapidly in the province. NEA statistics (NEA, 2025) show that electricity sales in Gandaki have increased several times over the last decade, rising from around 170–180 GWh in the late 2060s to well above 450 GWh by 2077/78, and over 600 GWh in recent years (WECS, 2024). This growth reflects:

- Expansion of grid coverage to almost all settlements,
- Increased use of electric appliances,
- Growth of hotels, commercial centers, and services in Pokhara and highway corridors,
- Rising electricity demand from hydropower construction sites and small industries.

This directly supports the argument that Gandaki is moving steadily toward electrification in households and commercial activities. Similarly, LPG consumption has grown strongly, particularly in urban areas. Census and energy surveys show that LPG is now the dominant cooking fuel in urban districts such as Kaski, Tanahun, and Nawalpur, while fuelwood remains dominant mainly in rural hill and mountain districts. For example, in Gandaki Province, LPG slightly exceeds fuelwood as a cooking fuel overall, indicating a major shift in household energy behavior. This confirms the transition from traditional biomass to commercial fuels in urban and semi-urban areas. The data indicated that the petroleum continues to dominate the transport sector. According to the Energy Sector Synopsis Report (WECS, 2024), transport energy in Gandaki (about 3,159 TJ) is almost entirely supplied by diesel, petrol, and aviation turbine fuel. At the same time, petroleum fuels are also dominant in:

- Construction and mining (about 592 TJ),
- Agriculture (over 1,130 TJ),
- A large part of industrial energy use (diesel alone is over 7,000 TJ).

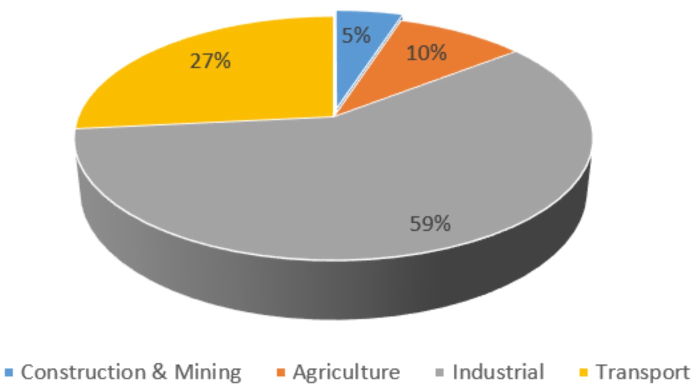


Figure 6-25. Petroleum Consumption Pattern in Gandaki Province

These figures show that even though electricity is expanding, petroleum remains structurally important for mobility, construction, and heavy machinery. Biomass is still important but declining in relative terms. The residential sector alone consumes over 19,000 TJ, and most of this is still fuelwood (about 16,000 TJ). This shows that biomass remains dominant in rural households. However, when compared with the rapid rise in electricity and LPG use, its share in the total energy mix is gradually shrinking. This confirms the “decline but not disappearance” of biomass energy.

6.4.6 Environmental Implications

The environmental implications of industry and energy in Gandaki Province differ clearly by geographical region because energy use patterns, types of industries, and ecosystem sensitivity vary strongly.

High Himal & High Mountain (Manang, Mustang)

- Low total energy use, but very high environmental sensitivity.
- Heavy dependence on LPG, diesel, and solar energy.
- Tourism-driven waste, wastewater, and fuel transport risks.

- Fragile alpine ecosystems mean even small disturbances have long-term impacts.
- Priority issues: solid waste management, clean tourism energy, protection of glacier-fed rivers.

High Mountain & Upper Mid-Mountain (Baglung, Myagdi, Parbat, Lamjung, Gorkha)

- Strong influence of hydropower construction and associated diesel use.
- High risk of slope instability, landslides, sedimentation, and river disturbance.
- Continued dependence on fuelwood in households adds forest pressure.
- Priority issues: basin-scale hydropower planning, spoil and quarry management, forest protection.

Mid-Mountain (Syangja, Tanahun, parts of Kaski and Gorkha)

- Rapid growth of trade, construction, and service industries.
- Increasing electricity use but persistent diesel dominance in transport and machinery.
- Growing air pollution, dust, wastewater, and riverbed material extraction.
- Priority issues: urban waste and wastewater treatment, cleaner construction practices.

Siwalik Belt (parts of Nawalpur and Tanahun)

- Expansion of industries, logistics, and highway-based trade.
- High diesel use and industrial electricity consumption.
- Vulnerability to erosion, flooding, and groundwater contamination.
- Priority issues: industrial zoning, effluent control, air quality management.

Terai (Nawalpur)

- Highest dependence on petroleum fuels for transport, agriculture, and industry.
- Major source of air pollution and greenhouse gas emissions in the province.
- Also highest potential for industrial electrification and solar-based energy systems.
- Priority issues: shift to electric transport, cleaner industrial energy, solar irrigation.

Overall message:

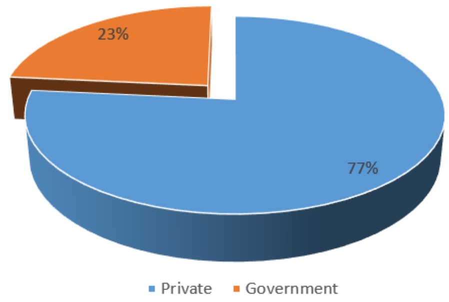
- High Himal → ecological fragility and tourism pressure.
- Mountain zones → hydropower construction impacts and biomass dependence.
- Mid-hills → cumulative urban and construction pollution.
- Siwalik & Terai → industrial pollution and petroleum dependence.

This shows that Gandaki's energy transition must be geographically differentiated, with region-specific strategies to reduce environmental pressure while supporting sustainable industrial and energy development.

6.4.7 Hydropower as an Industry and Sources of Clean Energy

Hydropower plays a dual role in Gandaki Province as it is both the backbone of clean electricity generation and one of the most important industrial sectors shaping the province's economy and landscape. According to IPPAN Energy Statistics (2025), Gandaki has one of the largest hydropower development pipelines in Nepal, concentrated mainly in the Marsyangdi, Seti, Kali Gandaki, and Budhi Gandaki river systems. This clearly establishes Gandaki as a primary hydropower production province of the country. The scale of development is substantial. Projects already in operation under production licences include private and government projects together amounting to about 979 MW (IPPAN, 2025) among which the contribution of private sector is significant (***Figure 6-26*****Table *6-38***). At the same time, the future pipeline is much larger:

- 84 private projects with construction licences totaling about 3,040.7 MW,
- 2 government projects with construction licences totaling 978 MW,
- 38 projects under PPA and construction totaling 1,037.2 MW,
- 52 projects in financial process with about 1,932.0 MW,
- several projects at survey and application stages.



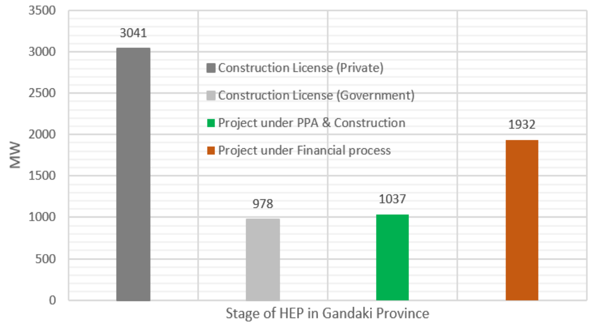


Figure 6-26. (left) Government and Private Sector Hydro-electric Project, (right) HEPs in Different Stages

This means that the hydropower capacity under development in Gandaki is many times larger than what is currently operational, highlighting the province's central role in Nepal's future electricity supply.

From an energy perspective, hydropower offers major environmental benefits. It produces renewable electricity with very low greenhouse gas emissions compared to petroleum fuels and biomass. It supports the expansion of electricity for cooking, industry, and potentially electric transport, helping reduce dependence on imported LPG, diesel, and petrol. The inclusion of solar (4 projects, 40 MW) and wind (1 project, 3 MW) also shows that Gandaki is gradually diversifying its renewable energy base beyond hydropower.

At the same time, hydropower is a powerful industrial driver. Large projects generate employment during construction, stimulate demand for cement, steel, transport services, quarrying, and heavy machinery, and lead to the development of access roads and transmission corridors. In districts such as Gorkha, Myagdi, Lamjung, Manang, and Kaski, hydropower construction has become a major economic activity shaping local development patterns.

However, hydropower also brings significant environmental risks if not carefully planned and managed. The concentration of projects along the same river systems can cause cumulative impacts that go far beyond individual project boundaries. Key environmental concerns include:

- River ecosystem alteration: Diversions, dams, and reduced environmental flows can fragment aquatic habitats and affect fish migration and river biodiversity.
- Sediment management problems: Trapping and sudden flushing of sediment can disturb downstream river morphology and agriculture.
- Slope instability and landslides: Road cutting, tunneling, and spoil disposal increase the risk of landslides, especially in fragile hill and mountain terrain.
- Quarrying and riverbed extraction: Large quantities of construction material are required, leading to pressure on riverbeds and hillsides.
- Forest and land disturbance: Transmission lines, roads, and project infrastructure lead to forest clearing and habitat fragmentation.

As noted in the IPPAN statistics (IPPAN, 2025), hydropower clusters in districts such as Gorkha, Myagdi, Lamjung, Manang, and Kaski demand basin-level planning, strict environmental flow compliance, and stronger monitoring of quarrying and spoil disposal. This highlights that hydropower cannot be managed safely on a project-by-project basis alone; it must be guided by river basin–scale environmental management (Sharma et al., 2021).

Hydropower in the Province represents both an environmental opportunity and a local environmental risk. It is the foundation for a clean energy transition that can support electric cooking, industrial electrification, and future electric mobility. At the same time, without strong safeguards, it can damage river systems, destabilize fragile slopes, and degrade forests and landscapes (Shrestha and Dixit, 2020). A State of Environment perspective therefore requires hydropower to be developed not only as an energy project, but as a landscape-level intervention that balances national clean energy goals with local ecological protection and community well-being.

6.4.8 Institutional and Policy Framework

Provincial Governance of Industry

The Ministry of Industry and Tourism (MoIT), Gandaki Province is the lead institution responsible for:

- Formulation and implementation of provincial industrial policies,
- Registration, renewal and regulation of industries,
- Promotion of micro, cottage, small and medium enterprises (MCSMEs),
- Trade, commerce and market regulation,
- Promotion of tourism-based industries,
- Coordination with district-level Tourism and Industry Offices.

At district level, Tourism and Industry Offices implement:

- Industry registration and record keeping,
- Renewal and monitoring of enterprises,
- Support to cottage and small industries,
- Linkages with local governments for enterprise promotion.

This decentralized structure places MoIT at the center of industrial development planning and environmental compliance enforcement within the province.

Provincial Governance of Energy

The Ministry of Energy, Water Resources and Water Supply (MoEWRWS), Gandaki Province oversees:

- Provincial energy planning and coordination,
- Water resources development,
- Drinking water and sanitation infrastructure,
- Facilitation of hydropower and renewable energy projects.

Although large-scale energy generation and distribution remain largely federal responsibilities, provincial institutions increasingly influence:

- Site approvals and environmental safeguards,
- Land acquisition coordination,
- Community consultation,
- Local benefit-sharing mechanisms.

Federal Institutions Shaping the Sector

Several federal agencies provide the technical and regulatory backbone for Gandaki's energy and industry sectors:

Table 6-46. Federal regulatory agencies

Institution	Role
WECS (Water and Energy Commission Secretariat)	National and provincial energy balance, outlook, and policy coordination
NEA (Nepal Electricity Authority)	Electricity generation, transmission, distribution, and sales
NOC (Nepal Oil Corporation)	Import and distribution of petroleum products

Institution	Role
AEPC (Alternative Energy Promotion Centre)	Renewable energy technologies (solar, biogas, micro-hydro, ICS)
Department of Industry / Cottage and Small Industry Offices	Registration and regulation of large and small industries

6.4.9 Energy and Industry Future Outlook

The future of industry and energy in Gandaki Province will be shaped by three major forces: rapid hydropower development, growing electricity demand, and continued reliance on petroleum fuels, especially in transport and construction. The province is clearly moving toward an electricity-based economy, but the transition will be gradual and uneven across districts and geographical regions.

At the provincial level, Gandaki is likely to strengthen its role as one of Nepal's main hydropower production centers. With about 1,085 MW already in operation and several thousand megawatts under construction, licensing, and financial processing, hydropower will dominate the energy supply landscape for decades to come. This creates a strong opportunity for clean energy expansion, including electric cooking, electrification of industries, and eventually electric mobility. At the same time, it also means increasing pressure on river systems, fragile slopes, forests, and local communities unless basin-level planning and strict environmental safeguards are enforced.

Electricity demand will continue to grow rapidly. Urbanization in Kaski (Pokhara), industrial expansion in Nawalpur, and commercial growth along highway corridors in Tanahun and Gorkha will drive higher consumption. Electricity will increasingly replace diesel generators in industries and commercial buildings, and LPG in some cooking uses. This trend will improve air quality and reduce fossil fuel dependence, but it will require stronger distribution networks, grid stability, and energy efficiency measures.

Petroleum use will remain significant in the medium term. Transport, construction machinery, agriculture mechanization, and hydropower construction will continue to rely on diesel and petrol. This means that even as hydropower expands, Gandaki will still face challenges related to air pollution, greenhouse gas emissions, and fuel import dependency. The transition to electric vehicles and electric construction equipment will likely begin in urban areas and the Terai first, especially in Kaski and Nawalpur, but will take time to reach hill and mountain districts.

Biomass energy will gradually decline in relative importance but will not disappear soon. Rural households in hill and mountain districts will continue to depend on fuelwood, even as LPG, biogas, and electricity become more accessible. The future challenge will be to reduce forest pressure while ensuring affordable and reliable alternatives for rural communities.

District-wise Future Outlook

Kaski: Urban–Tourism–Service Hub

Kaski will remain the largest energy consumer in the province. Electricity demand from hotels, hospitals, education institutions, commercial centers, and households will grow steadily. Pokhara also offers the strongest potential for:

- Electric cooking,
- Electric public transport,
- Energy-efficient buildings and hotels.

However, without cleaner transport systems, traffic-related air pollution and solid waste generation will increase. Kaski is the most suitable district to pilot low-carbon urban energy solutions.

Nawalpur: Industrial and Logistics Corridor

Nawalpur will continue to emerge as Gandaki's industrial electricity hub. Manufacturing, agro-processing, and logistics activities will expand due to highway connectivity and flat terrain. Electricity demand will rise strongly, but diesel use for freight and machinery will remain high. The future challenge here is to:

- Promote industrial electrification,
- Enforce wastewater and emission standards,
- Develop industrial zoning with environmental safeguards.

Tanahun and Gorkha: Growth Corridors

These districts will experience increasing commercial activity, construction, and hydropower-related development. Electricity demand will grow moderately but steadily. Diesel consumption for construction and transport will remain significant. Environmental pressure will intensify around:

- Quarrying,
- Riverbed material extraction,
- Road corridor development.
- Stronger land-use planning and river management will be essential.

Hydropower Districts: Baglung, Myagdi, Parbat, Lamjung, Syangja

These districts will increasingly be shaped by hydropower as an industry. While electricity access will improve and rural electrification will strengthen, construction-related impacts will expand:

- Spoil disposal,
- Slope instability,
- Forest clearance,
- River flow alteration.

Their future depends on how well hydropower is planned at basin scale rather than project-by-project.

Mountain Districts: Manang and Mustang

These districts will remain low-energy consumers in absolute terms but highly sensitive environmentally. Energy use will rely on:

- LPG,
- Solar PV,
- Limited grid electricity.

Tourism will continue to drive demand for heating, transport, and waste management. Their future requires strict control on:

- Waste disposal,
- Fuel transport risks,
- Unplanned tourism expansion.

Overall Direction

Gandaki Province is moving toward a future where:

- Electricity becomes the dominant form of energy for households, services, and industry,
- Hydropower becomes the backbone of both the energy system and the provincial economy,
- Petroleum fuels remain critical for transport and construction in the short to medium term,
- Environmental management becomes more complex and urgent.

The future sustainability of Gandaki's industry and energy system will depend on:

- Basin-scale hydropower planning,

- Electrification of industry and transport,
- Cleaner construction practices,
- Strong waste and wastewater management,
- Energy efficiency and demand management,
- Geographically differentiated environmental strategies.

If managed well, Gandaki can become a model province for clean energy–based development. If not, the same energy growth could deepen pressure on rivers, forests, air quality, and fragile mountain ecosystems.

6.4.10 DPSIR Analysis

The DPSIR framework helps to understand how industrial growth and changing energy use are shaping the environment of the Province, and how policy and management actions can guide this transition in a sustainable direction.

Driving Forces

The main driving forces behind changes in industry and energy in Gandaki Province are economic growth, urbanization, tourism expansion, and national energy policy priorities.

- Rapid growth of Pokhara as a metropolitan city has increased demand for electricity, transport services, hotels, trade, and construction.
- Hydropower development has become a strategic national priority, and Gandaki is one of the most important provinces for future electricity generation.
- Expansion of road networks and highway corridors has strengthened trade, logistics, and industrial activities, especially in Nawalpur, Tanahun, and Gorkha.
- Rising living standards have increased demand for modern energy services such as LPG, electricity, and transport fuels.
- National policies promoting renewable energy, rural electrification, and private investment in *hydropower have accelerated project development.

These driving forces are pushing Gandaki toward a more energy-intensive and industrialized economy.

Pressures

These driving forces create direct pressures on the environment through increased resource use and pollution.

- Increased use of petroleum fuels (diesel, petrol, ATF) in transport, construction, and industry, leading to air pollution and greenhouse gas emissions.
- High dependence on biomass (fuelwood) in rural households, creating pressure on forests and contributing to indoor air pollution.
- River diversion and infrastructure development associated with hydropower projects, including road cutting, tunneling, quarrying, and spoil disposal.
- Rising electricity demand, leading to denser networks of hydropower plants, transmission lines, and substations.
- Growth of tourism and service industries generating large volumes of solid waste and wastewater.
- Expansion of industrial activities in Nawalpur and urban centers increasing the risk of untreated industrial effluents.

These pressures are unevenly distributed across the province, being highest in urban centers, hydropower corridors, and highway zones.

State

The current state of the environment reflects the cumulative effect of these pressures.

- Air quality is deteriorating in urban areas such as Pokhara and along major highway corridors due to traffic, diesel generators, construction dust, and biomass burning.
- River systems are under stress in hydropower corridors, with altered flow regimes, increased sediment load, and localized degradation of aquatic habitats.
- Forests remain under pressure from fuelwood use in hill and mountain districts, although the pressure is slowly declining with LPG and electricity adoption.
- Solid waste management systems are overstretched in urban and tourism areas, leading to open dumping and river pollution.
- Land stability is increasingly fragile in hill districts due to road construction, quarrying, and hydropower-related excavation.

The environmental state shows a mix of progress (increased access to clean electricity) and growing stress on natural systems.

Impacts

Changes in environmental state are translating into tangible impacts on ecosystems, livelihoods, and public health.

- Increased respiratory and cardiovascular health risks due to air pollution in urban and roadside areas.
- Degradation of river ecosystems, loss of fish habitats, and reduced water availability for irrigation and cultural uses.
- Higher risk of landslides and erosion in hydropower and road construction zones.
- Decline in scenic and recreational value of rivers and landscapes, affecting tourism sustainability.
- Increased vulnerability of hydropower infrastructure itself to climate-related hazards such as floods, glacial lake outburst floods, and landslides.
- Social conflicts related to land acquisition, water use, and local environmental degradation around large projects.

These impacts show that energy and industrial growth, if unmanaged, can undermine the very development benefits they aim to create.

Responses

Responses are the actions needed to reduce pressures, improve environmental conditions, and steer development toward sustainability.

- Strengthening basin-level planning for hydropower rather than approving projects individually.
- Strict enforcement of environmental flow requirements and continuous monitoring at diversion sites.
- Promotion of electric cooking, industrial electrification, and electric mobility, especially in Kaski and Nawalpur.
- Improved waste and wastewater management systems in urban and tourism centers.
- Introduction of cleaner production standards and effluent treatment in industrial zones.

- Expansion of renewable energy technologies such as solar PV, biogas, and improved cookstoves in rural and mountain areas.
- Better quarry and spoil management, slope stabilization, and road construction standards in hydropower corridors.
- Public participation and transparency in hydropower monitoring and environmental compliance.

From a DPSIR perspective, Gandaki Province is at a critical transition point. The driving forces of hydropower expansion, urban growth, tourism, and rising energy demand are creating strong pressures on rivers, air quality, land stability, and waste management systems. These pressures are already changing the state of the environment and generating health, ecological, and social impacts.

At the same time, Gandaki also has exceptional opportunities. Its hydropower potential and growing electricity supply provide the foundation for a cleaner energy future based on electrification of cooking, industry, and transport. If the right responses are implemented now, Gandaki can transform its energy-driven development into a model of low-carbon and environmentally responsible growth.

6.4.11 Baseline Indicators

Baseline indicators for the energy and industry sector provide a quantitative foundation for assessing the current state and recent changes in Gandaki Province's development–environment nexus. Using 2020 as the reference baseline year and the most recent available data up to 2022, these indicators capture the scale, structure, and spatial distribution of industrial activity and energy use across the province. The selected indicators reflect key dimensions of environmental pressure, including energy demand and fuel mix, industrial concentration, construction activity, and renewable energy development, and are presented using a baseline–state–change–synthesis framework consistent with other State of Environment chapters. Where updated time-series data are unavailable, structurally robust datasets are used to establish baseline conditions, with changes interpreted through trend analysis and spatial differentiation across key districts.

Table 6-47. Baseline, State, Change and Synthesis of Industry

Indicator	Baseline (2020)	State (2022)	Change	Key Districts	Synthesis
Total industrial establishments	**100,684 establishments** (Economic Census 2018; used as 2020 baseline)	No new census; activity increased	Increasing (activity)	**Kaski (30,745)**, **Nawalpur (12,745)**, **Tanahun (12,433)**	Gandaki's industrial base is numerically large but dominated by micro and small enterprises, resulting in **diffuse, cumulative environmental pressures** rather than concentrated point-source pollution.
Persons engaged in industry	**332,472 persons**	Increased employment (2022)	Increasing	**Kaski (111,818)**, **Nawalpur (38,396)**	Rising industrial and service-sector employment increases indirect environmental pressure through **urban expansion, transport demand, energy use, and waste generation**.
Spatial concentration of industries	**≈31% of establishments in Kaski**	Further concentration	Concentrating	**Kaski (Pokhara Valley)**	High spatial concentration intensifies localized pressure on **air quality, waste management, and urban services**, similar to urban-environment stress patterns.

Indicator	Baseline (2020)	State (2022)	Change	Key Districts	Synthesis
Manufacturing & processing establishments	Moderate share (2018 structure)	Expanded activity	Increasing	**Nawalpur, Tanahun**	Growth in agro-processing and light manufacturing raises risks of **industrial effluent discharge, fossil fuel use, and material extraction** along highway corridors.
Construction-related industries	Moderate (2020)	High activity (2022)	Strong increase	**Kaski, Gorkha, Tanahun**	Infrastructure and hydropower development have significantly expanded construction industries, increasing **dust, quarrying, riverbed extraction, and slope instability**.
Industrial establishments in mountain districts	**Manang: 487; Mustang: 775**	Similar scale	Stable	**Manang, Mustang**	Even small numbers of industries exert **disproportionately high environmental pressure** due to ecological fragility and limited waste-management capacity.

Table 6-48. Baseline, State, Change and Synthesis of Energy

Indicator	Baseline (2020)	State (2022)	Change	Key Districts	Synthesis
Total final energy consumption	**≈42 PJ** (≈42,100 TJ)	**≈46 PJ** (≈46,462 TJ)	Increasing	Province-wide	Overall energy demand increased with economic recovery and urbanization, strengthening energy–environment linkages across sectors.
Industrial energy consumption	**≈1.2 PJ** (≈1,200 TJ)	**≈1.8 PJ** (≈1,800 TJ)	Increasing	**Kaski, Nawalpur**	Industrial energy demand has risen alongside construction and processing activities, increasing pressure on air quality and fuel imports.
Petroleum fuel use (industry & transport)	**Dominant share** (≈55% of industrial energy)	Reduced share (≈47%) but higher absolute use	Persistent (absolute)	**Kaski, Tanahun, Syangja**	Continued petroleum dependence remains a major driver of **urban and corridor air pollution**, despite expansion of hydropower.
Electricity consumption (industry)	**≈50 TJ** (≈4% of industrial energy)	**≈380 TJ** (≈21%)	Strong increase	**Nawalpur, Kaski**	Rapid industrial electrification represents the **most positive energy transition**, with strong potential to reduce emissions and local pollution.
Household biomass energy use	**47.1% of households** (2021)	Slightly reduced (2022)	Declining	**Baglung, Myagdi, Parbat, Syangja**	Persistent biomass use sustains **localized forest pressure**, linking energy poverty with forest degradation.
Hydropower development (>1 MW)	**≈14 plants**	**≈53 plants**	Rapid increase	**Gorkha, Lamjung, Myagdi, Kaski**	Hydropower expansion strengthens renewable supply but increases **river flow alteration, land disturbance, and cumulative basin-level impacts**.

Indicator	Baseline (2020)	State (2022)	Change	Key Districts	Synthesis
Electricity access (lighting)	**≈97–98% of households**	**>99% of households**	Improved	Province-wide	Near-universal access provides a strong enabling condition for **clean cooking, electrification of industry, and efficiency gains**.

6.4.12 Recommendations

The Province as a "transition province" that is moving from biomass and fossil fuels toward electricity-based clean energy. The recommendations should therefore focus on managing growth, reducing environmental pressure, and accelerating clean energy adoption.

Short-term measures (1–5 years)

These are actions that can be started immediately using existing institutions and technologies.

A. For industries and commercial energy use

- Promote industrial electrification, especially in Nawalpur, Kaski and Tanahun, by:
    - Incentives for replacing diesel generators with grid electricity,
    - Lower tariffs for off-peak industrial electricity use.
- Enforce effluent treatment and emission standards in industrial areas:
    - Mandatory wastewater pre-treatment,
    - Monitoring of air emissions from factories and brick kilns.
- Introduce clean construction guidelines:
    - Dust control,
    - Regulated quarrying,
    - Safe spoil disposal at hydropower and road projects.

B. For hydropower development

- Make basin-level planning mandatory for rivers such as Kali Gandaki, Marsyangdi, Seti and Budhi Gandaki.
- Strictly enforce:
    - Environmental flow (e-flow) compliance,
    - Spoil and quarry management,
    - Landslide and erosion control.
- Establish provincial hydropower environmental monitoring units.

C. For clean cooking – rural areas

- Expand:
    - Improved cookstoves (ICS),
    - Biogas plants**,**
    - Electric cooking pilots where grid supply is reliable.
- Provide:
    - Subsidies for induction cookers,
    - Community awareness programs on health impacts of fuelwood.
- Integrate clean cooking with:
    - Forest conservation programs,
    - Women's health initiatives.

D. For urban areas (LPG reduction)

- Promote electric cooking in cities (Pokhara, Damauli, Kawasoti):
    - Induction stove subsidy programs,

- Special electricity tariff for cooking,
- Demonstration kitchens in schools and hospitals.
- Encourage hotels and restaurants to adopt:
  - Electric boilers,
  - Induction cooking,
  - Energy-efficient appliances.

E. For transport

- Start electric mobility in urban hubs:
  - Electric buses in Pokhara,
  - Electric taxis and three-wheelers,
  - Charging stations along highways and tourist routes.

Long-term measures (5–20 years)

These shape Gandaki's future development pathway.

A. Transition to an electricity-based economy

- Make electricity the dominant energy source for:
  - Cooking,
  - Industry,
  - Transport.
- Gradually reduce:
  - LPG dependence in cities,
  - Diesel dependence in industry and construction.

B. Industrial transformation

- Develop green industrial zones in Nawalpur:
  - Powered mainly by electricity,
  - Mandatory waste and wastewater treatment,
  - Resource-efficient manufacturing.
- Encourage:
  - Agro-processing industries using electric boilers and dryers,
  - Cold storage and food processing powered by hydropower.

C. Clean cooking vision

- Rural areas:
  - Move from fuelwood → ICS/biogas → electricity.
- Urban areas:
  - Move from LPG → electricity.
- By 2040, aim for:
  - Majority of households cooking with electricity.

D. Sustainable hydropower

- Make Gandaki a model for:
  - Basin-scale hydropower planning,
  - Cumulative impact assessment,
  - Climate-resilient hydropower design.
- Protect:
  - River ecology,
  - Community water uses,
  - Cultural and tourism values of rivers.

E. Clean transport future

- Develop Gandaki as:
  - An electric mobility province:
    - Electric public transport,
    - Electric tourism vehicles,
    - Electric logistics for short distances.
- Reduce diesel use significantly in:
  - Pokhara valley,
  - Highway corridors.

Targeted strategies for fuelwood and LPG reduction

According to the 2021 census cooking energy is already in a tight transition stage: out of 661,632 households, about 341,017 households use LPG while 311,925 households still use wood/firewood as their usual cooking fuel; only 1,390 households report electricity as their usual cooking fuel, and 6,548 households use biogas. This means the province's clean cooking challenge has *two faces at the same time*: fuelwood remains a major rural reality, while LPG has become the dominant urban and market-centre fuel.

Therefore, the targeted strategy (***Table 6-49***) needs to be dual: in rural hills and mountains, the quickest environmental gains come from scaling improved cookstoves and biogas (because they directly reduce the large fuelwood base), while in urban areas the priority is to shift a portion of LPG users to electric cooking, since LPG already serves the majority and creates import-dependence and price vulnerability. The census also shows that Gandaki has widespread access to electricity for lighting (about 645,780 households), which strengthens the case for electric cooking expansion wherever supply is reliable.

Table 6-49. Targeted Strategies for Fuelwood and LPG Reduction

Area	Current problem	Short-term solution	Long-term vision
Rural hills & mountains	Heavy fuelwood use	ICS + biogas + awareness	Electric cooking as grid strengthens
Urban centers	High LPG use	Induction stove programs	Full shift to electric cooking
Tourism areas	Mixed LPG + wood	Electric kitchens, solar hot water	Low-carbon tourism energy systems

Table 6-50. Observed Trends, Risks, and Targeted Actions – Energy and Industry, Gandaki Province

Observed Trends	Key Risks	Targeted Actions
Increasing total energy demand, driven by urbanization, infrastructure development, tourism recovery, and industrial growth since 2020.	Rising pressure on air quality and increased dependence on imported fossil fuels, particularly petroleum products.	Promote industrial electrification, improve energy efficiency, and accelerate transition toward electricity-based end uses.
Rapid growth in electricity consumption, supported by hydropower expansion and near-universal access to electricity.	Without integrated planning, expanding hydropower and electricity demand may generate **cumulative river, land, and ecosystem impacts**.	Adopt basin-scale hydropower planning and strengthen environmental safeguards for energy infrastructure.
Persistent reliance on petroleum fuels in transport, construction, and some industrial activities, despite declining share.	Continued urban and corridor air pollution and exposure to fuel price volatility and energy insecurity.	Accelerate electric mobility, strengthen vehicle emission standards, and improve public transport systems.
Continued biomass use for cooking and small-scale industries in hill and mountain districts.	Localized forest degradation, indoor air pollution, and health risks in biomass-dependent communities.	Expand **clean cooking solutions**, promote improved cookstoves, and support household and community-level electrification.

Observed Trends	Key Risks	Targeted Actions
Spatial concentration of industrial activity in Pokhara Valley and highway corridors (Kaski–Tanahun–Nawalpur).	Intensification of localized environmental pressures, including waste generation, wastewater discharge, and air pollution.	Integrate **industrial and energy zoning** into provincial and municipal spatial planning to manage cumulative impacts.
Expansion of construction- and materials-based industries linked to infrastructure and hydropower development.	Increased risks of slope instability, riverbed degradation, sediment loading, and landscape fragmentation.	Strengthen regulation of **quarrying, construction materials extraction**, and environmental compliance for construction industries.
Dominance of micro and small enterprises in the industrial sector.	Cumulative pollution from dispersed sources that are difficult to monitor and regulate.	Promote **cleaner production practices**, strengthen environmental monitoring, and support compliance among small and medium enterprises.
Limited environmental monitoring and enforcement capacity relative to the pace of energy and industrial growth.	Growing gap between development expansion and environmental management, leading to unmanaged cumulative impacts.	Enhance **institutional capacity**, monitoring systems, and coordination between energy, industry, and environment agencies.

6.5 Forest and Biodiversity

6.5.1 Background

Forests and biodiversity shape the identity and everyday life of Gandaki Province. From the subtropical river valleys to the high mountain landscapes, forests protect soil and water, reduce landslide risk, support agriculture and tourism, and provide timber, fuelwood, fodder, and non-timber forest products. Biodiversity in Gandaki contains globally important habitats and several of Nepal's flagship species, while also facing increasing pressure from infrastructure expansion, forest fires, invasive species, unmanaged harvesting, and growing human–wildlife conflict. For a province with a strong dependence on nature-based livelihoods and tourism, protecting forests and biodiversity is not only an environmental priority but also a development necessity.

Recent provincial reporting MOFE (2026) shows that Gandaki's forest cover has increased significantly over the past decade, reaching 919,349 ha in 2025 (from 750,120 ha in 2015). Forest management is largely community-based: the province reported 3,972 community forests in 2025, alongside 1 collaborative forest and 1,147 leasehold forests (MOFE, 2026). In terms of area, community forests cover 283,073 ha (2025), while leasehold forests cover 5,773.68 ha. This highlights how strongly Gandaki's forest governance depends on local user groups and community stewardship.

The Province also contains a very large share of Nepal's protected landscapes. Provincial records list four major protected area components within the province: Annapurna Conservation Area (ACA), Manaslu Conservation Area (MCA), Dhorpatan Hunting Reserve (Baglung and Myagdi portion), and the Buffer Zone of Chitwan National Park in Nawalpur. The same provincial source reports a combined protected area coverage of 1,003,951 ha within the province (MOFE, 2026). Independent conservation management information also confirms ACA's scale, describing it as Nepal's largest protected area, covering 7,629 sq. km (≈762,900 ha) and hosting high biodiversity richness (ACA, 2026; NSO, 2024b).

At the same time, biodiversity protection is increasingly shaped by human pressures. Provincial reporting notes (MOFE, 2026) rising wildlife–human conflict impacts over time, including incidents affecting human lives (13 in 2015 to 21 in 2025). The province also identifies a wide set of flagship and diverse ecosystems ranging from tiger and rhinoceros in the lowlands to snow leopard, red panda, musk deer, and pangolin across hill and mountain habitats. These trends show that forest and biodiversity issues in Gat "conservation areas" or "forest cover" are equally about coexistence, governance, and how development choices interact with ecosystems.

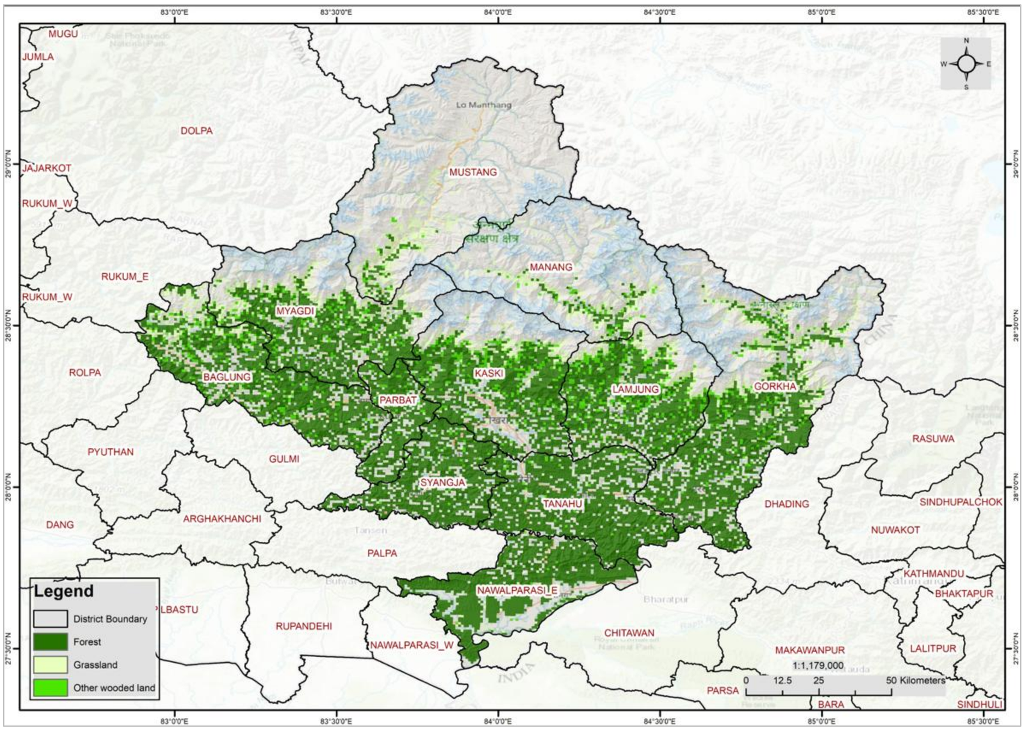


Figure 6-27. Forest Map of (2022) Gandaki Province

6.5.2 Land Cover Composition

The most reliable and nationally accepted source for land cover is the National Land Cover Monitoring System (NLCMS 2020–2022) prepared by the FRTC (2024), Ministry of Forests and Environment. It provides province-wise area statistics using satellite imagery and standardized classification.

Table 6-51. Land Cover Area of Gandaki Province (FRTC, 2024).

Land cover class	Area (ha)	Share of provincial area (%)
Forest	831,694	37.98
Grassland	482,077	22.01
Cropland	236,429	10.8
Bare rock	173,023	7.9
Snow	122,345	5.59
Glacier	169,343	7.73
Built-up area	54,629	2.5
River bed	24,276	1.11
Water bodies	7,403	0.34
Other wooded land (OWL)	87,655	4
Bare soil	1,042	0.05
Total	**2,189,916**	**100**

This table clearly shows that Gandaki is a forest and grassland dominated province, where together forests and grasslands account for about 60% of total land area. The presence of glaciers, snow, and bare rock is also significant because of the province's Himalayan geography, making Gandaki ecologically very different from the lowland provinces.

Forest cover and land-use pattern

Gandaki is a forest-dominated province, but its landscape is a true mix of forests, grasslands, agriculture, settlements, rivers and high mountain terrain. The most recent National Land Cover Monitoring System (NLCMS 2010–2024) shows that in 2022 the largest share of Gandaki's land was forest (37.98%), followed by grassland (22.01%), and then cropland as another major class (FRTC, 2024). This confirms that forests remain the backbone of the provincial landscape, but a large part of the province, especially in high altitude districts, is also grassland and rangeland. The table (**Table *6-52***) below presents the district-wise land and forest area in the province.

Table 6-52. District-wise Forest Area of Gandaki Province (Sources FRTC (2024)

District	Total Area (km2)	Forest (km2)		Grassland (km2)		Change (km2)	
		2010	2024	2010	2024	Forest	Grassland
Baglung	1806.04	1006.08	1073.64	246.89	165.45	67.56	-81.44
Gorkha	3654.35	1137.94	1267.96	848.35	394.49	130.02	-453.86
Kaski	2042.16	826.14	885.13	303.11	159.62	58.99	-143.49
Lamjung	1713.01	793.78	861.77	281.69	183.19	67.99	-98.5
Manang	2274.06	89.34	77.58	677.32	242.05	-11.76	-435.27
Mustang	3618.76	70.52	65.42	1459.76	257.33	-5.1	-1202.43
Myagdi	2325.22	790.67	825.26	574.16	294.35	34.59	-279.81
East Nawalparasi	1055.88	657.83	704.42	18	26.61	46.59	8.61
Parbat	500.06	300.15	349.08	9.45	4.6	48.93	-4.85
Syangja	1178.25	740.25	861.32	8.18	7.99	121.07	-0.19
Tanahu	1565.21	1099.78	1173.9	6.63	13.09	74.12	6.46
Total	**21733**	**7512.48**	**8145.48**	**4433.54**	**1748.77**	**633.00**	**-2684.77**

According to the Environment Statistics of Nepal 2024 reports (NSO, 2024b) Gandaki forest area as 814,548 ha (out of 2,173,300 ha total provincial area). While different datasets may use slightly different definitions and mapping methods, both confirm the same message: forests cover a substantial share of Gandaki and remain the province's most dominant land cover. During the provincial consultation, the MOFE indicates a strong increase in forest cover over a decade, reporting 750,120 ha in 2015 rising to 919,349 ha in 2025. In this report FRTC (2024) and MOFE data of 2025 have been used.

Land-use change

The strongest evidence for land-use change over time comes from NLCMS, because it produces consistent land cover maps across years and reports changes systematically. The NLCMS report explains that land cover statistics are available for 2019, and 2022 at province level (FRTC, 2024). At national scale, NLCMS finds that forest cover increased from 2019 to 2022, while built-up areas and grassland also increased, and cropland decreased.

- some other wooded land and cropland converted to forest,
- some cropland converted to built-up areas,
- and some bare rock converted to grassland (partly linked to snow fluctuations and exposure of land surfaces).

This national pattern is directly relevant for Gandaki because the province is experiencing the same drivers:

- settlement growth and infrastructure expansion, especially around road corridors and urban centres, pushes land toward built-up classes;
- agricultural land abandonment in the hills can allow forest or shrub recovery;

- snow variability and warming affects high mountain land cover classes, shifting the balance between snow, bare rock, and grassland.

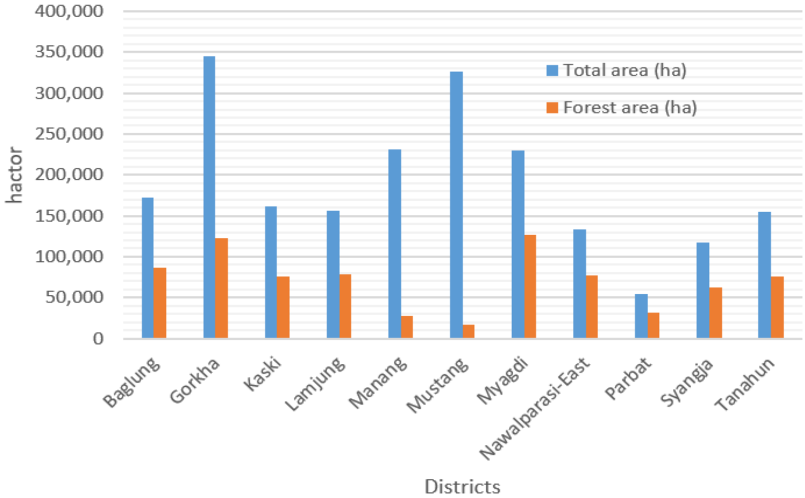


Figure 6-28. District-wise Land and Forest Area of Gandaki Province (NSO, 2024)

The NLCMS province-level data show that land-cover dynamics in Gandaki Province over the 2010–2024 period are characterized by the expansion of vegetated land covers alongside relative stability, with minor decline, in wetlands.

Table 6-53. Landuse Change of Gandaki Province

Land-use / land-cover class	2010 (km2)	2024 (km2)	Net change (2019–2022)
Forest land	7512.48	8145.48	+633.00
Grassland	4433.54	1748.77	-2684.77
Wetlands (water bodies)	10,171	9,659	−512

Forest land

Forest land increased from 751,248 ha in 2010 to 814,548 ha in 2024, representing a net gain of approximately 43,500 ha (FRTC, 2024). This upward trend is consistent with national NLCMS findings and reflects several long-standing processes in Gandaki Province, including:

- sustained community forestry management,
- natural regeneration in mid-hill districts where agricultural land has been abandoned, and
- improved forest protection and monitoring, particularly outside major urban centers.

Given Gandaki's strong community forestry presence and extensive hill and mountain terrain, forest recovery is most likely occurring in mid-hill and mountain districts, where demographic change and out-migration have reduced pressure on marginal farmland. Alongside satellite-based mapping, the Gandaki Ministry of Forest and Environment maintains administrative forest records. These show a strong increase in forest cover over the last decade (**Table 6-54**). This suggests that Gandaki has experienced a substantial increase in recorded forest area between 2015 and 2020, followed by stabilization. Possible reasons include:

- Regeneration on abandoned agricultural land,
- Expansion and strengthening of community forestry,
- Improved mapping and reporting systems,
- Conservation area management.

Table 6-54. Forest Cover Trend in Gandaki Province

Year	Total forest area (ha)	Sources
2010	751,248	FRTC (2024)
2015	750,120	MOFE (2025) Gandaki Porvince
2024	814,548	FRTC (2024)
2025	919,349	MOFE (2025) Gandaki Porvince

Source: Ministry of Forest and Environment, Gandaki Province

However, this must be interpreted carefully and together with NLCMS data, which uses a different scientific method. Both systems are valid, but they measure forests in different ways.

Forest degradation trend

Even while forest cover increases, degradation is also rising, which shows that forest quality is under pressure (***Table 6-55***).

Table 6-55. Forest Area Under Degradation in Gandaki Province

Year	Degraded Forest Area (ha)	Main reasons
2015	5,417	Natural calamities, forest fire
2020	5,625	Natural calamities, forest fire
2025	5,773	Natural calamities, forest fire

Source: Ministry of Forest and Environment, Gandaki Province

This shows a slow but steady increase in degraded forest area, mainly driven by:

- Forest fire,
- Landslides and floods,
- Extreme climatic events.

So, while forest area may increase, forest condition and ecological quality remain fragile.

Grassland

Grassland area in Gandaki Province declined substantially between 2010 and 2022, in contrast to the net increase observed in forest cover during the same period. District-wise land-cover analysis indicates that grassland loss was most pronounced in the high Himalayan and trans-Himalayan districts, particularly Manang and Mustang, while mid-hill districts also experienced gradual reductions. In the Gandaki context, grasslands include alpine and sub-alpine meadows in high-mountain regions as well as semi-natural grasslands and shrub–grass mosaics in the hills, both of which play important ecological and livelihood roles. The observed decline in grassland extent reflects a combination of factors, including:

- shrub and forest encroachment on former grazing lands, particularly in mid-hill districts,
- reduced grazing pressure and changes in pastoral systems linked to outmigration and livelihood transitions,
- climatic and cryospheric influences affecting alpine rangelands, and
- improved land-cover classification, where open rangelands are increasingly differentiated into shrubland, barren land, or snow and ice classes in recent satellite-based assessments.

From an ecosystem perspective, this trend has mixed implications. While forest expansion enhances carbon storage and watershed regulation, the loss and transformation of grasslands may reduce habitat availability for grassland-dependent species and undermine traditional grazing systems, particularly in high-altitude landscapes. These changes highlight the need for balanced ecosystem management that recognizes grasslands as distinct and valuable components of Gandaki's forest–biodiversity system, rather than transitional land awaiting forest regeneration.

Wetlands (water bodies)

Wetland area (mapped as water bodies) shows a slight decline, from 10,171ha in 2019 to 9,659ha in 2022 (FRTC, 2024). Although the absolute change (−512 ha) is small relative to total provincial area, it is environmentally significant because wetlands:

- play a critical role in flood regulation, groundwater recharge, and biodiversity, and
- are highly sensitive to seasonal variability, river dynamics, and human water use.

This decline may be influenced by inter-annual hydrological variation, reservoir drawdown, river channel shifts, or upstream water abstraction. As NLCMS captures surface water extent at the time of satellite acquisition, small changes have been interpreted cautiously but still warrant attention given Gandaki's flood- and landslide-prone river systems.

6.5.3 Biodiversity

Gandaki Province is one of Nepal's most biologically diverse regions because it spans a wide altitudinal range from lowland river valleys and forests in the south to alpine grasslands and high Himalayan ecosystems in the north. This diversity of landscapes supports a broad mix of ecosystems and species, including large mammals, rare alpine fauna, rich birdlife, and important plant communities (NSO, 2024b).

Gandaki's biodiversity value comes from its elevation range and its protected landscapes. Provincial information lists the major protected area components within Gandaki as Annapurna Conservation Area (ACA), Manaslu Conservation Area (MCA), Dhorpatan Hunting Reserve (Baglung/Myagdi portion), and the buffer zone of Chitwan National Park in Nawalpur, with a combined protected area coverage of 1,003,951 ha. These areas represent from lowland Sal forests to alpine ecosystems.

Habitat Change and Implications for Biodiversity

Recent satellite-based land-cover data provide strong evidence of habitat change in Gandaki Province. According to the National Land Cover Monitoring System (NLCMS), forest cover increased by more than 43,000 ha between 2019 and 2022, while grassland expanded by nearly 60,000 ha over the same period (FRTC, 2024). These changes suggest improving habitat availability for many forest- and grassland-dependent species, particularly in hill and mountain districts.

Forest expansion is widely linked to community forestry, natural regeneration, and the abandonment of marginal agricultural land due to migration and livelihood change. Grassland expansion, especially in high-elevation areas, reflects both land-use change and climatic influences. In contrast, wetland (water body) area declined slightly, raising concerns for aquatic biodiversity, migratory birds, and ecosystem services such as flood regulation (FRTC, 2024).

Biodiversity under pressure: key threats

Even with strong conservation landscapes, biodiversity in Gandaki faces growing pressure. The in threat" in biodiversity is to link to drivers and evidence discussed below;

Forest fire and climate stress:

Forest fire is repeatedly identified as one of the most damaging hazards in Gandaki, linked to dry spells, rising temperature, fuel load, and human activities (grazing, slash-and-burn, careless use of fire, and expanding rural roads). The repeated fires reduce regeneration, simplify forest structure, increase erosion, and weaken ecosystem services. The province forest degradation has increased over time (2015: 5,417 ha → 2025: 5,773 ha), with reasons such as natural calamities and fire.

Human–wildlife conflict:

Human–wildlife conflict has become an increasingly important issue in Gandaki Province as people and wildlife share overlapping landscapes. As forests recover and settlements, roads, and farms expand closer to forest areas, encounters between humans and wild animals are becoming more frequent. Species such as leopards, bears, monkeys, and wild boar are commonly involved, affecting both human safety and livelihoods. Human–wildlife conflict is a strong signal of ecological stress and changing land use.

Box 3: Human–Wildlife Conflict in Gandaki — When Lives, Livelihoods, and Forests Collide

In Gandaki Province, human–wildlife conflict is becoming more frequent and more painful as people and wildlife share the same landscapes. As forests recover and farms, roads, and settlements sit closer to forest edges, animals like leopards, bears, monkeys, and wild boar are entering villages more often putting people's safety and livelihoods at risk. The costs are rising. Provincial records show that cases affecting human lives (deaths/injuries) increased from 13 (2015) to 21 (2025). In the same period, reported livestock losses rose from 498 to 871. These are not just numbers each case represents fear, loss, and growing resentment at the forest–farm boundary.

For many communities, the biggest pressure is not always dramatic attacks, but it is constant crop raiding, especially by monkeys and wild boar. In Syangja, repeated monkey raids have been widely reported as destroying harvests and pushing farmers to the edge, including in areas like Khadgetari (Syangja): after continuous crop damage, some community members cleared nearby forest to chase monkeys away, even knowing it could bring legal consequences. That story shows the real intensity of conflict when families feel they must choose between food security and forest protection.

The message for the SoE is simple: if conflict is not managed, forests will suffer too. When people feel unsupported, they may respond in ways that damage conservation gains clearing vegetation, retaliating against wildlife, or refusing to cooperate with protection efforts.

What Gandaki needs most is practical coexistence support in hotspot areas: rapid response teams, effective crop and livestock protection, better management of attractants near settlements, and faster, fair relief mechanisms so communities are protected while wildlife and forests are conserved.

The provincial dataset reports an increase in conflict impacts over time: for example, cases affecting human lives rose from 13 (2015) to 21 (2025), and livestock losses increased from 498 (2015) to 871 (2025). This trend usually indicates (i) settlement and farming close to forests and corridors, (ii) changes in habitat quality (fire, fragmentation, disturbance), and (iii) better reporting over time.

Table 6-56. Human–wildlife Conflict Cases in Gandaki Province

Impact type	2015	2020	2025
Human deaths/injuries	13	16	21
Livestock loss (numbers)	498	712	871
Crop damage cases	6	6	4

Source: Ministry of Forest and Environment, Gandaki Province

This trend (***Table 6-56***) shows that wildlife is increasingly coming into contact with human settlements. The reasons are:

- Shrinking or disturbed habitats,
- Expansion of agriculture and settlements near forests,
- Decline of natural food sources inside forests,
- Improved reporting systems.

Provincial records indicate a rising trend in conflict impacts, including human casualties and livestock losses. This growing interaction reflects both improved wildlife habitat and increasing human pressure on natural landscapes. Addressing human–wildlife conflict is therefore essential not only for biodiversity conservation but also for protecting communities and sustaining long-term coexistence between people and wildlife in Gandaki Province.

Poaching/illegal trade pressure

Illegal wildlife trade and poaching remain a concern in the Province, particularly for high-value species such as pangolin and musk deer. While reported cases have declined in recent years, continued enforcement and community awareness are needed to prevent illegal exploitation and protect vulnerable wildlife. The same provincial dataset records illegal wildlife trade/poaching cases, showing that this remains an ongoing threat (***Table 6-57***).

Table 6-57. Reported Illegal Wildlife Trade/Poaching Cases

Year	Number of cases
2015	4
2020	4
2025	2

Source: Ministry of Forest and Environment, Gandaki Province

Although numbers are small, even a few cases are serious because Gandaki hosts globally important species like snow leopard, red panda, musk deer and pangolin. Even a small number may cause losses of high-value species.

6.5.4 Forest Management Systems and Protected Areas

Forest Management Systems

Forest management in the Province is strongly rooted in community participation largely managed by local user groups and community institutions. This system has helped restore forest cover, improve local ownership, and protect forests from open access exploitation. At the same time, protected areas cover a very large part of the province and form the backbone of biodiversity conservation at landscape scale. Together, community-managed forests and protected areas define how forests and biodiversity are governed in Gandaki. According to official data from the Ministry of Forest and Environment, Gandaki Province, the province has three main types of forest management systems:

- Community Forests (CF),
- Leasehold Forests (LF), and
- Collaborative Forest (CoF).

Table 6-58. Number of Forest Management Units and Area.

Year	Forest Type (Area in Ha)		
	Community (Area)	Leasehold (Area)	Collaborative (Area)
2015	3,840 (272,513)	1,091 (5417)	1 (673)
2020	3,941 (280,769)	1,124 (5625)	1 (673)
2025	3,972 (283,073)	1,147 (5774)	1 (673)

Source: Ministry of Forest and Environment, Gandaki Province.

This shows that community forestry is expanding steadily. Leasehold forestry is also increasing, which is important because leasehold forests are directly linked with poverty reduction and livelihood support. Community forests alone now manage over 283,000 ha, which is a very large share of Gandaki's total forest area. This confirms that local communities are the main custodians of forests in the province. Leasehold forests cover a much smaller area, but their role is socially significant because they support poorer households and help restore degraded land. The single collaborative forest reflects Gandaki's geography: unlike the Terai, where large government-managed forests exist, Gandaki is dominated by hill forests that are better suited for community-based management.

Protected Areas

Gandaki Province contains some of the most important protected landscapes in Nepal. The Province has rich forests and biodiversity resources, shaped by its wide range of landscapes from river valleys and mid-hills to high Himalayan ecosystems. Forests cover a large share of the province and support diverse plant and animal life, including many nationally and globally important species such as the snow leopard, red panda, pangolin, and tiger. Recent data show that forest and grassland areas have increased in parts of the province, reflecting community-based forest management and natural regeneration. At the same time, biodiversity faces growing pressure from human activities, climate change, and rising human–wildlife conflict, highlighting the need to balance conservation with development and livelihoods. Official provincial data identifies four protected area components within the province (***Table 6-59*****Figure *6-27***):

Table 6-59. Protected Areas Within Gandaki Province

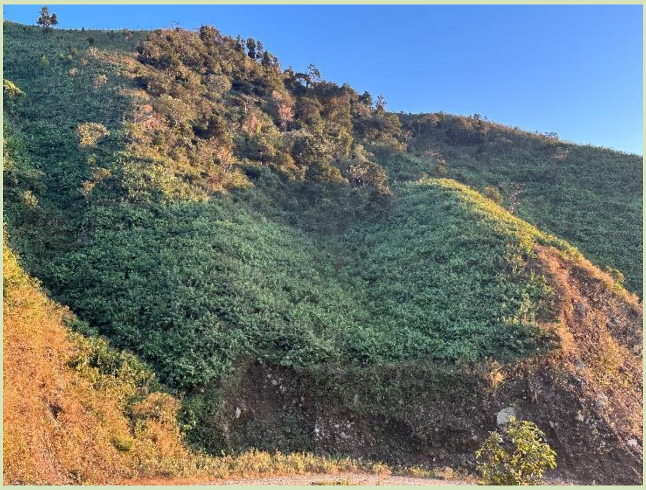
Protected Area	Area within Gandaki (ha)
Chitwan National Park (Buffer Zone only,	24,671
Annapurna Conservation Area (ACA)	762,900
Manaslu Conservation Area (MCA)	166,300
Dhorpatan Hunting Reserve (Baglung & Myagdi	50,110
Total protected area	**1,003,951**

Source: Ministry of Forest and Environment, Gandaki Province.

This means that almost half of Gandaki Province lies within protected or conservation-managed landscapes, which is exceptionally high by national standards, among these:

- Annapurna Conservation Area (ACA) alone accounts for more than 75% of the protected area within the province.
- ACA and MCA represent high-mountain biodiversity, alpine ecosystems, and critical wildlife corridors.
- The Chitwan buffer zone in Nawalpur protects lowland Sal forests and key wildlife habitats.
- Dhorpatan Hunting Reserve is unique in Nepal and plays a role in species management and controlled hunting.

Box 4: Healing the Hills, Securing Livelihoods: Leasehold Forestry in Kawasoti, Nawalpur



The Churia foothills around Kawasoti are ecologically fragile and historically affected by forest degradation due to overgrazing and fuelwood extraction. Degraded slopes in this Terai–Churia transition zone dry out quickly in the dry season and erode rapidly during intense monsoon rainfall, reducing forest productivity and increasing downstream risk.

Leasehold Forestry was introduced as a pro-poor forest management approach, granting small groups of poor and landless households long-term use rights over degraded forest land. In Nawalpur, leasehold groups typically include 5–15 households, managing around one hectare per household. Communities protect forest patches from open grazing, plant fodder and grass species, and gradually restore tree cover.

The ecological benefits are measurable. Restored leasehold forests in the district record average carbon stocks of about 14.5 t/ha, significantly higher than unmanaged degraded areas. Improved vegetation cover enhances soil moisture retention and reduces surface erosion on fragile Churia slopes.

Livelihood gains are equally important. Near Kawasoti, 46 households manage approximately 70–80 hectares of leasehold and community-managed forest land. Amriso (broom grass) is a key livelihood species, providing both fodder and cash income. In peak years, Amriso sales generated NPR 1.2–1.5 million annually, although recent price declines have reduced earnings. Even so, households report improved food security and more stable year-round incomes compared to the pre-leasehold period.

Overall, Leasehold Forestry in Kawasoti demonstrates how secure forest tenure for marginalized households can restore degraded ecosystems while strengthening livelihoods. By increasing biomass, carbon storage, and income stability, the model functions as a practical form of ecosystem-based adaptation in the climate-sensitive Churia–Terai interface of Gandaki Province.

6.5.5 High Mountain Bio-Diversity

The high-mountain region of Gandaki Province forms one of Nepal's most ecologically distinctive and biodiversity-rich landscapes, spanning the trans-Himalayan districts of Manang and Mustang, the northern belt of Gorkha, and the high-altitude areas of Lamjung, Baglung, and Myagdi. This region encompasses large parts of the Annapurna Conservation Area, Manaslu Conservation Area, and the high-mountain zone of the Dhorpatan Hunting Reserve, creating a continuous altitudinal gradient from sub-alpine forests to alpine grasslands and cold desert ecosystems. Despite relatively sparse forest cover due to climatic and topographic constraints, these landscapes support highly specialized flora and fauna, including several nationally and globally significant species such as the Snow leopard, Himalayan wolf, and blue sheep. National environmental assessments identify Gandaki's high-mountain belt as a core area for alpine biodiversity conservation in Nepal, while also highlighting its high sensitivity to climate change, rangeland transformation, and infrastructure expansion (NSO, 2024; FRTC, 2024).

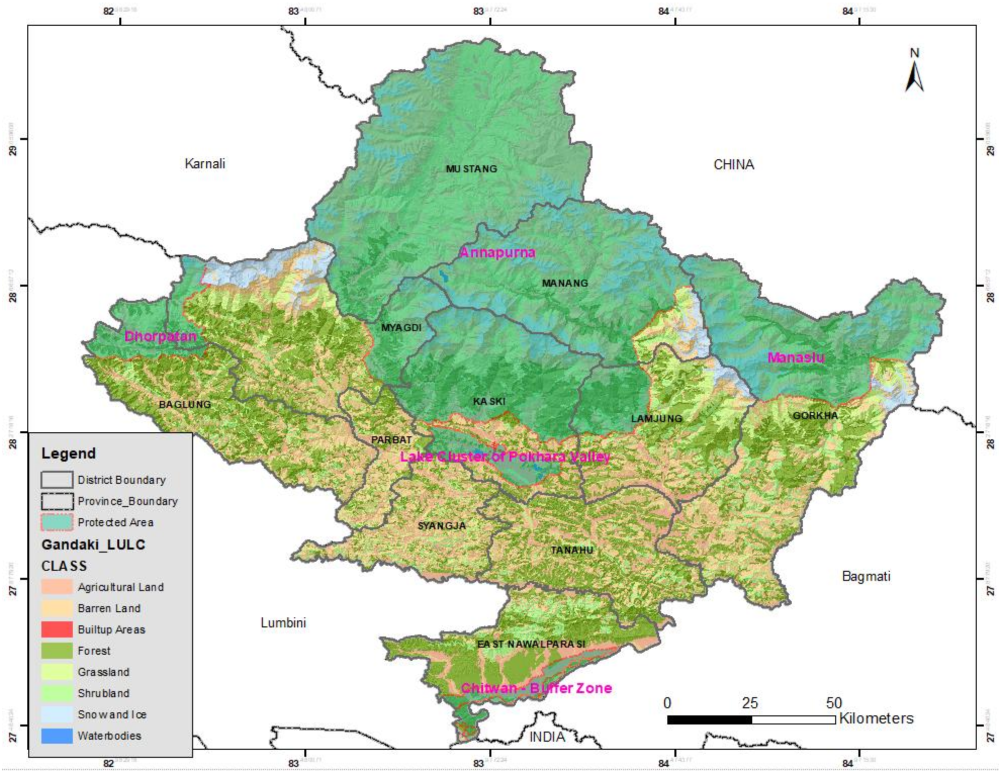


Figure 6-29. Protected Area in Gandaki Province

6.5.6 Flagship and threatened wildlife

Gandaki hosts many of Nepal's flagship species. A provincial response lists tiger, rhinoceros, snow leopard, elephant, red panda, pangolin, musk deer, sloth bear and clouded leopard among major species of concern. National datasets also show that several protected mammals have confirmed or potential distribution in ACA, MCA, and Dhorpatan, meaning Gandaki is central to their long-term survival in Nepal. For example, snow leopard *(Panthera uncia)*, red panda *(Ailurus fulgens)*, clouded leopard *(Neofelis nebulosa)*, Himalayan wolf *(Canis lupus)* and brown bear *(Ursus arctos)* are all linked to Gandaki's protected landscapes.

Table 6-60. Selected Protected Mammals Relevant to Gandaki

Species	Potential distribution that includes Gandaki	National estimated population (range/estimate)
Snow leopard *(Panthera uncia)*	ACA, MCA (and other mountain PAs)	392–629
Red panda *(Ailurus fulgens)*	Mountain PAs (incl. Gandaki	(By sub-populations; see Table 4.3)
Clouded leopard *(Neofelis*	Includes ACA (also other PAs)	300–500
Himalayan wolf *(Canis lupus)*	ACA, MCA, DHR (and others)	30–50
Brown bear (Ursus arctos)	ACA, MCA (and others)	NA

Source: Environment Statistics of Nepal 2024 (compiled from DNPWC and cited sources).

6.5.7 Policy and Institutional Framework

Forest and biodiversity governance in Nepal is defined by a federal legal framework that devolves major forest management functions to provinces and local governments, while protected areas and wildlife conservation remain strongly guided by federal mandates. In Gandaki, this is complemented by provincial legislation and implementing agencies responsible for forest management, ecosystem protection, watershed conservation, and biodiversity mainstreaming.

Federal framework (laws, policies and strategies)

Forest governance and sustainable forest management: The Forests Act, 2019 (2076) provides the principal legal basis for forest governance across Nepal. It recognizes multiple forest management regimes (e.g., community forestry and other modalities) and establishes institutional arrangements including Division Forest Offices under provincial government structures, indicating the operational shift toward sub-national implementation. The Forest Regulation, 2079 further operationalizes procedural requirements for forest management (planning, permitting, harvesting, transport, etc.), supporting implementation through rules-based compliance.

Protected areas and wildlife conservation: The National Parks and Wildlife Conservation Act, 1973 (2029) remains a foundational legal instrument for protected areas and wildlife conservation. It provides for multiple protected area categories and enables the Government of Nepal to entrust conservation area management to an institution through official notification an important basis for conservation area governance models such as those operating in the Annapurna landscape.

Box 5. High-Mountain Forest and Alpine Biodiversity

The high-mountain and trans-Himalayan region of Gandaki Province is the most distinctive and climate-sensitive forest and alpine ecosystems. Vegetation is naturally sparse and patchy due to cold temperatures, low precipitation, and shallow soils, transitioning from sub-alpine forests of Himalayan birch (*Betula utilis*), fir (*Abies spectabilis*), blue pine (*Pinus wallichiana*), and juniper (*Juniperus* spp.) to alpine scrub and meadow systems above the treeline. These ecosystems play a critical role in slope stabilization, rangeland productivity, and watershed regulation, while also acting as climate refugia for specialized high-altitude species (NSO, 2024; FRTC, 2024).

The high-mountain belt of Gandaki supports a unique assemblage of fauna adapted to alpine and trans-Himalayan conditions, including globally important and nationally protected species. Flagship mammals such as the Snow leopard, Himalayan wolf, blue sheep (*Pseudois nayaur*), Himalayan tahr, musk deer, and brown bear are closely associated with these landscapes, while high-altitude birds such as Himalayan griffon, lammergeier, and snow partridge are characteristic of open alpine habitats. National assessments identify the Annapurna–Manaslu–Dhorpatan landscape as one of Nepal's most important strongholds for snow leopard and associated prey species, highlighting Gandaki's central role in high-mountain biodiversity conservation (NSO, 2024; DNPWC, 2024). Although human population density is low, these ecosystems are increasingly vulnerable to climate change, rangeland transformation, infrastructure expansion, and grazing pressure, underscoring the need for targeted conservation, sustainable rangeland management, and protection of ecological connectivity across Gandaki's high-mountain districts.

However, the pronounced decline in grassland area in high-mountain districts of Gandaki Province, together with rising climate-related pressures such as increasing forest fire risk and temperature variability, signals growing vulnerability of alpine and sub-alpine ecosystems that underpin the habitat of high-altitude species and traditional rangeland-based livelihoods.

National biodiversity direction and international commitments: Nepal's National Biodiversity Strategy and Action Plan (NBSAP) 2014–2020 provides a strategic framework for biodiversity conservation and sustainable use, aligning national actions with international obligations under the Convention on Biological Diversity and guiding mainstreaming across sectors and levels of government. Recent national literature also indicates that an updated NBSAP (e.g., 2025–2030) has been under finalization, reflecting ongoing alignment with evolving global biodiversity frameworks.

Gandaki Province Framework

Provincial forest legislation and governance scope: Gandaki Province has enacted the Gandaki Province Forest Act, 2080, published through the Province Gazette. The Act sets the provincial legal basis for regulating and managing forests in the province and explicitly recognizes broader environmental linkages biodiversity, wildlife, watershed, and environmental management within its scope. The Act includes concepts relevant to ecological connectivity (e.g., “biological corridor”/movement pathway concepts), which is especially relevant given the province’s altitude gradient and corridor dynamics.

Institutional roles and implementation support**:** Provincial forest governance typically operates through provincial ministries and implementing offices (e.g., forest directorates/division forest offices), while conservation landscapes and protected areas intersect with federal institutions and conservation partners. This multi-level arrangement is particularly relevant in Gandaki, where biodiversity is structured across sharp elevation zones and connected landscapes.

Key Limitations and Governance Challenges

Despite a relatively comprehensive policy and institutional framework, several limitations constrain effective forest and biodiversity conservation in Gandaki Province, particularly in landscapes experiencing rapid infrastructure development, urban expansion, and climate stress.

Mandate–capacity mismatch: Although responsibilities for forest management and biodiversity conservation have been devolved to sub-national levels, institutional capacity at provincial and local levels often remains limited. Shortages of technical staff, financial resources, and monitoring infrastructure weaken effective implementation, especially in remote mountain and hill districts.

Fragmented sectoral planning and coordination: Forests, biodiversity, wildlife, infrastructure development, tourism, hydropower, and settlement expansion are frequently planned and implemented through separate sectoral processes. Limited coordination among these sectors leads to habitat fragmentation, cumulative environmental impacts, and increasing pressure on ecologically sensitive areas and wildlife corridors.

Challenges in protecting ecological corridors: Gandaki’s forests and biodiversity are structured along strong vertical and landscape gradients, with ecological corridors linking lowland valleys, mid-hills, and high mountain ecosystems. While the importance of connectivity is increasingly recognized in policy, protecting corridors on the ground is difficult due to competing land uses, expanding settlements, agricultural mosaics, and the need for coordination across multiple local governments.

Pressure on protected areas and buffer zones**:** Protected areas benefit from strong legal recognition and management frameworks, yet biodiversity outcomes are increasingly influenced by external pressures such as road expansion, tourism growth, grazing, and resource extraction in surrounding landscapes. Buffer zones and interface areas often face complex governance challenges, where enforcement is weaker and development pressures are high.

Limited biodiversity monitoring and data availability: Biodiversity monitoring remains uneven across taxa and geographic zones. While protected areas and research sites generate relatively robust data, many forests and landscapes outside protected areas lack systematic monitoring of species populations, habitat condition, invasive species, and climate-related changes. This constrains evidence-based planning and adaptive management at provincial and local levels.

Climate change and increasing uncertainty: Climate change is intensifying pressures on forest and biodiversity systems through shifting species ranges, altered fire regimes, and changes in hydrology. Current governance and management systems are not yet fully equipped to anticipate and respond to these dynamic changes, increasing the risks associated with business-as-usual conservation approaches.

6.5.8 Future Outlook: Forest and Biodiversity

The future of forests and biodiversity in Gandaki will be shaped by how land-use change, climate stress, and conservation efforts interact with each other. Existing data already show both encouraging trends and emerging risks that will strongly influence the ecological condition of the province.

The NLCMS (2020–2022) reports that in 2022 forests covered about 37.98% of the provincial area**,** confirming that Gandaki is one of Nepal's most forested provinces (FRTC, 2024). At the same time, provincial records show that total forest area increased from 750,120 ha in 2015 to 919,349 ha in 2025 (MoFE, Gandaki Province). This suggests that forest recovery and expansion are likely to continue, especially in the middle hills where agricultural land is being abandoned and natural regeneration is taking place. However, forest area alone does not reflect ecosystem health. The same provincial data show that degraded forest area increased from 5,417 ha in 2015 to 5,773 ha in 2025, mainly due to forest fire and natural disasters (MoFE, Gandaki Province). This indicates that while forests may be expanding in extent, their quality and ecological stability are under pressure. In the future, Gandaki is likely to face a situation where forest cover looks stable or improving, but forest condition and biodiversity values may decline if degradation is not controlled.

From a biodiversity perspective, Gandaki holds a nationally critical position. The province contains more than 1,003,951 ha of protected areas, including Annapurna Conservation Area, Manaslu Conservation Area, parts of Dhorpatan Hunting Reserve, and the buffer zone of Chitwan National Park (MoFE, Gandaki Province). These areas support globally important species such as snow leopard, red panda, musk deer, pangolin, clouded leopard, Himalayan wolf, tiger, rhinoceros, and elephant. Environment Statistics of Nepal (2024) shows that key populations of snow leopard and red panda are directly linked to the Annapurna–Manaslu and Dhorpatan landscapes, placing Gandaki at the centre of high-mountain biodiversity conservation. Despite this strength, biodiversity faces increasing stress. Provincial records show a steady rise in human–wildlife conflict:

- Human impacts increased from 13 cases in 2015 to 21 cases in 2025**,**
- Livestock losses increased from 498 to 871 over the same period (MoFE, Gandaki Province).

These trends suggest that wildlife habitats are becoming more disturbed and fragmented, forcing animals to move closer to settlements in search of food and space. If this continues, conflict will become one of the main threats to biodiversity conservation and to community support for protected areas. Land-use change will be a major driver of future biodiversity outcomes. The NLCMS shows that at national level:

- Built-up areas are increasing,
- Cropland is decreasing, and
- Some cropland is being converted into settlements and infrastructure (FRTC, 2024).

In Gandaki, this is already visible along highways, river valleys, hydropower corridors, and tourism centres. These areas often overlap with wildlife movement routes and riverine habitats. If development continues without ecological zoning and corridor protection, habitat fragmentation will increase and biodiversity loss will accelerate, even if forest area remains high.

Climate change adds further pressure. Forest fire is already identified by the province as a major cause of forest degradation (MoFE, Gandaki Province). With longer dry seasons and rising temperatures, fire risk is likely to increase, damaging wildlife habitat, reducing regeneration, and releasing carbon into the atmosphere. In the high Himalaya, changes in snow cover and temperature will affect alpine ecosystems that support species such as snow leopard, Himalayan wolf, and musk deer (Environment Statistics of Nepal, 2024). These species are highly sensitive to habitat disturbance and climate variability.

At the same time, Gandaki has strong opportunities for biodiversity protection. More than 283,000 ha of forest are managed under community forestry, showing a strong base of local stewardship (MoFE, Gandaki Province). If community forests are managed not only for timber and fuelwood but also for habitat quality, corridor protection, and fire control, they can become powerful tools for biodiversity conservation outside protected areas. The future of biodiversity in Gandaki therefore depends on how well three systems are linked:

1. Protected areas that safeguard core habitats,
2. Community forests that maintain ecological connectivity, and
3. Land-use planning that prevents uncontrolled fragmentation.

Gandaki's forests may continue to expand in area, but biodiversity will only remain secure if forest quality improves, wildlife corridors are protected, and conflict with communities is reduced. Without stronger management, the province risks having more forest cover but weaker ecosystems and declining wildlife. With careful, data-driven planning and strong local institutions, Gandaki can instead become a national example of how forest recovery, biodiversity conservation, and community livelihoods can progress together.

6.5.9 Environmental Implications

Changes in forest and biodiversity systems have wide environmental consequences for Gandaki Province.

- First, forests regulate water systems. Degradation and fire reduce infiltration and increase runoff, which affects spring recharge, irrigation reliability, and sediment load in rivers. This directly impacts hydropower, agriculture, and drinking water systems.
- Second, forest degradation increases soil erosion and landslide risk. Gandaki's steep terrain is already fragile, and loss of vegetation cover makes slopes more unstable during heavy rainfall.
- Third, forest fires worsen air quality and contribute to greenhouse gas emissions. Smoke affects public health, tourism visibility, and climate mitigation commitments.
- Fourth, biodiversity loss weakens ecosystem resilience. When species diversity declines, forests become more vulnerable to pests, disease, and climate extremes.
- Finally, increasing human–wildlife conflict creates social and economic stress. Livestock loss, crop damage, and threats to human safety reduce community support for conservation unless effective compensation and prevention mechanisms are in place.

Thus, forest and biodiversity degradation is not only an environmental issue; it directly affects livelihoods, safety, infrastructure sustainability, and provincial development.

6.5.10 DPSIR Analysis: Forest and Biodiversity

The DPSIR framework is applied to analyze the underlying causes, pressures, current condition, impacts, and responses related to forest and biodiversity systems in Gandaki Province. This analysis integrates observed land-cover changes, ecological patterns across elevation zones, and governance responses, and provides a structured basis for identifying priority interventions.

Drivers

The key drivers influencing forest and biodiversity dynamics in Gandaki Province include:

- Demographic and socio-economic change: particularly rural outmigration and declining dependence on subsistence agriculture, leading to land abandonment in mid-hill areas
- Infrastructure expansion**:** including roads, hydropower, and tourism facilities, especially in mountain and hill districts
- Economic transformation**:** with shifts away from traditional agro-pastoral systems
- Climate change**:** altering temperature, precipitation patterns, and ecosystem boundaries along elevation gradients
- Policy-driven forest regeneration**:** particularly through long-standing community forestry and conservation programs

Pressures

These drivers generate multiple pressures on forest and biodiversity systems:

- Land-use conversion and fragmentation associated with roads, settlements, and energy infrastructure
- Reduction of grassland and rangeland areas, particularly in alpine and trans-Himalayan districts
- Increased human–wildlife interaction as regenerating forests expand closer to settlements and wildlife uses corridor landscapes
- Forest fire risk and invasive species spread, exacerbated by land abandonment and changing climatic conditions
- Localized resource extraction and grazing pressure, especially in forest–grassland transition zones

State

The current state of forests and biodiversity in Gandaki Province reflects both recovery and emerging imbalance:

- Total forest area increased by approximately 543 km² (7.3%) between 2010 and 2022, with forest expansion recorded in 9 out of 11 districts
- Grassland area declined by about 2,685 km² (around 61%), with the largest reductions occurring in Manang and Mustang
- Forest regeneration is most pronounced in mid-hill districts, while high Himalayan districts show stable or declining forest cover due to ecological constraints
- Large protected areas continue to dominate the provincial landscape, maintaining core biodiversity values, while forests outside protected areas are expanding
- Ecological connectivity remains functionally intact, but increasingly stressed in corridor and interface zones

Impacts

Changes in the state of forests and biodiversity have multiple ecological and socio-economic impacts:

- Improved ecosystem services such as carbon sequestration, slope stabilization, and watershed regulation in forest-regenerating areas
- Loss and degradation of grassland-dependent ecosystems, affecting alpine biodiversity and traditional grazing systems
- Rising human–wildlife conflict, particularly in mid-hill districts where forest recovery overlaps with agricultural and settlement areas
- Increased pressure on corridor landscapes, with implications for wide-ranging species and long-term landscape connectivity
- Uneven distribution of conservation benefits, with stronger outcomes inside protected areas than in multi-use landscapes

Responses

Responses to forest and biodiversity challenges operate across multiple governance levels:

- Expansion and consolidation of community forestry: contributing to forest regeneration and local stewardship
- Protected area management and landscape-level conservation initiatives: maintaining core biodiversity and connectivity

- Provincial forest and environment legislation: providing an enabling framework for forest governance and biodiversity conservation
- Human–wildlife conflict mitigation measures**:** including compensation mechanisms and awareness programs
- Emerging focus on corridor conservation and climate-adaptive management**:** though implementation remains uneven
- Biodiversity monitoring and assessment efforts**:** stronger in protected areas than in municipal and corridor landscapes

Table 6-61. Forest and Biodiversity DPSIR Synthesis

DPSIR Element	Key Synthesis Points
Drivers	Socio-economic transition and rural outmigration; infrastructure development (roads, hydropower, tourism); changing land-use practices; climate change; long-standing forest and conservation policies
Pressures	Habitat fragmentation and edge effects; conversion and decline of grasslands and rangelands; increased human–wildlife interaction; forest fire risk and invasive species spread; localized extraction and grazing pressure
State	Net forest increase of about 543 km² (+7.3%) between 2010 and 2022, concentrated in mid-hill districts; grassland decline of about 2,685 km² (−61%), most pronounced in high Himalayan and trans-Himalayan districts; large protected areas remain intact but multi-use landscapes are under increasing pressure
Impacts	Improved forest-based ecosystem services (carbon storage, watershed regulation, slope stability); degradation of grassland-dependent ecosystems; rising human–wildlife conflict; increasing stress on north–south ecological corridors; uneven conservation outcomes between protected and non-protected areas
Responses	Community forestry and protected area management; provincial forest and environment legislation; corridor-focused conservation initiatives; human–wildlife conflict mitigation measures; biodiversity monitoring and assessment efforts, with variable coverage

6.5.11 Baseline Indictors, State and Trend

The forest and biodiversity indicator baseline for Gandaki Province is developed to provide a quantitative reference for assessing current conditions and long-term change in forest cover, grassland extent, and associated biodiversity systems. The indicators (**Table 6-62**) are based on district-wise land-cover data for 2010 and 2022, and are designed to capture extent, spatial distribution, and directional trends across the province's diverse physiographic zones. Over the period, Gandaki Province recorded a net increase of approximately 543 km² of forest area (about 7.3%), alongside a substantial decline in grassland area of about 2,685 km² (around 61%). Forest expansion was concentrated in the mid-hill districts, while grassland reduction was most pronounced in the high Himalayan and trans-Himalayan districts. Together, these indicators establish a baseline for tracking changes in ecosystem condition, evaluating pressures on forest and biodiversity systems, and informing future planning and management interventions.

Table 6-62. Forest and Biodiversity Indicators

Indicator	Baseline	Current State	Trend	Interpretation
Total forest area (11 districts)	7,512.48 km² (FRTC, 2024)	8,145.48 km² (FRTC, 2024)	Increasing (+~3%)	Strong net forest gain driven by regeneration and community forestry
Forest area – mid-hill districts	6,571.56 km² (2010)	7,203.06 km² (2022)	Increasing	Mid-hills are the main contributors to forest recovery
Forest area – high Himalayan districts	159.86 km² (2010)	143.00 km² (2022)	Slightly decreasing	Ecological constraints limit forest expansion

Indicator	Baseline	Current State	Trend	Interpretation
Total grassland area	4,433.54 km² (2010)	1,748.87 km² (2022)	Strongly decreasing (−60.6%)	Structural shift toward woody ecosystems
Forest-to-grassland ratio	1.67 : 1 (2010)	4.55 : 1 (2022)	Increasing	Transition toward forest-dominated landscapes
Protected area coverage	~45% of provincial area	~45% (stable)	Stable	Large conservation landscapes maintain core biodiversity
Forest fire incidence (events/year)	~450–500 (≈2010)	~900–1,100 (2022)	Increasing	Rising fire risk degrades forest quality
Degraded forest area	5,417 ha (2015)	~5,700 ha (2022)	Gradually increasing	Quality decline despite forest expansion
Area under community forestry	272,513 ha (2015)	283,073 ha (2025)	Increasing	Community forests are the backbone of forest stewardship
Number of community forest user groups (CFUGs)	3,840 (2015)	3,972 (2025)	Increasing	Strong institutional coverage at landscape scale
Human–wildlife conflict (human casualties)	13 cases (2015)	~18 cases (2022)	Increasing	Interface pressure between forests and settlements
Human–wildlife conflict (livestock loss)	498 cases (2015)	~740 cases (2022)	Increasing	Rising livelihood impacts
Snow leopard population (national estimate; Gandaki core habitat)	Presence-confirmed	392–629 (2022)	Likely stable	Gandaki is a key national stronghold
Tiger population (buffer zone)	Limited presence (2010)	Stable–increasing (2022)	Stable	Provincial role focused on connectivity and coexistence

Note: 1) Community forestry indicators are derived from provincial administrative records and reflect governance and stewardship responses rather than direct ecological outcomes. 2) Baseline years differ across indicators due to data availability.

6.5.12 Observed Trends, Risks, and Targeted Actions

Observed Trends (Evidence-based)	Key Risks	Targeted Actions
Net forest increase of ~543 km² (2010–2022), concentrated in mid-hill districts	Forest expansion occurs without coordinated land-use planning, increasing edge effects and encroachment near settlements	Integrate forest conservation into municipal land-use plans and infrastructure screening to manage forest–settlement interfaces
Sharp decline in grassland area (~2,685 km²; −61%), especially in high Himalayan and trans-Himalayan districts	Loss of grassland-dependent biodiversity and reduced viability of pastoral livelihoods	Develop targeted grassland and rangeland management plans for high-altitude districts; recognize grasslands as priority ecosystems
Forest regeneration outside protected areas is increasing	Conservation outcomes become uneven due to variable municipal capacity and weak monitoring	Strengthen technical support to municipalities and community forest user groups; standardize monitoring outside protected areas
Ecological connectivity remains functional but under pressure from roads and settlements	Fragmentation of north–south wildlife corridors and increased human–wildlife conflict	Identify and protect critical corridor segments through zoning, incentives, and integration into infrastructure planning
Rising human–wildlife interactions in regenerating forest landscapes	Increased crop damage, livestock loss, and safety risks for communities	Scale up conflict mitigation measures, early warning systems, and compensation mechanisms in hotspot municipalities

Observed Trends (Evidence-based)	Key Risks	Targeted Actions
Increasing forest fire and invasive species risk under changing climate conditions	Degradation of forest quality and biodiversity loss despite stable or increasing forest area	Implement fire risk management, invasive species control, and climate-adaptive forest management practices
Biodiversity monitoring remains uneven across districts and elevation zones	Limited capacity to detect ecosystem degradation or respond proactively	Establish a standardized forest and biodiversity indicator set for periodic SoE updates and provincial planning

6.5.13 Recommendations

Based on observed trends in forest expansion, grassland decline, biodiversity pressures, and governance challenges, the following recommendations are proposed to strengthen forest and biodiversity management in the Province. These recommendations emphasize integrated landscape management**,** institutional coordination, and adaptive planning, consistent with the State of Environment analytical framework.

1. Strengthen Integrated Landscape and Land-use Planning

Forest and biodiversity conservation should be more explicitly integrated into provincial and municipal land-use planning processes. While forest cover has increased in many mid-hill districts, uncoordinated infrastructure development and settlement expansion continue to fragment habitats and stress ecological corridors. Provincial and local governments should ensure that roads, hydropower projects, urban expansion, and tourism infrastructure are planned using landscape-scale environmental screening, with specific attention to forest continuity, wildlife movement pathways, and grassland ecosystems.

2. Balance Forest Regeneration with Grassland and Rangeland Conservation

The substantial decline in grassland area, particularly in high Himalayan and trans-Himalayan districts, highlights the need for a more balanced ecosystem management approach. Conservation strategies should recognize grasslands and alpine rangelands as ecologically important systems, not merely as transitional land uses. Targeted management plans are needed to prevent excessive shrub and forest encroachment in key grazing areas, while supporting sustainable pastoral practices and biodiversity associated with open habitats.

3. Enhance Protection and Management of Ecological Corridors

Gandaki Province plays a critical role in maintaining north–south ecological connectivity between lowland river valleys, mid-hills, and high mountain ecosystems. Corridor areas outside protected areas require focused attention through coordinated action among municipalities, community forest user groups, and provincial agencies. Measures such as land-use zoning, incentive-based conservation, and integration of corridor considerations into infrastructure planning are essential to maintain long-term connectivity and reduce human–wildlife conflict.

4. Improve Forest and Biodiversity Monitoring Systems

Although forest extent has increased, **systematic biodiversity monitoring remains uneven**, particularly outside protected areas. The province should strengthen monitoring of forest condition, grassland extent, wildlife movement, invasive species, and forest fires using a combination of remote sensing and field-based data. Establishing a **s**tandardized indicator set for periodic State of Environment updates will improve evidence-based decision-making and allow early detection of emerging risks.

5. Strengthen Institutional Capacity at Provincial and Local Levels

Effective implementation of forest and biodiversity policies requires enhanced technical, financial, and human capacity, especially at the municipal level. Provincial institutions should provide targeted technical support to local governments on forest management planning, corridor protection, human–wildlife conflict mitigation, and climate-adaptive conservation. Strengthening coordination between provincial forest offices and municipalities is particularly important in rapidly changing mid-hill and peri-urban landscapes.

6. Integrate Climate Change Adaptation into Forest and Biodiversity Management

Observed changes in forest and grassland distribution underscore the growing influence of climate change on ecosystem dynamics. Conservation and forest management strategies should explicitly incorporate climate adaptation, including flexible management of forest–grassland boundaries, fire risk management, and protection of climate refugia across elevation gradients. Adaptive planning will be essential to sustain biodiversity and ecosystem services under increasing climatic uncertainty.

7. Promote Community-based and Incentive-driven Conservation Approaches

Community forestry has played a central role in forest recovery across Gandaki Province and should continue to be strengthened. Incentive mechanisms that reward conservation outcomes such as maintaining corridor forests or protecting grasslands—can further align local livelihoods with biodiversity objectives. Ensuring equitable benefit-sharing and local participation will enhance the sustainability of conservation efforts beyond protected areas.

6.6 Urban Environment and Waste Management

6.6.1 Background

Situated in the central of the country, Gandaki Province, is distinguished by its diverse geography, rich cultural heritage, and significant economic activities. The province spans multiple ecological zones, ranging from the low-lying Terai plains to the high Himalayan region, creating a complex setting for both urban and rural development. Urban areas in Gandaki are shaped by a coexistence of long-standing traditional practices and expanding modern infrastructure, reflecting the pressures and opportunities of rapid urbanization. These urban environments also face growing environmental challenges, including land-use change and resource stress. At the same time, Gandaki's municipalities are increasingly seeking pathways that balance economic growth, cultural preservation, and environmental sustainability.

Historically, settlements in the Province were characterized by small market centres embedded within predominantly agrarian landscapes. Over the past decade, district headquarters municipalities have become the principal nodes of urban growth, driven by administrative restructuring, improved road connectivity, concentration of services, tourism development, and land-market pressures. This has resulted in a predominantly horizontal pattern of urban expansion, where built-up areas spread outward into surrounding peri-urban land rather than densifying within existing urban cores. Land-use data for 2010–2022 show that built-up areas have increased in all district headquarters municipalities. The magnitude of change varies widely, from metropolitan-scale expansion in Pokhara to smaller but consistent growth in hill and mountain towns. Importantly, built-up expansion has continued even in municipalities where population growth has been modest or negative, indicating that urban spatial growth is not solely driven by demographic change, but also by economic restructuring and changing settlement preferences.

6.6.2 Districts and Municipalities

Administratively, Gandaki Province consists of 11 districts and 85 municipalities (**Figure 2-2***Figure 2-2*), including both urban (sub-metropolitan and metropolitan) municipalities (27) and rural municipalities (58) (***Figure 6-31***). The provincial capital, Pokhara, is one of Nepal's most important tourism, economic, and environmental hubs. Notably, the headquarters of these districts play a crucial role in the governance and development of the urban environments in the province.

1. Baglung District contains 10 local units out of which 4 are urban. Baglung Municipality, the district headquarters, is strategically located along trade routes, contributing to its significance as a commercial center.

2. Gorkha District is divided into 11 local units (2: Urban and 9 Rural). The headquarters, Gorkha Municipality, is historically significant as the origin of the Shah kings. It features a blend of traditional architecture and modern services, surrounded by stunning natural landscapes.
3. Kaski District is divided into 5 municipalities (1 Metropolitan and 4 Rural). Pokhara Metropolitan City, the capital of Kaski and also the province, is not only a hub for tourism but also a growing center for trade, education, and health services, boasting well-developed infrastructure.
4. Lamjung District is divided into 8 local units. Beshishahar Municipality serves as the district headquarters, known for its picturesque scenery and as the gateway to the Annapurna Circuit, blending cultural richness with natural beauty.
5. Manang District contains four local units, all of them are rural municipalities. Chame, the district headquarters, offers a unique urban environment influenced by Tibetan culture, with its communities engaged in agriculture and tourism.

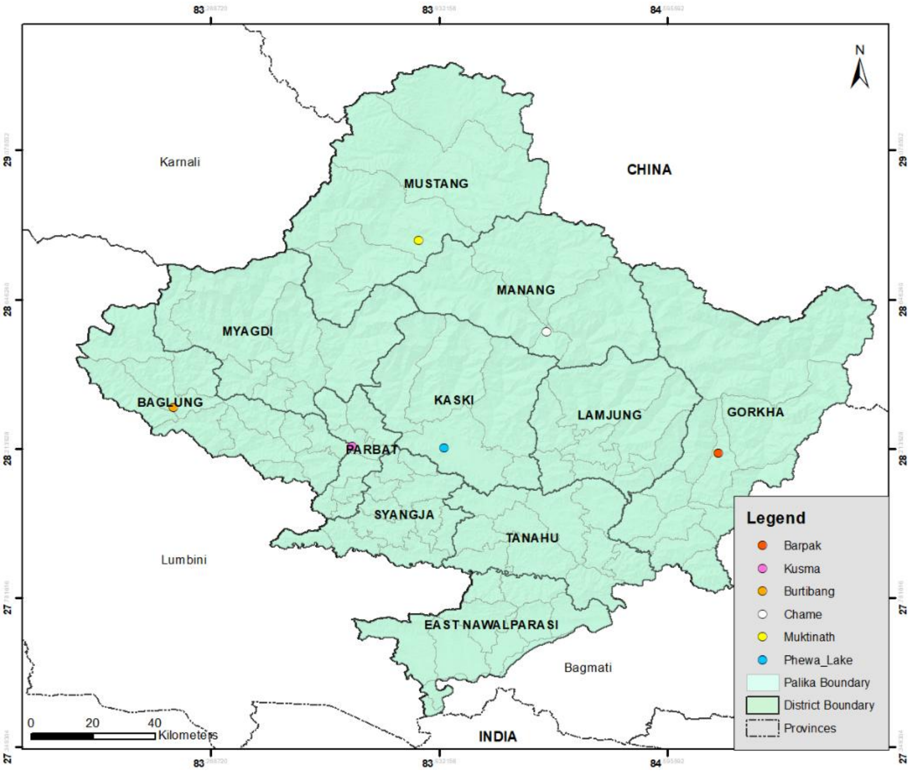


Figure 6-30. Districts of Gandaki Province

6. Myagdi District has 6 local units out of which one is Urban Municipality. Beni, the district headquarters, serves as a key point for tourism and agriculture, nestled in the beautiful Annapurna region and promoting local traditions.
7. Mustang District comprises five rural municipalities. Jomsom, as the headquarters located at a crucial point for trekkers and a center for trade, showcasing a distinct cultural heritage influenced by its Tibetan roots.
8. Nawalparasi-East (also called Nawalpur) District is located in the southern section of the province comprises eight local units out of which 4 are Urban Municipalities. Kawasoti Municipality serves as a transitional urban area, promoting agricultural and commercial development along the East-West Highway.
9. Parbat District contains seven local units out of which 2 are urban municipalities. Kushma Municipality is known for its stunning natural beauty and the Kushma Cave, attracting both tourists and locals with its cultural and geological significance.

10. Syangja District is divided into 11 local units (5 Urabn and 6 Rural)**.** The town of Syangja acts as the administrative center, promoting agriculture and local crafts while preserving its rich cultural heritage.
11. Tanahu District has 10 local units (4 Urban and 6 Rural). Damauli, the district headquarters, is evolving into an urban center, balancing traditional lifestyles with new development initiatives.

The district headquarters of all districts in Gandaki have achieved urban municipality status, except for the two mountainous districts of Manang and Mustang. Currently, the headquarters of Chame Rural Municipality and Gharapjhong Rural Municipality retain their status as rural municipalities. To enhance local governance and development, it is recommended that the headquarters of these two mountain districts be designated as special urban municipalities. This change would facilitate improved infrastructure, access to essential services, and targeted development initiatives, ultimately supporting the unique needs of these communities while preserving their cultural heritage and natural environment. Upgrading their status could also boost tourism and economic opportunities in these scenic areas.

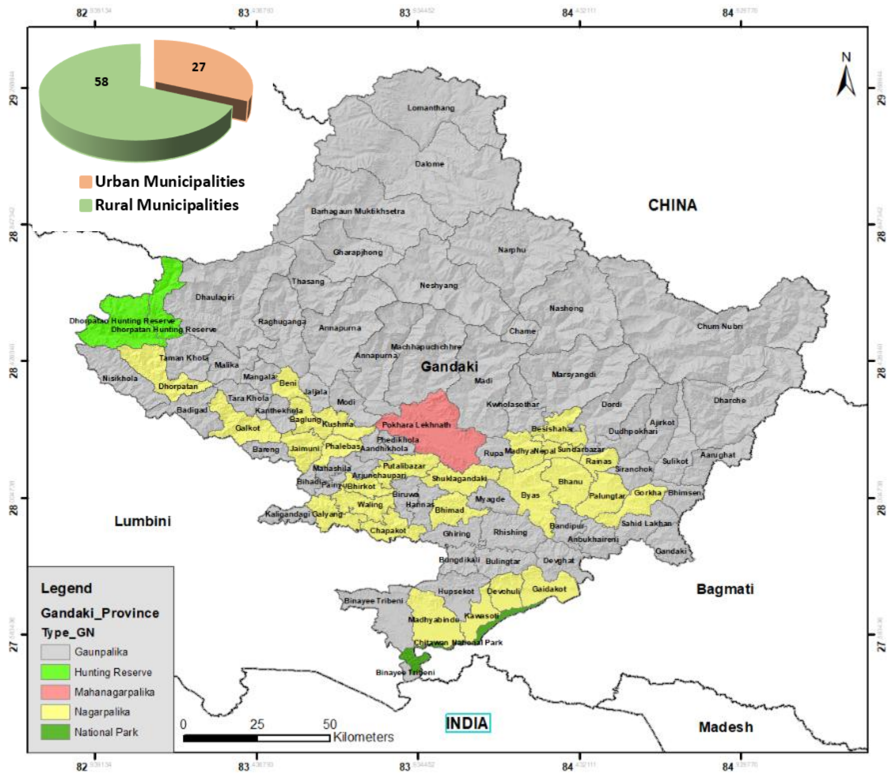


Figure 6-31. Distribution of Urban - Rural Municipality of Gandaki Province

The rural-urban municipality classification indicates that approximately 32% of municipalities are urban, while a substantial 68% remain rural municipalities, suggesting a predominance of rural governance and lifestyles in the province. The list of the Urban Municipalities including one Metropolitan city is shown in in figure (**Figure 6-31**).

6.6.3 Urban Population Dynamics and Landuse Changes

Population dynamics: uneven growth and decoupling from spatial expansion

Urban population change in the Province over the last decade has been highly uneven across district headquarters municipalities **(*Figure 6-32*)**. While some centres experienced rapid population growth, others recorded stable or declining populations. This uneven demographic pattern is important because urban land expansion has continued even where population growth is weak or negative, indicating that urbanisation in Gandaki is not driven by population increase alone.

Between 2011 and 2021, Pokhara Metropolitan City recorded strong population growth, reinforcing its role as the province's primary urban centre. Kawasoti Municipality also experienced rapid population increase, reflecting Inner-Terai in-migration and corridor-based development. In contrast, several hill headquarters such as Baglung, Kusma, Besishahar, Putalibazar, and Beni experienced stagnant or declining populations, yet still expanded spatially.

This decoupling between population growth and land-use change suggests that economic restructuring, administrative functions, service concentration, housing preferences, and land-market dynamics are key drivers of urban expansion, particularly in secondary and hill towns.

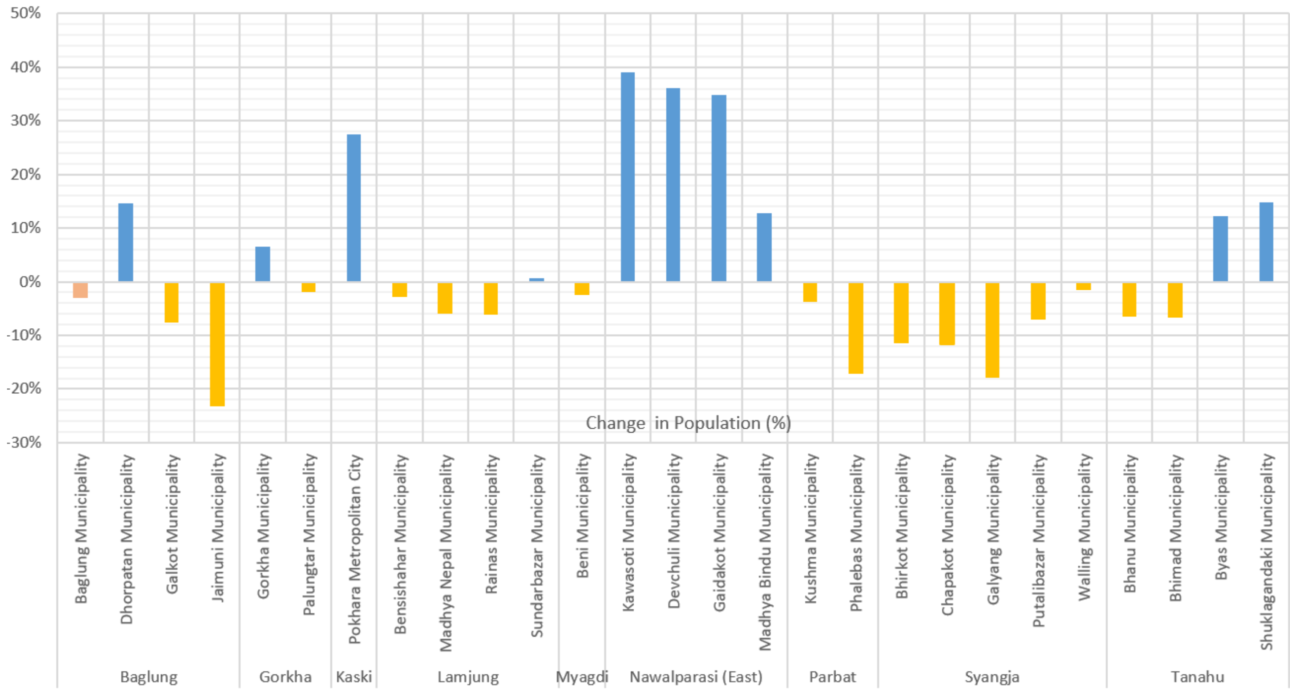


Figure 6-32. Change in Urban Municipality Population (CBS 2011 to CBS 2021)

Review of land-use for 2010–2022 (FRTC, 2024; MOALD, 2025; MOFE, 2026) shows a systematic increase in built-up land in all 11 district headquarters municipalities **(*Table 6-63*)**. The scale of expansion varies widely:

- Pokhara exhibits metropolitan-scale growth, with a dramatic increase in built-up area.
- Kawasoti shows the second-highest expansion, rapidly transforming into a highly urbanised Inner-Terai town.
- Secondary hill headquarters show smaller absolute increases (typically 1–9 km^2), but these changes are environmentally significant due to steep terrain, proximity to rivers, and limited infrastructure.

Even municipalities with very small urban cores in 2010 (e.g., Kusma, Putalibazar, Besishahar) have recorded multi-fold increases in built-up land, indicating structural urban transition rather than incremental infill**.**

Table 6-63. Change in Built Up Area in the District Headquarter (Municipality) of Gandaki Province

District	Municipality (HQ)	Total area (km²)	Built-up 2010 (km²)	Built-up 2010 (%)	Built-up 2022/24 (km²)	Built-up 2022/24 (%)	Δ Built-up (km²)
Gorkha	Gorkha	139.86	2.55	1.80%	6.48	4.60%	3.93
Lamjung	Besishahar	127.64	0.67	0.50%	2.92	2.30%	2.25
Tanahun	Byas (Damauli)	248	0.33	0.10%	9.28	3.70%	8.95
Syangja	Putalibazar	147.29	0.16	0.10%	2.33	1.60%	2.17
Kaski	Pokhara (Metro)	464.24	7.88	1.70%	91.51	19.70%	83.63
Manang	Chame	78.86	0.02	0.03%	0.2	0.25%	0.18
Mustang	Gharapjhong (Jomsom)	316	3.53	1.10%	8.7	2.80%	5.17
Myagdi	Beni	76.57	0.33	0.40%	1.81	2.40%	1.48
Parbat	Kusma	93.18	0.29	0.30%	2.73	2.90%	2.44
Baglung	Baglung	98.01	0.41	0.40%	3.51	3.60%	3.1
East Nawalparasi	Kawasoti	108.36	0.39	0.40%	26.62	24.60%	26.23

Sources: FRTC 2024 and ICIMOD 2024

Across all district headquarters, loss of agricultural land is the dominant land-use change between 2010 and 2022 (FRTC, 2024; MOALD, 2025; MOFE, 2026). In most municipalities, agricultural land loss far exceeds built-up gain, reflecting conversion not only to settlements but also to roads, institutions, and associated infrastructure. This pattern confirms that urban expansion in Gandaki Province is agriculture-driven rather than forest-driven. From an urban environmental perspective, this transition has several implications:

- Reduction of peri-urban open space and infiltration areas
- Loss of traditional organic waste reuse pathways
- Increased dependence on municipal service systems
- Greater surface runoff and pollution transport to rivers

Forest cover, by contrast, has remained broadly stable or increased in most municipalities, reflecting community forestry and regeneration on abandoned terraces rather than direct urban encroachment.

Table 6-64. Population Change and Land-use Transition in the District Headquarter (CBS, 2011; CBS, 2021a; FRTC, 2024)

District HQ Municipality	Population Change 2011→2021	Built-up Increase 2010→2022 (km²)	Agricultural Land Change (km²)	Key Urban-environment Signal
Pokhara (Metro)	27%	83.63	−192.27	Metropolitan expansion; very high urban pressure
Kawasoti	~+39%	26.23	−35.10	Fastest Inner-Terai growth; floodplain sensitivity
Byas (Damauli)	12%	8.95	−50.50	Rapid peri-urban expansion; agri + forest pressure
Baglung	−3%	3.1	−42.72	Urban growth without population growth
Gorkha	5%	3.93	−33.99	Moderate growth; river-slope sensitivity

District HQ Municipality	Population Change 2011→2021	Built-up Increase 2010→2022 (km²)	Agricultural Land Change (km²)	Key Urban-environment Signal
Kusma	−4%	2.44	−38.89	Compact growth; sharp agri loss
Besishahar	−3%	2.25	−44.15	Spatial expansion despite demographic decline
Putalibazar	−7%	2.17	−36.42	Urban consolidation under population loss
Beni	−2%	1.48	−36.76	Service-centre expansion; river corridor risk
Gharapjhong (Jomsom)	+23%*	5.17	−3.31	Tourism-driven growth; high ecological sensitivity
Chame	+13%*	0.18	−1.15	Very small scale; low volume, high vulnerability

**Population figures for mountain municipalities are based on CBS census and local-level summaries; seasonal variation due to tourism is significant.*

These trends show that urbanization in Gandaki Province is spatially widespread but demographically uneven**.** District headquarters municipalities are expanding physically regardless of whether their populations are growing, stable, or declining. The consistent conversion of agricultural land around urban cores indicates that land-use change, rather than population pressure alone, is the key driver shaping the urban environment**.** This dynamic sets the stage for rising environmental pressure particularly waste generation and management challenges.

Built-up Areas and Urban Waste Production

The expansion of built-up areas across district headquarters municipalities is the most visible physical manifestation of urbanization in the Province. Between 2010 and 2022, all 11 district headquarters recorded increases in built-up land, ranging from marginal growth in high-mountain towns to metropolitan-scale expansion in Pokhara (FRTC, 2024). This spatial expansion has direct implications for waste production. As built-up land increases, residential density, commercial activity, institutional presence, and service functions also expand, leading to higher volumes of municipal solid waste (MSW). Importantly, waste generation increases not only with population growth, but also with changes in land use and consumption patterns associated with urban lifestyles.

The relationship between built-up expansion and waste production is particularly clear in:

- Pokhara Metropolitan City, where large-scale built-up expansion coincides with very high daily waste generation.
- Kawasoti Municipality, where rapid spatial growth in an Inner-Terai setting has resulted in rising waste volumes despite its smaller population compared to Pokhara.
- Secondary hill headquarters, where even modest built-up expansion has led to noticeable increases in waste pressure due to limited treatment and disposal capacity.

Estimated Municipal solid waste generation in district headquarters

Date obtained from census (CBS, 2021a) and nationally accepted urban waste-generation coefficients according to the CBS (2020a) in Waste Management Baseline Survey, 2020, district headquarters municipalities in Gandaki Province are estimated to generate several hundred tonnes of municipal solid waste per day. Waste generation is highly uneven across municipalities:

- Pokhara Metropolitan City alone generates over 230 tonnes per day, accounting for the majority of urban waste in the province.
- Kawasoti Municipality generates approximately 40–45 tonnes per day**,** reflecting higher per-capita waste generation typical of Inner-Terai urban centres.
- Secondary hill headquarters such as Byas (Damauli), Baglung, and Gorkha generate 15–30 tonnes per day each.
- Smaller hill and mountain headquarters generate lower absolute volumes, but often face greater environmental risk per unit of waste due to fragile terrain and limited infrastructure.

This pattern shows that waste pressure does not scale linearly with population size alone; instead, it reflects a combination of built-up expansion, economic activity, and urban form. The table below presents the waste production in the district headquarter of the province.

Table 6-65. District Headquarter Municipality-Daily Generation of Wastes

District	Municipality (HQ)	Population 2021	Rate (kg/cap/day)	Waste (t/day)	Waste (t/year)
Baglung	Baglung	56,102	0.35	19.6	7,154
Gorkha	Gorkha	52,468	0.35	18.4	6,716
Kaski	Pokhara (Metro)	513,504	0.45	231.1	84,360
Lamjung	Besishahar	38,232	0.35	13.4	4,891
Tanahun	Byas (Damauli)	78,939	0.35	27.6	10,074
Myagdi	Beni	32,697	0.35	11.4	4,152
Parbat	Kusma	38,101	0.35	13.3	4,846
Syangja	Putalibazar	41,743	0.35	14.6	5,329
Nawalpur (East)	Kawasoti	~58,003	0.5	29	10,586
Manang	Chame	~1,700*	0.2	0.34	124
Mustang	Gharapjhong (Jomsom)	~7,000*	0.2	1.4	511

**Population rounded from CBS RM/municipality figures due to seasonal fluctuation and tourism.*

Waste composition and implications for the urban environment

Across Gandaki Province, the composition of municipal solid waste closely follows national urban patterns. According to the Waste Management baseline Survey of Nepal (CBS, 2020b):

- Organic (biodegradable) waste constitutes approximately 60–70% of the total waste stream.
- Plastics account for 15–20%, making them the most problematic non-biodegradable fraction.
- Paper, glass, metal, and other materials make up the remainder.

This composition has important environmental implications. The dominance of organic waste means that untreated waste rapidly decomposes, creating odour, attracting vectors, and generating leachate that contaminates soil and water. Plastics, on the other hand, persist in the environment and are easily transported into rivers and drainage systems, particularly during monsoon periods.

Table 6-66. Types of Municipal Waste (Estimated) Production in District Headquarters of Gandaki Province

Municipality	Total waste (t/day)	Organic (t/day)	Plastic (t/day)	Paper (t/day)	Others (t/day)
Baglung	19.6	12.7	3.5	2	1.4
Gorkha	18.4	12	3.3	1.8	1.3
Pokhara (Metro)	231.1	150.2	41.6	23.1	16.2

Municipality	Total waste (t/day)	Organic (t/day)	Plastic (t/day)	Paper (t/day)	Others (t/day)
Besishahar	13.4	8.7	2.4	1.3	0.9
Byas (Damauli)	27.6	17.9	5	2.8	1.9
Beni	11.4	7.4	2.1	1.1	0.8
Kusma	13.3	8.6	2.4	1.3	0.9
Putalibazar	14.6	9.5	2.6	1.5	1
Kawasoti	29	18.9	5.2	2.9	2
Chame	0.34	0.22	0.06	0.03	0.02
Gharapjhong	1.4	0.91	0.25	0.14	0.1

Sources: Estimate based on CBS, 2020 and Population of the Municipality.

In hill and mountain municipalities, where settlements are often located along narrow valleys and river terraces, even small volumes of unmanaged waste can result in disproportionate downstream pollution. In floodplain municipalities such as Kawasoti, plastic waste is easily mobilised during high-flow events, increasing risks to river systems and urban drainage.

District headquarters municipalities of the Province together generate several hundred tonnes of municipal solid waste daily, with Pokhara Metropolitan City alone accounting for the dominant share due to its large population and metropolitan consumption patterns. Hill district headquarters such as Baglung, Gorkha, Byas, and Kusma generate moderate daily waste volumes (10–30 t/day), while Inner-Terai Kawasoti shows higher per-capita waste generation reflecting highway-oriented urbanization. Across all municipalities, organic waste constitutes roughly two-thirds of the waste stream, indicating strong potential for composting-based diversion, while plastics form a significant secondary fraction posing risks to river systems and drainage infrastructure.

6.6.4 District Head Quarter Municipality Profile

Pokhara Metropolitan City

Pokhara Metropolitan City exhibits the highest urban environmental pressure in Gandaki Province. Rapid expansion of built-up land across the Pokhara Valley since 2010 reflects metro-politanization following administrative expansion, infrastructure investment, tourism growth, and real-estate development. Agricultural land loss has been substantial, while forest cover has remained broadly stable, confirming that urban growth has occurred primarily through conversion of cultivated valley-floor land rather than deforestation.

Waste generation has increased sharply with population growth and spatial expansion. Pokhara now produces several hundred tonnes of waste daily, dominated by organic material but with a large plastic fraction that poses risks to lakes and river systems. Despite improvements in collection, segregation and treatment capacity lag behind the scale of urban growth, making waste management one of Pokhara's most critical environmental challenges.

Key Statistics

- Population : 402,995 (2011) → 513,504 (2021) (+27.4%)
- Built-up area : 7.88 → 91.51 km² (+83.63 km²; 19.7% of area)
- Agricultural land : −192.27 km²
- Forest cover : ~50.3% (stable/slightly increasing)
- Waste generation : ~231 t/day (Organic ~150 t/day, Plastic ~42 t/day)

Critical waste challenges

- Scale mismatch between waste generation and treatment capacity
- Plastic leakage to lakes (Phewa, Begnas) and Seti River
- Heavy reliance on disposal rather than diversion

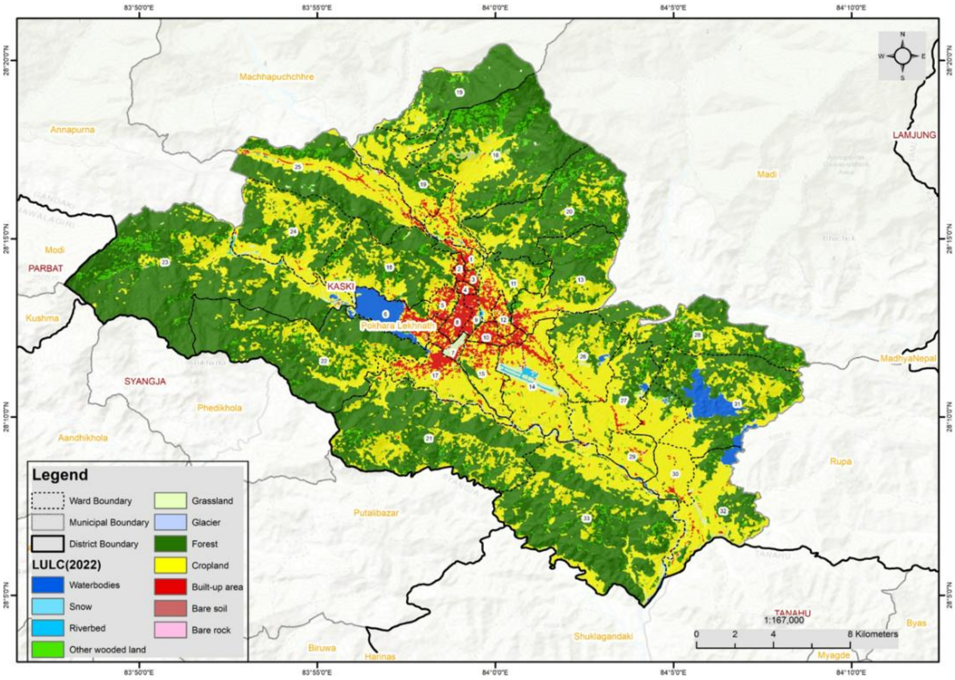


Figure 6-33. Pokhara Metropolitan City Landuse Map

Kawasoti Municipality

Kawasoti Municipality is one of the fastest-growing urban centres in Gandaki Province. Built-up land expansion has been extremely rapid, driven by highway-oriented development in the Inner-Terai and strong population growth between 2011 and 2021. Agricultural land loss has been significant, while forest cover has increased modestly, indicating a transition from farming to urban uses in the floodplain.

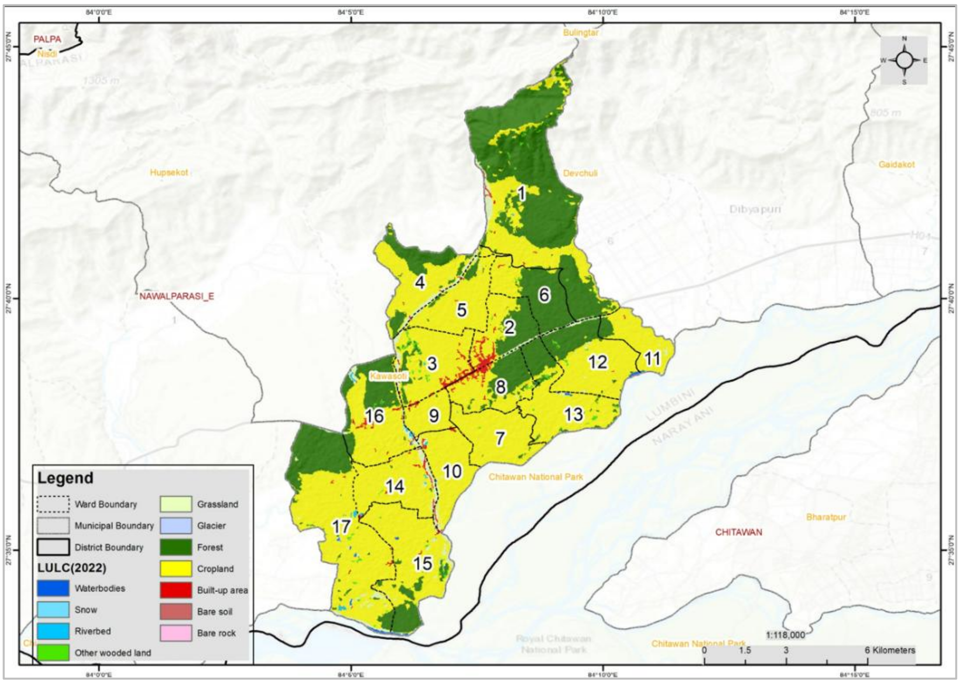


Figure 6-34. Landuse Map of Kawasoti Municipality in Nawalparasi-East (Nawalpur)

Urban expansion has sharply increased waste generation, with per-capita waste levels higher than in hill municipalities. Kawasoti's flood-prone setting amplifies environmental risks, as unmanaged waste can be mobilised during monsoon events and dispersed into rivers and drains. Early intervention is crucial to avoid long-term waste and drainage crises.

Key statistics

- Population : ~62,421 (2011) → ~86,821 (2021) (+~39%)
- Built-up area : 0.39 → 26.62 km² (+26.23 km²; 24.6% of area)
- Agricultural land : −35.10 km²
- Forest cover : ~31.7% (increasing)
- Waste generation : ~43 t/day (Organic ~28 t/day, Plastic ~8 t/day)

Critical waste challenges

- Urban growth outpacing waste infrastructure
- High flood and monsoon dispersion risk
- Limited organic waste treatment despite high potential

Byas Municipality

Byas Municipality is transitioning from a semi-rural service centre to a rapidly consolidating urban hub. Built-up land expansion along river terraces and transport corridors has been accompanied by population growth and significant agricultural land loss. Unlike many hill towns, Byas also shows a measurable decline in forest cover, reflecting infrastructure and settlement pressure within the broader municipal boundary.

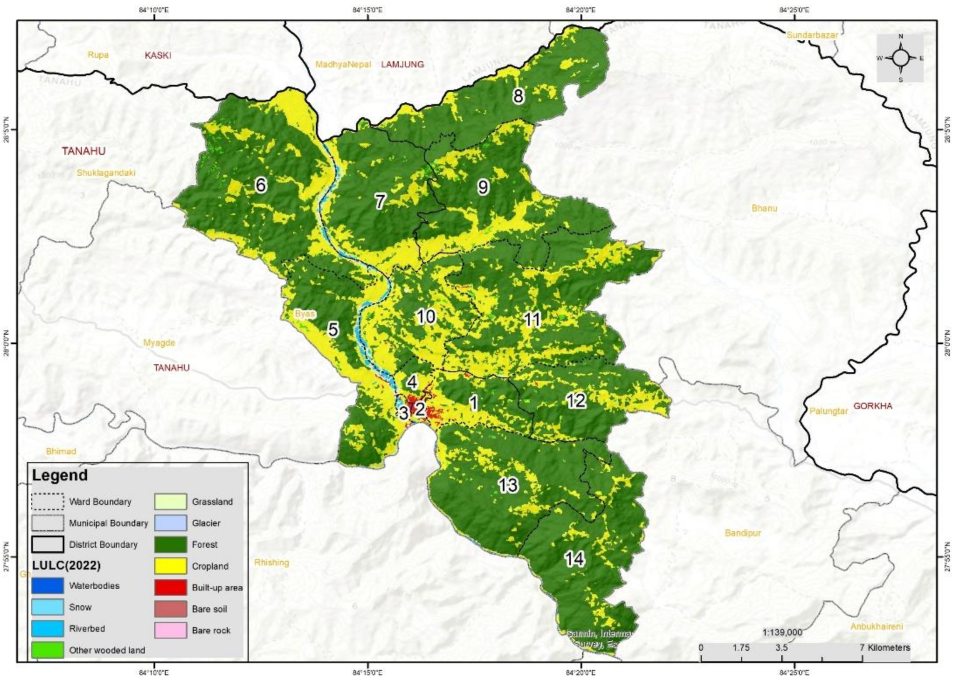


Figure 6-35. Landuse Map of Bays Municipality in Tanahu District

Waste generation has increased alongside urban growth, while the decline of surrounding agricultural land has reduced informal organic waste reuse. The municipality faces growing pressure on collection and disposal systems, underscoring the need for planned treatment facilities and stronger segregation practices.

Key statistics

- Population : 70,335 → 78,939 (+12.2%)
- Built-up area : 0.33 → 9.28 km² (+8.95 km²)
- Agricultural land : −50.50 km²
- Forest cover : ~66.6% (declining)
- Waste generation : ~27.6 t/day

Critical waste challenges

- Limited treatment and disposal facilities
- Loss of organic reuse pathways
- Growing waste concentration in peri-urban areas

Baglung Municipality

Baglung Municipality illustrates hill-town urbanisation without population growth. Built-up land expanded steadily despite population decline, driven by spatial reorganization and service-centre consolidation. Agricultural land loss has been substantial, while forest cover has remained stable due to community forestry and regeneration on abandoned terraces.

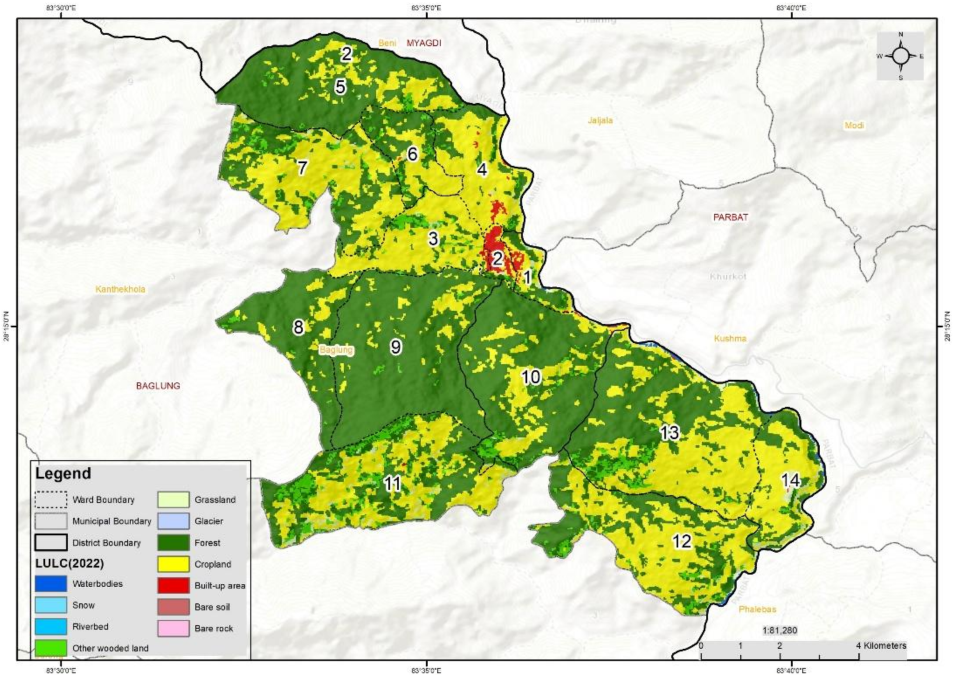


Figure 6-36. (Left) Baglung District and Municipality, (Right) Baglung Municipality, Indicating the District Headquarters on Open-Street Map

Baglung is one of the few municipalities with a measured waste-generation study, confirming relatively high per-capita waste and a dominant organic fraction. The municipality's steep terrain and proximity to the Kaligandaki River increase sensitivity to poor waste handling, making effective segregation and composting especially important.

Key statistics

- Population : 57,823 → 56,102 (−3.0%)
- Built-up area : 0.41 → 3.51 km² (+3.10 km²)
- Agricultural land : −42.72 km²
- Forest cover : ~48.1% (stable)
- Waste generation : ~24 t/day (measured rate 0.43 kg/cap/day)

Critical waste challenges

- Limited segregation and treatment of organic waste
- Riverbank pollution risk
- Terrain-related collection and disposal constraints

Gorkha Municipality

Gorkha Municipality has experienced moderate but consistent urban expansion since 2010. Built-up growth has occurred mainly near the municipal core and along access roads, while agricultural land has declined sharply. Forest cover remains high, indicating limited deforestation pressure.

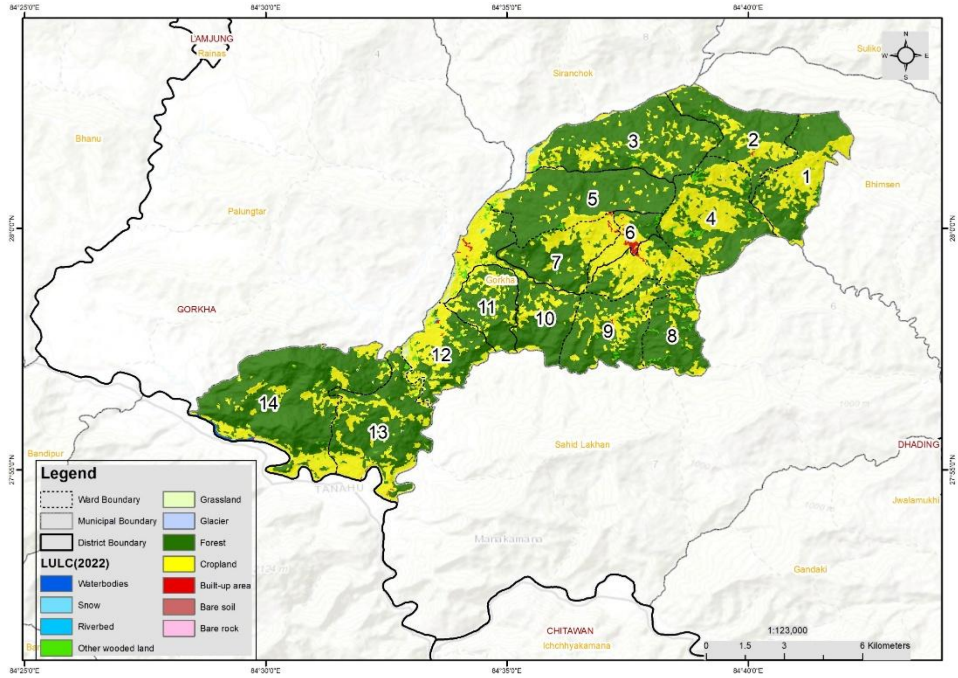


Figure 6-37. Landuse Map of Gorkha Municipality in Gorkha District

Waste generation is moderate in volume but environmentally significant due to slope conditions and river proximity. Studies indicate relatively low per-capita waste, but gaps in segregation and disposal increase the risk of informal dumping and burning.

Key statistics

- Population : 49,928 → 52,468 (+5.1%)
- Built-up area : 2.55 → 6.48 km² (+3.93 km²)
- Agricultural land : −33.99 km²
- Forest cover : ~59.3% (stable)
- Waste generation : ~12–18 t/day (measured ~0.24 kg/cap/day)

Critical waste challenges

- Incomplete collection and segregation coverage
- Informal dumping and burning
- Limited treatment infrastructure

Kusma Municipality

Kusma Municipality shows a pattern of small but impactful urban growth. Built-up land increased between 2010 and 2022, while agricultural land declined sharply despite a slight population decrease over the same period. This suggests that land-use change is driven by functional urban consolidation rather than population pressure. Forest cover has increased modestly, reflecting regeneration on marginal farmland.

Waste generation in Kusma remains moderate but concentrated in a compact urban area. The dominance of organic waste offers strong potential for decentralized composting, which could substantially reduce disposal needs. Given Kusma's river-terrace setting, failure to manage waste effectively would heighten risks to water quality and downstream environments.

Key statistics

- Population : 39,679 → 38,101 (−4.0%)
- Built-up area : 0.29 → 2.73 km² (+2.44 km²)
- Agricultural land : −38.89 km²

- Forest cover : ~55.3% (increasing)
- Waste generation : ~13 t/day

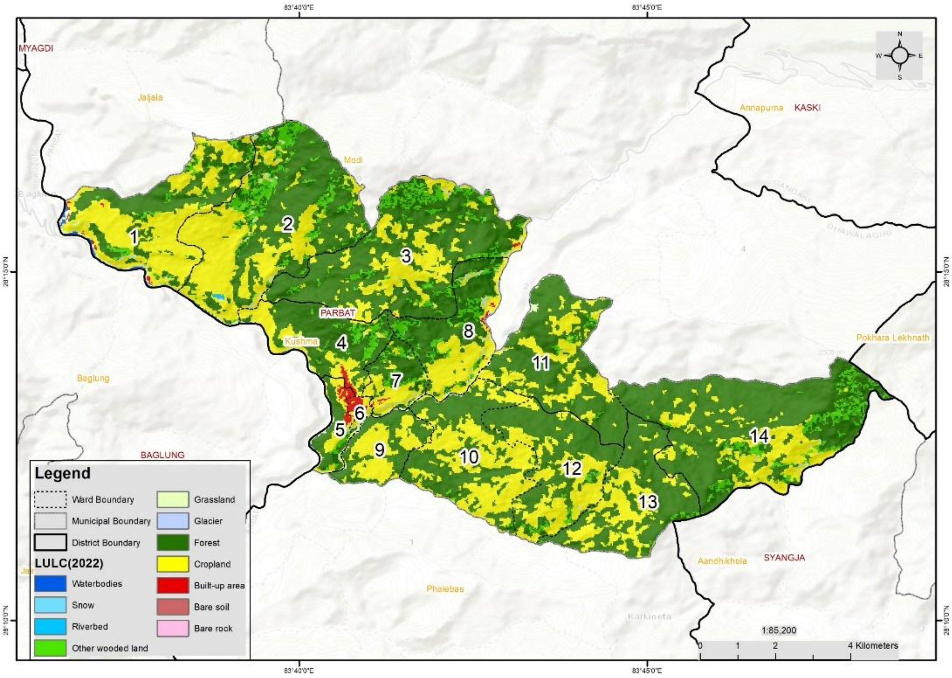


Figure 6-38. Landuse Map of Kusma Municipality in Parbat District

Critical waste challenges

- Concentrated waste generation in a compact area
- Limited composting and recycling capacity
- River and slope sensitivity

Besishahar Municipality

Besishahar Municipality has undergone noticeable land-use transformation despite a relatively stable or declining population. Built-up land increased between 2010 and 2022, while agricultural land declined steeply. Forest cover increased substantially, consistent with abandonment of marginal farmland and regeneration under community management.

Waste generation in Besishahar is moderate and increasingly urban in character. Although absolute volumes are lower than in larger towns, limited technical capacity poses challenges. Strengthening segregation and linking composting and recycling to regional systems would allow Besishahar to manage growth without escalating environmental pressure.

Key statistics

- Population : 39,356 → 38,232 (−2.9%)
- Built-up area : 0.67 → 2.92 km² (+2.25 km²)
- Agricultural land : −44.15 km²
- Forest cover : ~70.1% (increasing)
- Waste generation : ~13 t/day

Critical waste challenges

- Limited technical capacity
- Weak segregation and composting systems
- Dependence on disposal

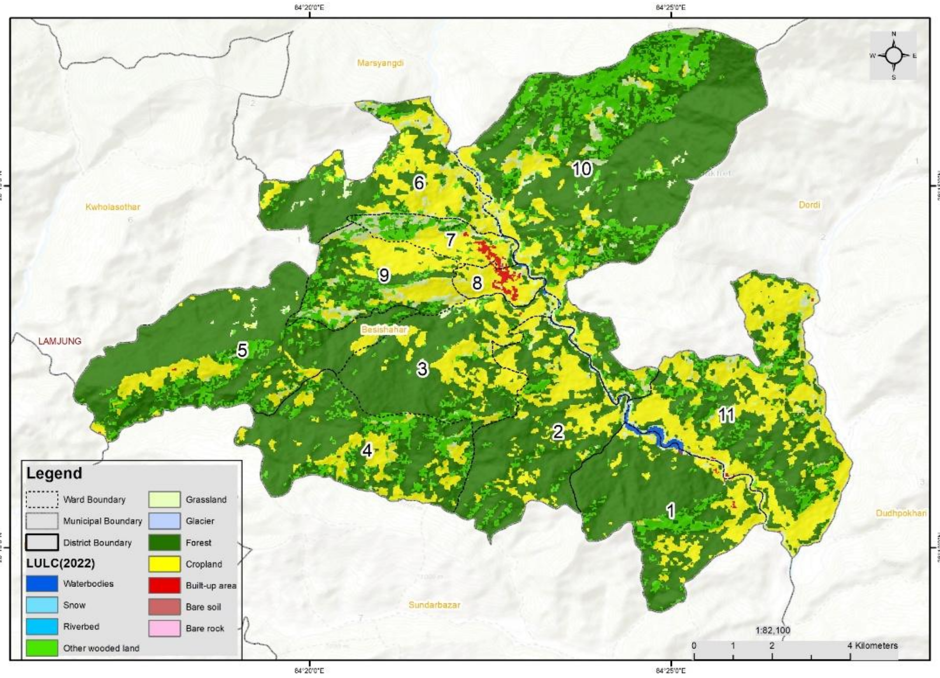


Figure 6-39. Landuse Map of Besishar Municipality in Lamjung District

Putalibazar Municipality

Putalibazar Municipality illustrates urban expansion under demographic stagnation. Built-up land increased between 2010 and 2022/24 even as population declined, indicating a spatial spread of urban functions. Agricultural land loss was substantial, while forest cover declined slightly, reflecting development pressure near the municipal core.

Waste generation remains moderate but increasingly urbanized, with rising plastic and packaging waste. Given Putalibazar's limited waste infrastructure, unmanaged waste poses risks to drainage and nearby watercourses. Improving segregation and low-cost organic treatment is essential to stabilise environmental conditions as land-use change continues. Waste management challenges stem from limited infrastructure and increasing plastic waste, posing risks to drainage and water bodies.

Key statistics

- Population : 44,876 → 41,743 (−7.0%)
- Built-up area : 0.16 → 2.33 km² (+2.17 km²)
- Agricultural land : −36.42 km²
- Forest cover : ~68.3% (slight decline)
- Waste generation : ~15 t/day

Critical waste challenges

- Plastic accumulation
- Inconsistent segregation
- Drainage and river pollution risk

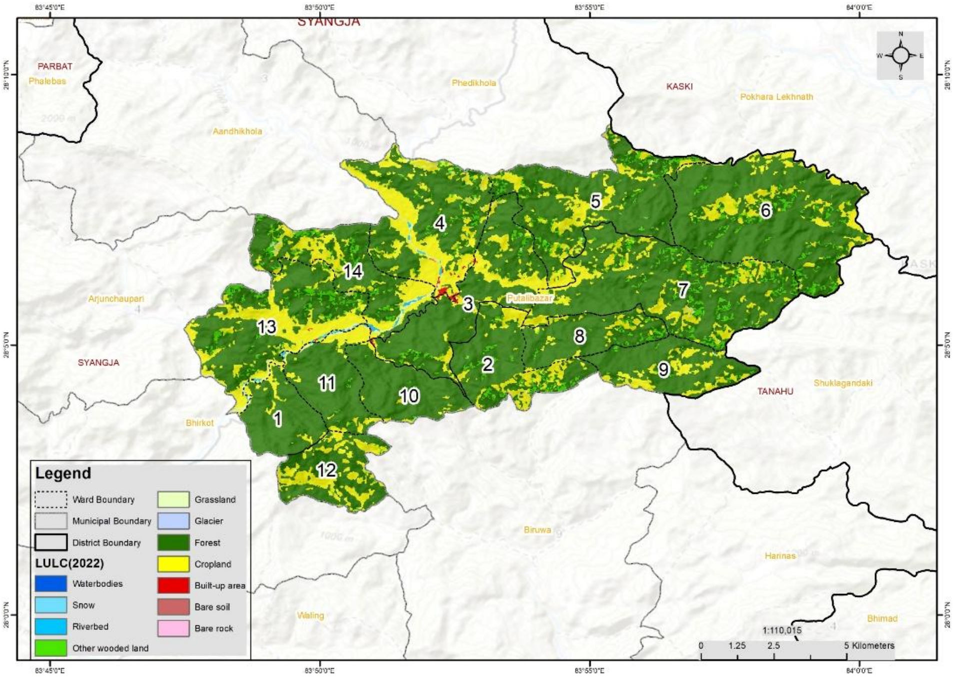


Figure 6-40. Landuse Map of Putalibazaar Municipality in Syangja District

Beni Municipality

Beni Municipality has experienced incremental urban growth, with built-up land expanding modestly between 2010 and 2022/24. Population declined slightly over the decade, but agricultural land loss was substantial, indicating land-use transition driven by service-centre consolidation. Forest cover increased, reflecting regeneration on abandoned land. The Municipality has seen modest built-up expansion alongside population decline. Agricultural land loss and forest regeneration reflect structural economic change rather than growth pressure.

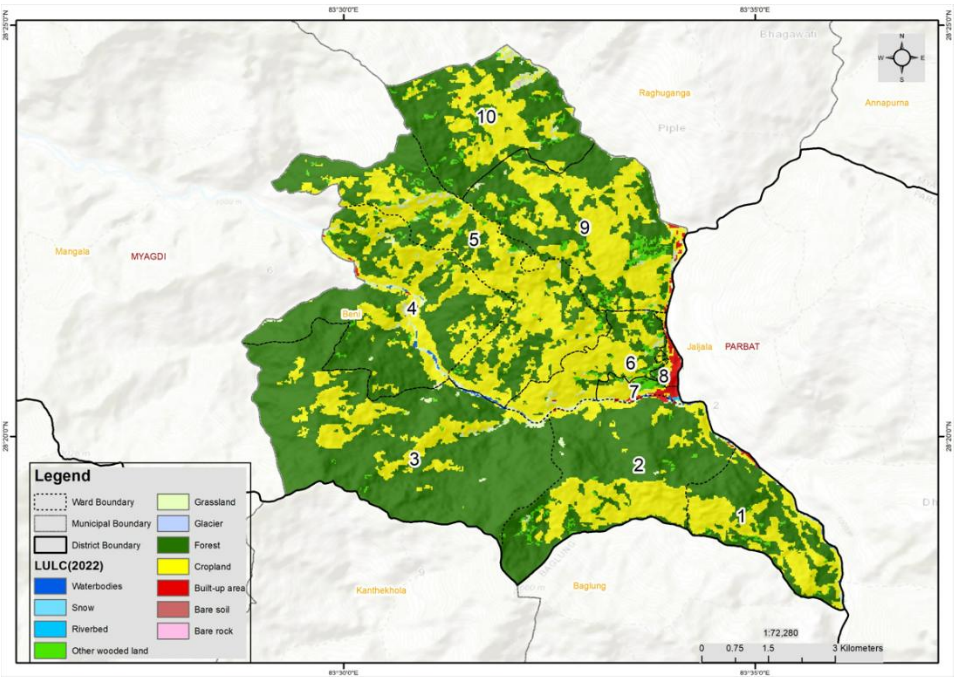


Figure 6-41. Landuse Map of Beni Municipality in Myagdi District

Waste generation in Beni is moderate but environmentally sensitive due to proximity to the Kaligandaki River. Past riverbank dumping highlights the consequences of inadequate disposal. Prioritizing composting and enforcing river-buffer protection are central to reducing pollution risks in this strategically located hill town.

Key statistics

- Population : 33,495 → 32,697 (−2.4%)
- Built-up area : 0.33 → 1.81 km² (+1.48 km²)
- Agricultural land : −36.76 km²
- Forest cover : ~46.6% (increasing)
- Waste generation : ~11 t/day

Critical waste challenges

- Riverbank dumping risk
- Limited disposal facilities
- Seasonal waste surges

Gharapjhong Rural Municipality

Gharapjhong (Jomsom) presents a case of low population but high ecological sensitivity. Built-up land increased between 2010 and 2022/24, largely linked to tourism and connectivity improvements. Agricultural land is minimal and has declined further, while forest and shrub cover increased slightly.

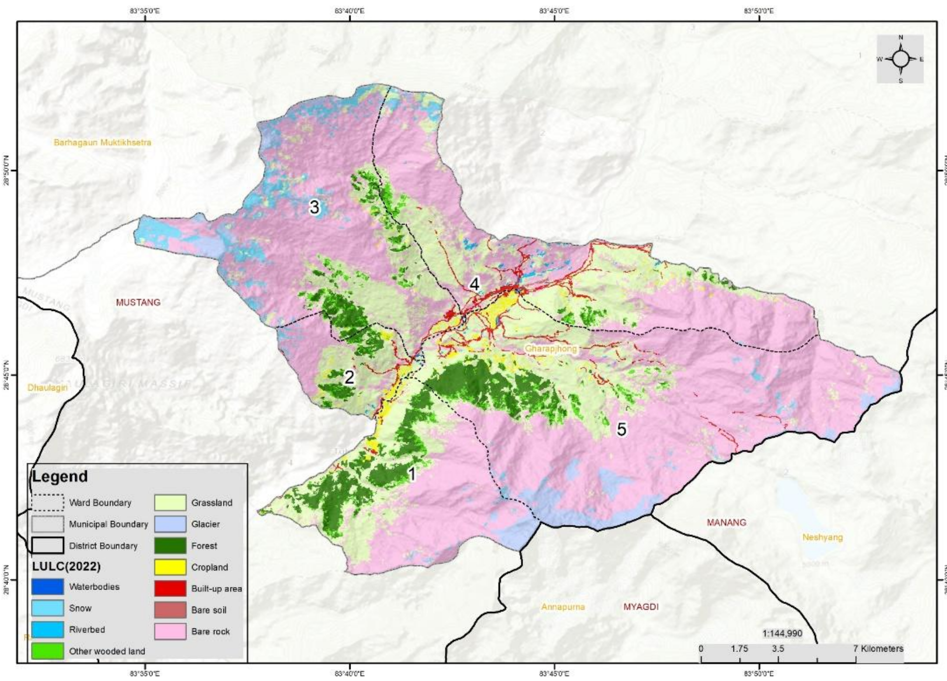


Figure 6-42. Landuse Map of Gharapjhong Rural Municipalit, Mustang

Waste volumes are low in absolute terms but seasonally variable due to tourism. In the fragile trans-Himalayan environment, even small quantities of unmanaged waste can cause lasting damage. A zero-waste tourism approach, with back-hauling of recyclables and strict litter control, is essential for environmental protection.

Key statistics

- Population : 3,029 → 3,712 (+22.5%)
- Built-up area : 3.53 → 8.70 km² (+5.17 km²)
- Agricultural land : −3.31 km²
- Forest cover : ~10.9% (increasing)
- Waste generation : ~0.7–1.0 t/day

Critical waste challenges

- Tourist-season waste spikes
- Lack of safe final disposal
- Persistent plastic pollution

Chame Rural Municipality

Chame Rural Municipality remains very small in scale, with minimal built-up expansion and low population. Land-use change has been limited, with only marginal changes in agriculture and forest cover. However, the alpine setting amplifies environmental sensitivity.

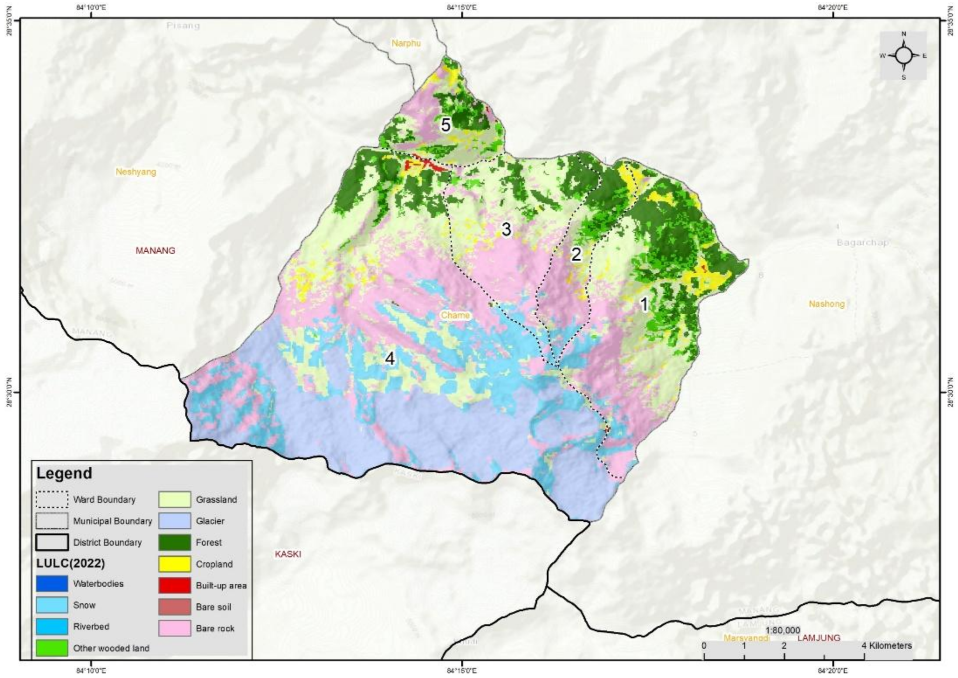


Figure 6-43. Landuse Map of Chame in Manang District

Waste generation is very low in daily volume but increases sharply during tourist seasons. The absence of safe final disposal options means that even small waste quantities pose risks. Sustainable waste management in Chame depends on prevention, strict segregation, and removal of waste from the valley rather than local disposal. Chame is a low-volume but high-vulnerability municipality. Limited land-use change masks the sensitivity of the alpine environment to unmanaged waste, particularly during trekking seasons.

Key statistics

- Population : 1,129 → 1,276 (+13.0%)
- Built-up area : 0.02 → 0.20 km² (+0.18 km²)
- Agricultural land : −1.15 km²
- Forest cover : ~18.5% (stable)
- Waste generation : ~0.25 t/day

Critical waste challenges

- No safe disposal options
- Seasonal waste surges
- Dependence on waste removal outside the district

6.6.5 Degree of Urbanization

Based on the Table 4, the analysis of ward wise degree of urbanization (NSO, 2024a) at local-level of Gandaki Province reveals a significant dominance of rural municipalities, which constitute 73.91% of the total categories, highlighting their critical role in the province's demographic landscape. Peri-urban areas, although important for transitional urban development, represent only 15.55%, while urban areas account for a mere 10.54%, further illustrating the rural inclination of this province. Within the urban classification, Urban Municipality emerges as the most prevalent form, highlighting the urbanization trends taking shape despite the overall smaller proportion of urban areas. This distribution highlights the need for targeted policies to address the unique challenges and opportunities presented by each local type, particularly in enhancing the transition from rural to urban settings.

Table 6-67. Ward-wise Degree of Urbanization at Local-Level

Local Level Type	Nos. of Municipality	Wards			
		Peri-urban	Rural	Urban	Total
Rural Municipality	57	11	383	14	408
Metropolitan City	1	11	6	16	33
Urban Municipality	27	96	172	50	318
Total	85	118	561	80	759

District-wise Degree of Urbanization in Ward Level

The degree of urbanization across the 11 districts of Gandaki Province (***Figure 6-45***) reveals significant disparities in rural, peri-urban, and urban wards (NSO, 2024a). Analyzing the data highlighted in ***Figure 6-44*** indicates that Gorkha, Mustang and Manang stand out with the highest rural percentages, at 89.36%, 100% and 100%, respectively, reflecting minimal urban development. Policymakers should consider implementing targeted rural development programs to gradually shift these areas toward peri-urban or urban classifications. In contrast, Nawalpur District (Nawalparasi-East) exhibits a promising peri-urban presence at 46 %, suggesting an ongoing phase of urban transition. This highlights the need for sustainable infrastructure development in peri-urban zones, focusing on essential services like transportation, waste management, and housing to accommodate future growth and mitigate urban sprawl.

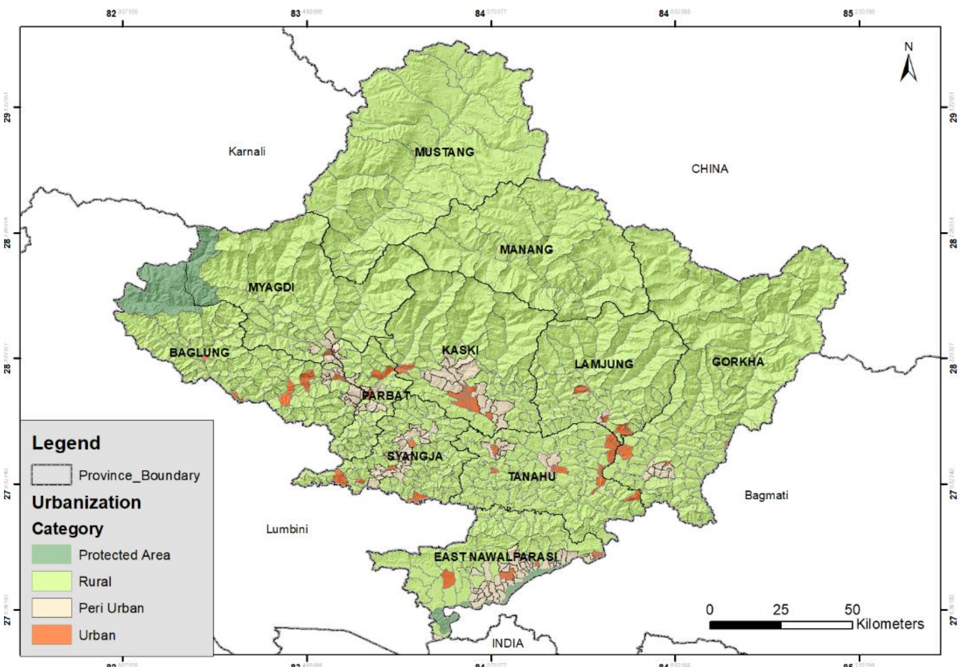


Figure 6-44. Urban, Per-Urban and Rural Wards of Gandaki Province

Kaski also presents a balanced urban environment with 25% of its wards classified as urban. Strategic urban planning practices here should prioritize sustainability, emphasizing green spaces and public amenities to enhance the quality of life for residents. On the other hand, both Mustang and Manang demonstrate a complete absence of urban areas. This highlights an opportunity for economic stimulation. Policymakers could consider offering incentives for businesses and agriculture to facilitate sustainable practices and encourage migration or settlement in these districts. The districts of Syangja and Parbat show potential for growth, with rural percentages around 72-73%. This indicates opportunities for development into urban areas, warranting partnerships with local communities to create urban strategies that respect existing lifestyles while introducing modern amenities.

The analysis of urbanization in Gandaki Province highlights a significant variation across districts, with a vast majority of wards being rural. Policymakers should focus on developing strategies that promote sustainable urban growth, transitional peri-urban areas, and comprehensive rural development programs, ultimately improving living standards and environmental conditions across the province.

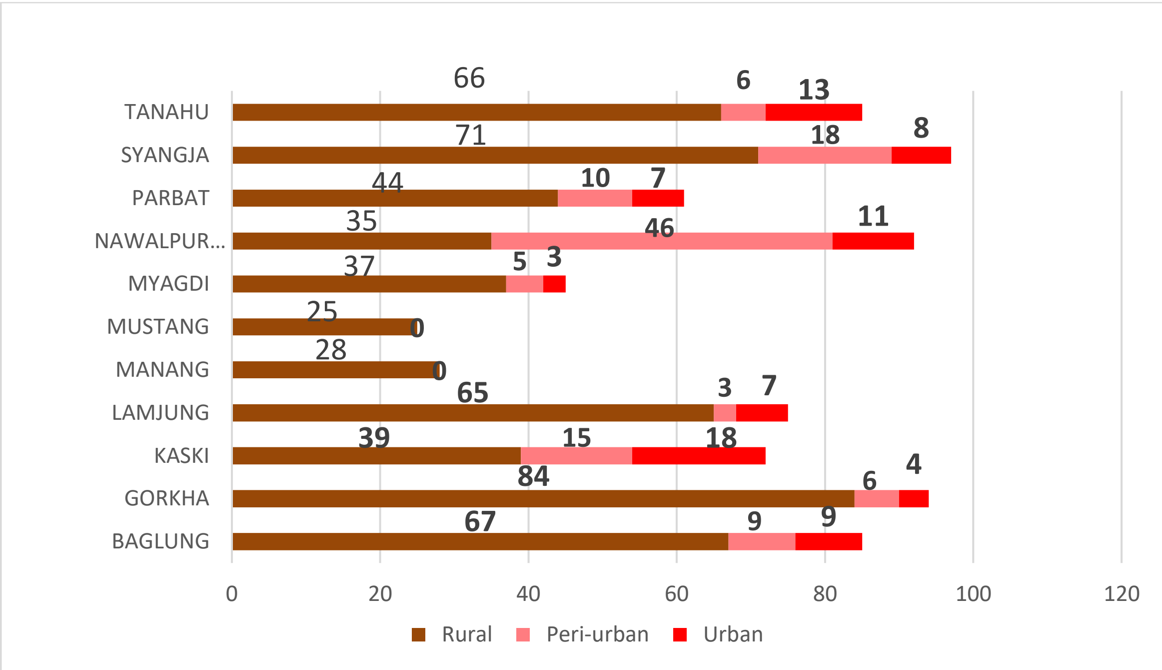


Figure 6-45. District-wise Degree of Urbanization in Ward-level in Gandaki Province

Analysis of Urban, Peri-Urban, and Rural Wards by topography

Analyzing the Table 5, the ward distributions across the physiological regions of Gandaki Province, the Hills region stands out with the highest total of 614 wards, far exceeding the 53 wards in the Mountains and 92 in the Terai. Notably, the Mountains are entirely rural, lacking any peri-urban or urban wards, suggesting a reliance on agriculture and natural resources. In terms of urbanization, the Mountains consist solely of 53 rural wards, while the Hills exhibit a notable shift with 473 rural wards, 72 peri-urban wards, and 69 urban wards, indicating significant economic development. The Terai presents a mixed picture, containing 35 rural wards, 46 peri-urban wards, and 11 urban wards, reflecting growth but remaining less urbanized than the Hills (***Table 6-68*** and **Figure *6-46***).

Proportionately, the Mountains are 100% rural; the Hills have about 77% rural, 12% peri-urban, and 11% urban wards; while the Terai is approximately 38% rural, 50% peri-urban, and 12% urban, suggesting a predominantly rural but more balanced character.

Table 6-68. Gandaki Province's Degree of Urbanization in Three Physiological Regions

Region	Rural Wards	Peri-Urban Wards	Urban Wards	Total Wards
Mountains	53	0	0	53
Hills	473	72	69	614
Terai	35	46	11	92
Total	561	118	80	759

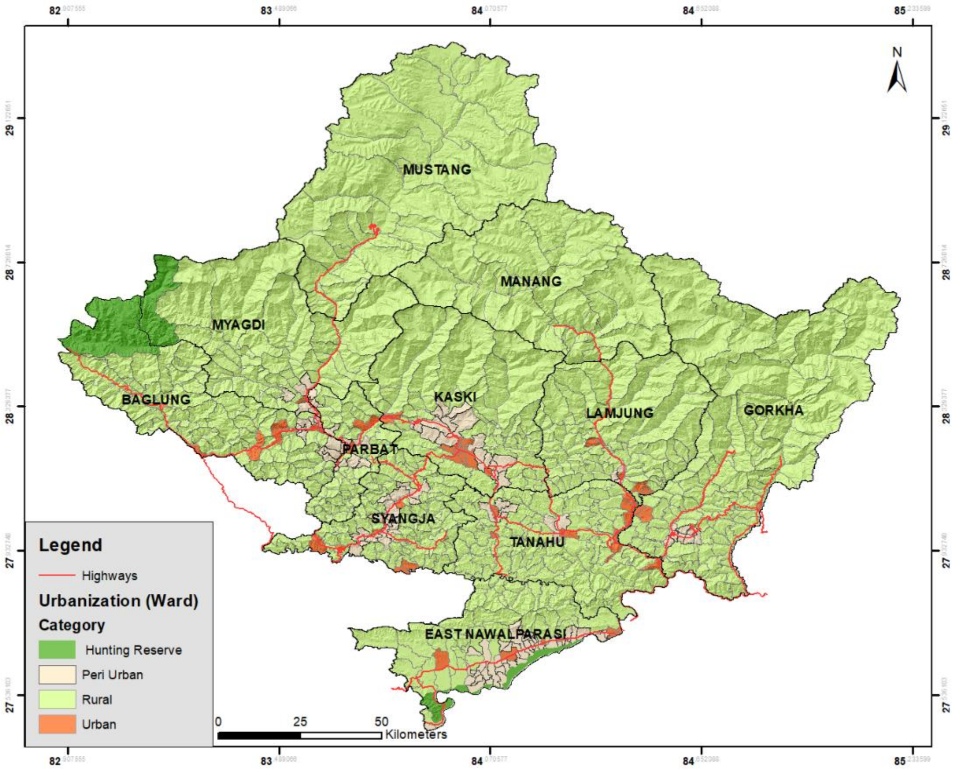


Figure 6-46. Degree of Urbanization Classification of Ward in Terms of Urban, Per-urban and Rural (NSO, 2024a)

This analysis reveals that Gandaki Province's degree of urbanization varies significantly across the Mountains, Hills, and Terai regions. The data indicates a clear trend of urbanization in the Hills, with the Terai showing potential but still largely rural. The Mountains remain entirely rural, underscoring the need for targeted developmental strategies.

Analysis of Urban, Peri-Urban, and Rural Wards by topography

From the analysis of ***Table 6-69*** the degree of urbanization in districts of Gandaki Province reveals varying patterns across its three physiological regions: Mountains, Hills, and Terai.

In the Hills, districts such as Baglung, Kaski, and Syangja show significant transitions from rural to peri-urban and urban settings. For instance, Kaski has 39 rural, 15 peri-urban, and 18 urban wards, highlighting ongoing urbanization and the need for effective urban planning.

The Terai district of Nawalpur features a strong peri-urban presence with 46 peri-urban wards out of a total of 92, indicating substantial growth potential and a pressing need for infrastructure and service planning.

In the Mountains, Manang and Mustang remain entirely rural, lacking any urban development. This lack points to a need for planning aimed at sustainable rural livelihoods while addressing ecological impacts.

To address these insights, it is essential to enhance infrastructure in the growing areas of the Hills and Terai, implement sustainable development policies in the Mountains, and develop tailored urban strategies that reflect the unique characteristics and needs of each district.

Table 6-69. Gandaki Province's District-wise Degree of Urbanization in Three Physiological Regions

District	Ecological Category	Rural Wards	Peri-urban Wards	Urban Wards	Total Wards
Baglung	Hill	67	9	9	85
Gorkha	Hill	84	6	4	94
Kaski	Hill	39	15	18	72
Lamjung	Hill	65	3	7	75
Myagdi	Hill	37	5	3	45
Nawalpur (Nawalparasi-East)	Terai	35	46	11	92
Parbat	Hill	44	10	7	61
Syangja	Hill	71	18	8	97
Tanahu	Hill	66	6	13	85
Manang	Mountain	28	0	0	28
Mustang	Mountain	25	0	0	25

Observed Changes and Insights for Improvement

The land use and cover changes in Gandaki Province over the years reveal a complex interplay of trends. Agricultural land has experienced a significant decline across all districts, most notably in Pokhara Metropolitan City of Kaski, which saw a staggering 93% reduction, and Beni Municipality of Myagdi, where declines reached an alarming 97%, in Kawasoti reduced by 57%. In stark contrast, built-up areas have expanded dramatically, particularly in Pokhara Metropolitan City Kaski, where urbanization surged by an unprecedented 1,194% and Kawasoti Municipality of Nawalpur District, where built up area has found increased by 9475% with in the span of forty years. This rapid development highlights the pressures faced by urban planners and the need for sustainable practices. On a brighter note, forest cover has shown generally positive growth in most districts, with significant increases of 127% in Putali Bazar Municipality of Syangja and 120% in Kushma of Parbat, indicating successful conservation efforts. Barren land presents mixed results; while many districts have seen notable declines, suggesting effective land management strategies, others maintain more static conditions. Additionally, ice and snow areas have increased specifically in Ghorapjhong Rural Municipality of Mustang and Chame Rural Municipality of Manang, potentially reflecting broader climatic changes that warrant further investigation. Collectively, these trends paint a picture of a rapidly evolving landscape, necessitating careful consideration of future development strategies to balance growth with environmental sustainability.

To improve the urban environment in Gandaki Province, several key insights should be prioritized. First, sustainable urban planning is vital; the significant increase in built-up areas necessitates a robust approach to infrastructure development that balances growth with the preservation of natural landscapes. By integrating green spaces into urban designs, cities can mitigate heat islands and enhance air quality, contributing to a healthier environment. Protecting agricultural land is equally crucial; implementing protective zoning laws will safeguard these vital areas from urban encroachment. Encouraging urban agriculture can further bolster local food security, promoting self-sufficiency within communities. Additionally, green initiatives, such as vertical gardens and rooftop farms, should be encouraged, as these not only enhance biodiversity but also create healthier urban spaces. Engaging local communities in urban planning decisions is essential; grassroots movements can raise awareness and foster a deeper commitment to preserving local ecosystems. Finally, the establishment of monitoring systems for land use changes will facilitate adaptive management strategies. Regular assessments will help identify inefficiencies and areas for improvement, ensuring that urban development aligns with sustainable practices. Together, these strategies can guide Gandaki Province toward a thriving, environmentally friendly urban future.

6.6.6 Urban Environment Assessment by LISA

The assessment of urban municipalities in Gandaki Province highlights varying institutional capacities based on the Local Government Institutional Capacity Self-Assessment (LISA), reflecting their performance across multiple governance and operational parameters. The evaluation includes 27 municipalities, including notable ones like Pokhara, Gorkha, and Baglung. The key parameters taken for assessment include:

- Government Administration
- Organization and Administration
- Annual Budget and Plan Management
- Financial and Economic Management
- Service Delivery
- Judicial Proceedings
- Physical Infrastructure
- Social Inclusion
- Environmental Protection and Disaster Management
- Cooperation and Coordination

6.6.7 LISA of Urban Municipalities District-wise

Gorkha District

- **High Performers:** Palungtar Municipality (95.75) and Dharche
- Municipality (94.75) exhibit strong management and service delivery, showcasing effective governance and community engagement.
- **Challenges:** Gorkha Municipality (70.5) lags notably in financial and economic management, indicating a need for improved budgetary planning and resource allocation.

Lamjung District

- **Solid Mid-Range Scores:** Many, like Madhy Nepal Municipality (82.75) and Dordi Municipality (81.25), reflect balanced governance with decent service delivery.
- **Below Average:** Besishahar Municipality (75) indicates potential issues in organization and service delivery, warranting a focused review.

Tanahun District

- **Strong Leadership:** Aambukhaireni Municipality (92.5) leads with impressive scores across all categories, especially in governance and service delivery.
- **Variability:** Bandipur Municipality (65.25) reveals significant gaps in administrative capabilities and financial management, highlighting inconsistency within the district.

Syangja District

- **High Performers:** Syangja municipalities mostly score well, with notable examples like Arjunchowpari Municipality (98) demonstrating exceptional service delivery and governance.
- **Lower Scores:** Biruwa Municipality (77.25) and others need analysis to enhance their organizational structures and service effectiveness.

Manang and Mustang Districts

- **Limited Urban Development:** Manang's Chame Municipality (75.5) and Mustang's Gharapjhong Municipality (80) show moderate scores, primarily reflecting the rural nature and structured but limited services due to geographic challenges.
- **Focus on Basic Services:** Both districts require concentrated efforts to boost infrastructure and service delivery capabilities, especially in remote areas.

6.6.8 Strengths and Opportunities

The urban municipalities and rural municipalities of district headquarters of Manang and Mustang in Gandaki Province display a mixed performance landscape, indicating pockets of excellence alongside areas needing substantial improvement. The focus for future development should be on enhancing financial management, service delivery, and infrastructure in lower-scoring municipalities, while building on the strengths of higher-scoring ones to support balanced regional

The urban environment in Gandaki Province showcases a diverse range of institutional capacities among municipalities, identifying both strengths and areas needing improvement.

- **Strengths**: Municipalities like Pokhara, Bhirkot, and Gaidakot are noted for robust governance structures.
- **Challenges**: Gorkha, Bhimad, and Kushma indicate weaknesses requiring strategic interventions in governance, financial management, and service delivery.

6.6.9 Urban Waste Management Practices

Urban waste management practices in the Province's district headquarters municipalities remain largely collection-oriented and disposal-dependent**,** with limited emphasis on segregation, treatment, or material recovery. While all headquarters municipalities have initiated some form of municipal solid waste (MSW) management primarily through door-to-door or roadside collection system capacity has not expanded at the same pace as built-up area growth and changing consumption patterns.

The diversity of urban contexts within the province metropolitan (Pokhara), Inner-Terai (Kawasoti), hill towns, and high-mountain municipalities has resulted in highly uneven waste management performance**,** but several common structural features are evident across almost all district headquarters.

Waste collection practices

Most district headquarters municipalities operate partial door-to-door collection systems, supplemented by roadside pickup in peri-urban areas. Collection coverage is generally highest in dense urban cores and market areas, and lowest in newly expanding settlements at the urban fringe. Key characteristics include:

- Incomplete coverage in rapidly expanding peri-urban wards, particularly where built-up growth has outpaced service extension.
- Irregular collection frequency in hill and mountain municipalities due to terrain constraints, vehicle limitations, and seasonal disruptions.
- Limited service reach in informal or newly developed areas, increasing the risk of open dumping and burning.

In Pokhara Metropolitan City, collection coverage is comparatively high, but the sheer scale of waste generation creates operational stress. In smaller hill headquarters, absolute waste volumes are lower, but service gaps are more environmentally consequential due to proximity to rivers and steep slopes.

Segregation at source: policy intent vs practice

Although waste segregation at source is formally promoted in several municipalities, actual segregation remains weak and inconsistent across district headquarters. Common issues include:

- Segregation practiced only by a small proportion of households
- Mixing of segregated waste during collection due to lack of separate vehicles or routes
- Limited enforcement mechanisms and weak incentive structures
- Low public compliance linked to lack of visible downstream treatment

This gap is critical because organic waste constitutes roughly 60–70% of the waste stream, meaning that failure to segregate directly undermines composting and recycling potential (CBS, 2020).

Box 5: A Landfill Site Transformed: The Inspiring Sanctuary of Pokhara



Once a bustling municipal landfill shadowed by the construction of Pokhara International Airport, the site in Bachhebuduwa has undergone a remarkable transformation. This area, which served as a dumping ground for two decades, was closed due to the risks posed by scavenging birds to aviation safety. In its place, the Pushkarini Paropakar Gokul Dham Gaushala has emerged as a beacon of animal welfare and sustainable land use.

Established by the National Philanthropic Association under the leadership of President Kamal Nayan Gautam, the Gaushala now shelters over 300 cows in thoughtfully constructed sheds with paved pathways and secure fencing. The initiative transformed the once unsightly place into a vibrant refuge for these animals. Visitors flock to the Gaushala to observe playful calves frolicking in a space that was once filled with refuse.

With a team of about 12-13 dedicated workers, the Gaushala provides proper shelter, regular feeding, and veterinary care, resulting in significantly improved animal health. Mortality rates have dropped to 4-5 cows per month, a stark contrast to the dangers faced by strays on city streets. The facility ensures steady milk production of 60-65 liters a day, illustrating both animal recovery and operational sustainability.

As the Gaushala progresses, it plans to incorporate agricultural demonstrations using manure for organic vegetable farming, contributing to local food security. With continuous investment, the project aims to become economically self-reliant, potentially evolving into a vibrant educational and tourist destination that champions compassion and productivity. What was once a public nuisance being now a shining example of community collaboration, redefining urban spaces for the better.

Note: Insights gathered through informal field interviews. Worker observations represent experiential knowledge rather than formal veterinary assessment.

Treatment practices: limited composting and recovery

Despite the dominance of biodegradable waste, treatment capacity remains extremely limited across most district headquarters.

- Composting facilities, where present, are generally small-scale, intermittent, or under-utilised.
- Material recovery facilities (MRFs) are rare, and informal recycling operates largely outside municipal systems.
- Treatment initiatives are often project-based rather than integrated into long-term municipal planning.

As a result, the majority of waste generated across district headquarters municipalities is not treated, but instead transported directly to dumping or disposal sites. This represents a major missed opportunity: organic waste diversion is widely recognised as the most cost-effective and environmentally beneficial intervention for Nepalese municipalities.

Disposal practices and environmental risks

Disposal remains the weakest link in the waste management chain across Gandaki's district headquarters. Key patterns include:

- Open dumping or semi-controlled disposal at temporary sites
- Limited availability of engineered landfills
- Poor site selection, often near rivers, streams, or steep slopes
- Inadequate leachate control and environmental safeguards

In hill towns such as Baglung, Gorkha, Kusma, and Beni, disposal sites are frequently located along river corridors, increasing the risk of plastic leakage, leachate contamination, and downstream pollution especially during monsoon periods. In Inner-Terai Kawasoti, floodplain conditions amplify the risk of waste mobilization during high-flow events. In mountain municipalities such as Chame and Gharapjhong (Jomsom), safe disposal options are extremely limited, making waste prevention and off-site removal more critical than local dumping.

Institutional and operational challenges

Across district headquarters municipalities, several cross-cutting institutional challenges constrain effective waste management:

- Mismatch between built-up expansion and service scaling**,** with waste systems lagging behind spatial growth
- Limited technical and financial capacity**,** particularly in smaller municipalities
- Dependence on short-term project**s** rather than sustained system investment
- Weak integration of informal recyclers**,** reducing efficiency and equity
- Low prioritization of waste treatment relative to collection and disposal

These challenges are consistently highlighted in national and provincial assessments of municipal waste management and are reflected in the observed performance of Gandaki's urban centres (CBS, 2020; provincial feasibility studies).

6.6.10 Policy and Institutional Framework

Urban environmental management and solid waste management in Nepal are governed through a multi-tiered policy and legal framework spanning federal, provincial, and local levels. While the framework is largely adequate in intent, persistent gaps remain between policy provisions and on-ground implementation, particularly in rapidly urbanizing provinces such as Gandaki.

Federal Policy and Legal Framework

The Solid Waste Management Act, 2068 (2011) provides the principal legal basis for municipal solid waste management in Nepal. The Act assigns primary responsibility for solid waste collection, transportation, treatment, and final disposal to local governments, and authorizes them to formulate local standards, service systems, and operational arrangements. The Solid Waste Management Rules, 2070 (2013) further operationalize the Act by outlining procedural and institutional requirements for waste management services.

The Local Government Operation Act, 2074 (2017) reinforces this mandate by explicitly listing sanitation and solid waste management as core functions of local governments. Municipalities are empowered to prepare local laws, levy service fees, contract private operators, and regulate waste-related activities within their jurisdictions.

From an environmental safeguard perspective, the Environment Protection Act, 2076 (2019) and Environment Protection Rules, 2077 (2020) establish pollution control standards and require environmental assessment (IEE/EIA) for projects with potential environmental impacts, including waste treatment and disposal infrastructure. These provisions are intended to prevent inappropriate site selection, environmental degradation, and public health risks.

At the strategic level, the National Urban Development Strategy (2017) recognizes solid waste mismanagement, open dumping, and inadequate sanitation as major urban environmental challenges and calls for integrated urban infrastructure planning, including waste, drainage, and land-use systems. In addition, national measures such as plastic bag restrictions and waste reduction initiatives aim to reduce non-biodegradable waste at source.

Provincial Framework in Gandaki Province

Gandaki Province has enacted its own Provincial Environment Protection Act, 2076 (with amendments), which provides the legal basis for provincial-level environmental governance, coordination, and oversight. The province also follows the Environment Protection Regulation, 2077, which guides implementation of environmental standards and assessment processes within provincial jurisdiction.

At the policy and planning level, provincial studies and feasibility assessments on solid waste management have been undertaken to understand waste characteristics, existing practices, and technical options suitable for the province's geographic and urban contexts. These documents provide an important evidence base for supporting municipalities, particularly smaller hill towns with limited technical capacity. However, responsibility for day-to-day waste management operations remains largely with municipal governments, with the province playing a facilitative, coordinating, and technical support role rather than a direct service delivery role.

Key Policy and Implementation Limitations

Despite a relatively comprehensive legal and policy framework, several limitations constrain effective urban environmental and waste management in Gandaki Province: Mandate–capacity mismatch: While federal laws clearly assign responsibility to municipalities, many local governments lack adequate technical staff, financial resources, and institutional capacity to implement integrated waste management systems. As a result, waste management often remains limited to collection and transport, with minimal treatment and environmentally safe disposal.

Weak enforcement and operationalization of source segregation: Although policies promote waste segregation at source, municipal systems frequently lack separate collection mechanisms, treatment facilities (such as composting plants or material recovery facilities), and market linkages. This leads to mixing of segregated waste during collection, undermining public trust and compliance.

Challenges in disposal site selection and management: Environmental protection laws require careful site selection and safeguards, yet municipalities particularly in river-valley and hill-slope towns face acute land scarcity. Disposal sites are often located near rivers or environmentally sensitive areas, increasing risks of leachate contamination, flooding impacts, and downstream pollution, especially during the monsoon.

Limited capacity to comply with environmental assessment requirements: IEE/EIA provisions under federal and provincial laws are critical safeguards, but municipalities often face technical and financial barriers in preparing quality assessments and implementing environmental management plans. This can delay infrastructure development or result in informal and temporary dumping practices.

Fragmented urban environmental governance: Urban environment issues solid waste, drainage, water bodies, air quality, and land-use planning are governed by multiple institutions and sectoral plans. Weak coordination among these systems limits integrated urban environmental management, despite national policy recognition of the need for integration.

Plastic waste control and market constraints: National restrictions on plastic bags and single-use plastics exist, but enforcement remains inconsistent. Limited availability of affordable alternatives and weak monitoring of production and supply chains continue to undermine policy effectiveness at the local level.

6.6.11 Waste Management of Pokhara Metropolitan city

Pokhara Metropolitan City faces significant challenges in solid waste management, as highlighted by the 2022 CBS publication on Solid Waste Account for Urban Municipalities of Nepal 2022. The city generates approximately 134,500 kg of waste daily, amounting to around 49 million kg annually, placing a considerable strain on waste management systems. A major contributor to this waste is households, which produce 70% (or 94,150 kg/day) of the total, underscoring the importance of residential waste generation. Other sources include businesses (5%), industries (5%), educational institutions (10%), and health institutions (3%). Alarmingly, the waste composition reveals that 73% is organic, while inorganic and other wastes account for 24% and 3%, respectively. In terms of waste collection and disposal, around 55% of the generated waste approximately 73,975 kg/day is effectively collected and sent to landfills (but not the sanitary landfill), indicating some success in waste management. However, a troubling 38% is estimated to be dumped directly into the environment, leading to dire public health risks and environmental degradation.

There is a noticeable lack of data regarding household waste management practices, such as composting, which is particularly concerning given the high percentage of organic waste produced. The improper disposal of waste not only contributes to air and water pollution but also poses significant health hazards to the community. There is a lack of proper sewage networks and treatment facilities for wastewater. Septic tanks lack ground sealing, resulting in pollution of land and water bodies, which increases risks to the urban environment and public health. In conclusion, the urgent need for improved waste collection systems and community engagement in waste management is clear. Addressing these issues is essential for reducing environmental impacts and enhancing public health outcomes in Pokhara Metropolitan City.

6.6.12 Future Outlook of Urban Environment and Waste Management

The future condition of the urban environment in the Province will be shaped by how effectively urban growth is managed in district headquarters municipalities over the coming decade. Evidence from recent trends shows that urban expansion is likely to continue, driven by service concentration, infrastructure development, land-market dynamics, and tourism, even in municipalities where population growth is slow or declining. Without targeted interventions, the environmental pressures already visible in 2022 particularly land conversion and waste management stress are expected to intensify.

Likely trajectory under current trends

If current patterns of urbanisation and management persist, built-up areas in district headquarters will continue to expand horizontally, primarily through conversion of remaining peri-urban agricultural land. Secondary cities and district headquarters are expected to experience the fastest proportional growth, as they absorb administrative functions, market activity, and in-migration from surrounding rural areas. In metropolitan Pokhara and fast-growing Kawasoti, urban intensity is likely to increase further, pushing built-up land shares well beyond current levels.

Under this trajectory, urban waste generation will rise faster than population growth**,** reflecting both spatial expansion and changing consumption patterns. Municipalities that already face high waste pressure—such as Pokhara, Kawasoti, and Byas are likely to encounter escalating challenges related to collection capacity, treatment, and disposal. In hill towns, even moderate increases in waste volumes will continue to have disproportionate environmental impacts due to steep terrain, river proximity, and limited disposal options. In high-mountain towns, tourism-driven seasonal waste surges are likely to increase, amplifying risks to fragile ecosystems.

At the same time, forest cover is expected to remain broadly stable in most municipalities, while agricultural land around urban cores will continue to decline, further reducing environmental buffers and informal waste reuse pathways. As these buffers disappear, urban drainage congestion, surface runoff, and pollution transport to rivers are likely to worsen, especially during monsoon periods.

Emerging risks and pressure hotspots

Looking ahead, several urban environmental risk hotspots are likely to emerge or intensify:

- Metropolitan and Inner-Terai centres (Pokhara, Kawasoti) may face system-wide waste management stress, including disposal site saturation, plastic leakage to rivers and lakes, and rising public health concerns.
- Secondary hill headquarters (Byas, Baglung, Gorkha, Kusma, Beni, Besishahar) risk gradual but cumulative degradation of river corridors and urban living environments if waste systems continue to lag behind spatial growth.
- High-mountain municipalities (Chame, Gharapjhong/Jomsom) face increasing vulnerability as tourism grows, where even small increases in unmanaged waste can result in long-term ecological damage.

Without early intervention, today's secondary cities could replicate the environmental challenges currently faced by larger metropolitan areas, but with fewer resources and weaker institutional capacity.

Alternative pathway: managed urban growth and waste reduction

The outlook for Gandaki's urban environment is not predetermined. The baseline evidence shows that most urban waste is organic, and that forest systems remain largely intact. These conditions provide a strong foundation for a more sustainable trajectory.

If municipalities prioritize early intervention, particularly in secondary cities and fast-growing towns, several positive outcomes are achievable:

- Decentralized composting and organic waste diversion could significantly reduce disposal pressure, odour, and river pollution at relatively low cost.
- Improved segregation at source, even at a basic level (organic vs non-organic), would enhance recycling potential and system efficiency.
- Better integration of land-use planning with waste, drainage, and river protection could reduce long-term environmental risks associated with peri-urban expansion.
- Preventive approaches in mountain towns, including zero-waste tourism models and off-site waste removal, could avoid irreversible environmental damage.

Under this managed-growth scenario, urban environmental pressure would still increase in absolute terms, but at a slower rate and with fewer negative impacts, allowing municipalities to maintain livability and environmental quality.

6.6.13 DPSIR Analysis: Urban Environment

The DPSIR framework helps to explain why urban environmental problems are emerging, how they manifest, and where policy intervention is most effective. Applied to Gandaki Province, the framework highlights that urban environmental stress is not driven by a single factor, but by the interaction of spatial growth, land-use transition, and weak waste management responses particularly in district headquarters municipalities.

Drivers

The key drivers shaping the urban environment in the Province are:

- Administrative and service concentration in district headquarters municipalities, attracting population, markets, and institutions
- Infrastructure development, especially road connectivity and urban expansion corridors
- Economic restructuring, with declining dependence on agriculture and increased reliance on services, tourism, and remittances
- Urban lifestyle and consumption change, increasing use of packaged goods
- Tourism growth, particularly in Pokhara, Jomsom (Gharapjhong), and Chame

These drivers operate across the province, but their intensity varies by municipality, resulting in differentiated urban trajectories.

Pressures

The main pressures exerted on the urban environment include:

- Expansion of built-up areas, largely through conversion of peri-urban agricultural land
- Loss of agricultural buffers, reducing infiltration, open space, and informal organic waste reuse
- Rising municipal solid waste generation, increasing faster than population growth
- Plastic waste accumulation, especially along roads, drains, and river corridors
- Increased surface runoff and drainage congestion, particularly in hill towns and floodplains

These pressures are strongest in rapidly expanding municipalities such as Pokhara and Kawasoti, but are increasingly evident in secondary district headquarters as well.

State

The current state of the urban environment in the Province reflects the cumulative effects of these pressures:

- Growing urban footprints in all district headquarters municipalities
- Sharp decline in agricultural land around urban cores
- Forest cover largely stable or increasing, indicating that deforestation is not the primary urban driver
- High and rising waste loads, with organic waste dominating the waste stream
- Limited waste treatment capacity, with most waste still managed through collection and disposal

The urban environment is therefore characterized by spatial expansion without corresponding improvement in environmental infrastructure.

Impacts

If unmanaged, these changes translate into multiple environmental and social impacts:

- River and stream pollution, particularly from plastic leakage and leachate during monsoon periods
- Blockage of urban drainage systems, increasing flood and waterlogging risk
- Degradation of urban living environments, including odour, vectors, and visual pollution
- Public health risks, especially in dense settlements and informal dumping areas
- High ecological vulnerability in mountain towns, where even small waste volumes cause lasting damage

Impacts are often more severe in hill and mountain municipalities, where terrain and river proximity amplify environmental consequences.

Responses

Responses to date have focused primarily on waste collection, with limited emphasis on prevention, segregation, or treatment. However, the DPSIR analysis highlights several response pathways with strong potential:

- Early intervention in secondary cities, before waste volumes become unmanageable
- Segregation at source, at least into organic and non-organic streams
- Decentralised composting, to address the dominant organic waste fraction
- Plastic recovery and river protection measures, especially near drainage outlets
- Integration of land-use planning with waste and drainage management
- Zero-waste tourism approaches in high-mountain municipalities

Strengthening institutional capacity, financing, and provincial technical support is critical for translating these responses into sustained improvements.

Table 6-70. Urban Environment DPSIR Summary

DPSIR Element	Key Synthesis Points
Drivers	Administrative and service concentration in district headquarters; infrastructure expansion; economic restructuring away from agriculture; tourism growth; changing urban consumption patterns
Pressures	Horizontal expansion of built-up areas; conversion of peri-urban agricultural land; rising municipal solid waste generation; plastic accumulation; increased surface runoff and drainage congestion
State	Built-up areas increased in all district headquarters (2010–2022); agricultural land declined sharply; forest cover largely stable or increasing; high and rising waste loads dominated by organic and plastic fractions
Impacts	River and stream pollution; blockage of urban drainage; localized flooding and waterlogging; degradation of urban living environments; public health risks; high ecological vulnerability in hill and mountain towns
Responses	Waste collection systems expanded but remain disposal-oriented; limited segregation and treatment; emerging composting and plastic control initiatives; policy frameworks in place but unevenly implemented

The DPSIR analysis shows that urban environmental degradation in Gandaki Province is not inevitable, but results from a growing gap between urban expansion (drivers and pressures) and waste management and planning responses. Closing this gap especially in district headquarters municipalities offers the most effective pathway to improving the urban environment in the coming years.

6.6.14 Baseline Urban Environment Indicators

Establishing a clear baseline is essential for understanding the current condition of the urban environment in Gandaki Province and for tracking how urbanization pressures evolve over time. The baseline indicators presented in this section capture the state of urban land use, demographic pressure, and waste generation across district headquarters municipalities as of 2022. Together, these indicators provide a snapshot of how towns and cities in the province have physically expanded, how surrounding agricultural and forest landscapes have been transformed, and how urban environmental pressures, particularly municipal solid waste are currently distributed. By grounding the assessment in consistent, comparable data, the baseline serves as a reference point against which future changes, risks, and policy responses can be measured in subsequent State of Environment assessments.

Table 6-71. Urban Environment Indicators of District Headquarter of Gandaki Province

District HQ Municipality	Population (2021, proxy for 2022)	Built-up Area (% of municipal area, 2022)	Built-up Area (km^2, 2022)	Agricultural Land (% of area, 2022)	Agricultural Land (km^2, 2022)	Forest Cover (% of area, 2022)	Estimated MSW Generation (t/day, 2022)
Pokhara (Metro)	513,504	**19.7**	**91.51**	3.7	17.31	50.3	**231.1**
Kawasoti	~58,003	**24.6**	**26.62**	35.7	38.74	31.7	**29.0**
Byas (Damauli)	78,939	3.7	9.28	3.5	8.56	66.6	27.6
Baglung	56,102	3.6	3.51	5.1	5.04	48.1	19.6
Gorkha	52,468	4.6	6.48	10.5	14.70	59.3	18.4
Kusma	38,101	2.9	2.73	3.4	3.15	55.3	13.3

District HQ Municipality	Population (2021, proxy for 2022)	Built-up Area (% of municipal area, 2022)	Built-up Area (km², 2022)	Agricultural Land (% of area, 2022)	Agricultural Land (km², 2022)	Forest Cover (% of area, 2022)	Estimated MSW Generation (t/day, 2022)
Besishahar	38,232	2.3	2.92	2.2	2.76	70.1	13.4
Putalibazar	41,743	1.6	2.33	3.3	4.82	68.3	14.6
Beni	32,697	2.4	1.81	1.4	1.05	46.6	11.4
Gharapjhong (Jomsom)	~7,000*	2.8	8.70	0.06	0.19	10.9	1.4
Chame	~1,700*	0.25	0.20	0.01	0.01	18.5	0.34

** Mountain municipalities show strong seasonal variation due to tourism; census-based permanent population used.*
Note:
Municipal Solid Waste (MSW) Generation (2022)
Estimated using CBS-recommended urban coefficients: Metropolitan: 0.45 kg/cap/day (Pokhara), Inner-Terai: 0.50 kg/cap/day (Kawasoti), Hill HQs: 0.35 kg/cap/day, Mountain HQs: 0.20 kg/cap/day

Table 6-72. Urban Environment Indicator Baseline (2010–2022)

Indicator	Baseline (2010)	State (2022)	Net Change (2010–2022)	Interpretation
Built-up area in district HQ municipalities (km²)	~16.6	~156.1	**+139.5 km²**	Rapid horizontal urban expansion across all district headquarters, including secondary hill towns
Average built-up share of municipal area (%)	<2%	~6–20% (range)	Strong increase	Urban growth driven more by spatial expansion than population increase
Agricultural land in district HQ municipalities (km²)	~610	~96	**−514 km²**	Sharp loss of peri-urban agricultural land, reducing environmental buffers and local food systems
Forest cover within municipal boundaries (%)	Largely stable	45–70% (most HQs)	Stable to increasing	Forests persist or expand despite urban growth, especially in hill municipalities
Municipal solid waste generation (t/day)	Low, localized	~380 t/day (total)	Strong increase	Waste generation rising faster than service and treatment capacity
Organic fraction of municipal waste (%)	Dominant	~60–70%	Stable	Indicates high potential for composting and decentralized treatment
Plastic waste fraction (%)	Increasing	~12–15%	Increasing	Key contributor to drainage blockage and river pollution
Waste treatment and disposal	Informal / open dumping	Disposal-oriented systems	Limited improvement	Collection expanded, but segregation and treatment remain weak
Weste generation and disposal in Pokahra City	No reliable recordings	~231 t/day	Strong increase	Weak collection and disposal to the dumping sites, no segregation in the source
Weste generation form Tourist	No reliable recordings	0.28kg/capita/day	-	Collection of Toursit waste is largely informal and systamatic provision has observed

Indicator	Baseline (2010)	State (2022)	Net Change (2010–2022)	Interpretation
Urban environmental risk hotspots	Limited	Expanding	Increasing	Hill and mountain towns highly vulnerable due to terrain and drainage constraints

Table 6-73. Observed Trends, Risks, and Targeted Actions

Observed Trends (Evidence-based)	Key Risks	Targeted Actions
Built-up area increased in all district headquarters (2010–2022), including municipalities with stagnant or declining population	Urban sprawl without corresponding service expansion; inefficient land use	Integrate land-use planning with environmental infrastructure; promote compact growth and serviced expansion
Sharp decline in peri-urban agricultural land across all municipalities	Loss of infiltration areas, green buffers, and informal organic waste reuse	Protect remaining peri-urban agricultural land through zoning; integrate green buffers and urban agriculture
Municipal solid waste generation rising faster than population growth	System overload, disposal dependence, escalating management costs	Prioritize early waste-reduction and diversion measures, especially in secondary cities
Organic waste dominates the waste stream (60–70%)	Missed opportunity for low-cost treatment; odour, leachate, and vector risks	Scale up decentralized composting at ward, market, and institutional levels
Plastic waste accumulation along roads, drains, and rivers	River pollution, drainage blockage, downstream environmental damage	Strengthen plastic segregation, recovery, and river-outfall controls
Waste disposal sites frequently located near rivers and steep slopes	Leachate contamination, monsoon-driven pollution, public health risks	Improve site selection, access control, and basic environmental safeguards
Peri-urban expansion outpacing service coverage	Informal dumping and burning in newly developed areas	Extend collection and treatment services proactively to peri-urban wards
High-mountain municipalities generate low waste volumes but face extreme ecological sensitivity	Irreversible environmental damage from even small unmanaged waste	Adopt zero-waste tourism models and off-site waste removal strategies

6.6.15 Recommendations for Urban Environment and Waste Management

The assessment of urbanization dynamics, land-use change, waste generation, and management practices in Gandaki Province shows that urban environmental pressure is rising faster than response capacity, particularly in district headquarters municipalities. Addressing this challenge requires early, differentiated, and scalable actions, rather than uniform solutions. The following recommendations are structured at provincial, municipal, and context-specific levels.

Province-level recommendations

1. **Prioritize waste management as a core urban environmental issue**: Waste management should be treated as a central component of urban environmental governance, on par with land-use planning and water management. Provincial planning frameworks should explicitly recognize waste as a key environmental pressure linked to urban expansion.
2. **Support secondary cities before pressures become unmanageable**: While Pokhara already faces metropolitan-scale challenges, emerging urban centres such as Kawasoti, Byas (Damauli), Baglung,

Gorkha, and Kusma represent the most cost-effective intervention points. Early investment in these municipalities can prevent future large-scale environmental crises.

3. **Promote decentralized, low-cost treatment solutions**: Given the dominance of organic waste, the province should prioritize decentralized composting systems that can be implemented at ward or cluster level. These solutions are technically simpler, less capital-intensive, and well suited to hill and small-town contexts.
4. **Strengthen provincial technical backstopping**: Many municipalities lack the technical capacity to design, operate, and monitor waste systems. A provincial technical support mechanism—covering segregation, composting, material recovery, and safe disposal would significantly improve municipal performance.
5. **Integrate land-use planning with environmental infrastructure**: Urban expansion plans should be aligned with waste management, drainage, and river protection measures. This integration is particularly important in floodplains and river corridors, where unmanaged growth leads to disproportionate environmental impacts.

Municipal-level recommendations (District Headquarters)

1. **Enforce basic segregation at source**: Municipalities should move beyond awareness campaigns and establish enforceable minimum segregation standards, at least separating organic and non-organic waste. Even partial segregation can substantially improve treatment outcomes.
2. **Scale up composting for organic waste**: With organic waste comprising 60–70% of the waste stream, composting offers the fastest and most effective reduction in disposal pressure. Municipalities should prioritise composting in markets, institutions, and residential clusters.
3. **Improve plastic waste control and recovery**: Plastic waste poses the greatest risk to rivers and drainage systems. Municipalities should strengthen plastic collection, support recycling linkages, and implement targeted controls near riverbanks, drains, and transport corridors.
4. **Upgrade disposal practices and site management**: Where engineered landfills are not feasible, municipalities should at minimum improve site selection, access control, and basic environmental safeguards to reduce river pollution and public health risks.
5. **Extend services to peri-urban growth areas**: Rapidly expanding peri-urban settlements are often excluded from waste services. Proactive extension of collection and treatment systems to these areas can prevent informal dumping and long-term environmental degradation.

Context-specific recommendations

a) Metropolitan and fast-growing centres (Pokhara, Kawasoti):

- Invest in large-scale composting and material recovery facilities
- Strengthen segregation enforcement and compliance monitoring
- Integrate waste management with lake, river, and drainage protection

b) Secondary hill headquarters (Byas, Baglung, Gorkha, Kusma, Beni, Besishahar, Putalibazar)

- Focus on decentralized composting and small material recovery units
- Enforce river-buffer protection to prevent dumping
- Use low-cost, locally manageable solutions suited to terrain constraints

c) High-mountain municipalities (Chame, Gharapjhong/Jomsom)

- Adopt zero-waste and low-waste tourism models
- Prioritize waste prevention and off-site removal over local disposal
- Enforce strict controls on littering and packaging in sensitive ecosystems

Cross-cutting recommendations

1. **Strengthen data and monitoring systems**: Regular tracking of built-up expansion, waste generation, and management performance is essential for updating the State of Environment and guiding investment decisions.
2. **Integrate informal recyclers into municipal systems**: Recognizing and integrating informal recycling actors can improve efficiency, reduce costs, and enhance social equity.
3. **Promote behaviour change alongside infrastructure**: Infrastructure alone will not solve waste problems. Public engagement, incentives, and visible improvements in treatment outcomes are necessary to sustain segregation and compliance.

Urban environmental pressure in Gandaki Province is manageable if addressed early, particularly in district headquarters that are transitioning from small towns to more complex urban systems. The most effective pathway forward is not high-cost infrastructure alone, but a combination of early intervention, organic waste diversion, plastic control, and integrated urban planning. Acting now can protect rivers, improve urban livability, and avoid long-term environmental and financial costs.

6.7 Water Resources and Water Quality

6.7.1 Overview of Water Resources in Gandaki Province

The Gandaki Province lies within the Gandaki river basin. The basin drains the central part of Nepal with Koshi river basin in the east and Karnali river basin in the west. The Gandaki River is a trans-boundry river basin as some tributaries emanate from China, flow through Nepal, merge to become the Narayan river and emerge into India to confluence with the Ganges river in Bihar, India. It is called the Gandak river in India.

The river system is also called Sapta Gandaki, as there are seven main tributaries of this river (Figure 6-47. **Major River Basin of Gandaki Province**

Table -*6-74* and Figure 6-47). The total catchment area of Gandaki Basin at the Nepal-India border is 36,497 km² of which 88% is in Nepal (equivalent to around 23 percent of the country's land area). The Kali Gandaki is the largest sub-basin at around 11,900 km² which is about a third of the overall river basin area.

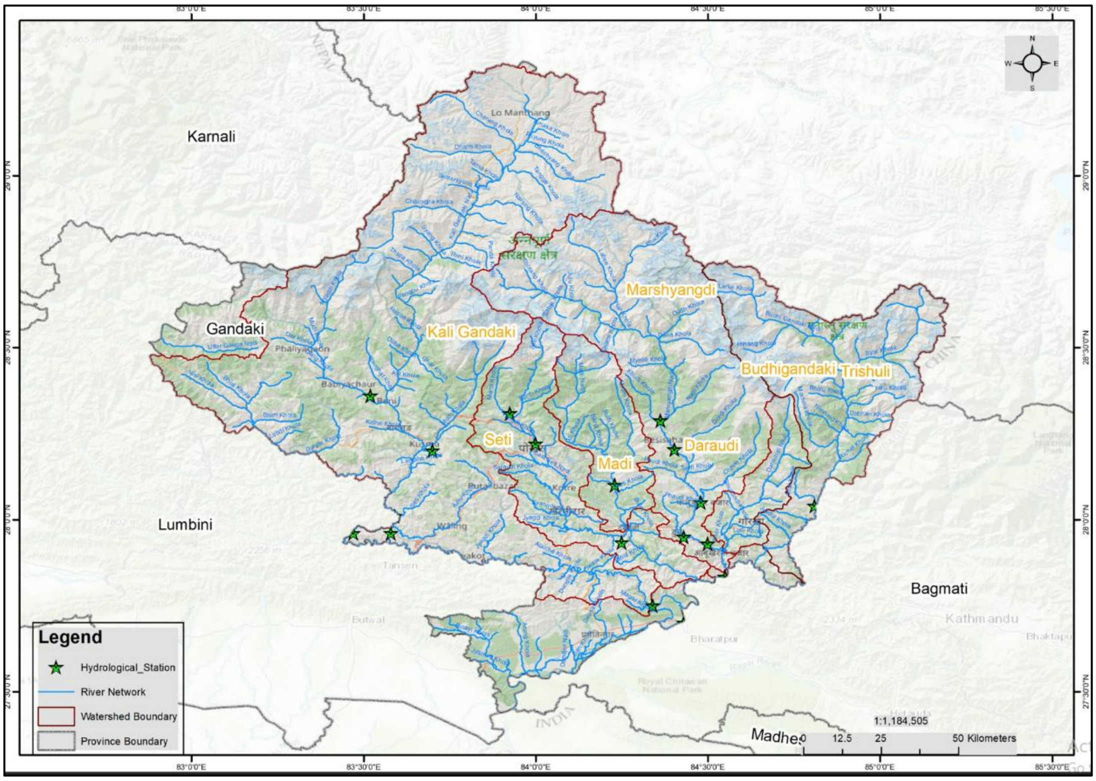


Figure 6-47. Major River Basin of Gandaki Province

Table -6-74: Drainage Area and Slope Details of the Tributaries of the Gandaki River

S N	Tributary Name	Sub-basin Area in Nepal (km^2)	Sub-basin Area in China (km^2)	Maximum Elevation (m)	Minimum Elevation (m)	Average Elevation (m)	Average Slope (Deg)
1	Kali Gandaki	11,797	21	8,167	190	2,784	25.25
2	Seti	2,936		7,469	220	1,429	21.37
3	Madi	1,117		7,915	305	1,915	23.85
4	Daraundi	606		6,036	280	1,460	22.66
5	Marsyangdi	4,772		8,103	240	3,617	27.20
6	Budhi Gandaki	3,607	1,368	7,979	320	3,256	30.08
7	Trishuli	16,777	2,961	7,200	190	2,163	25.62

Madi rivers converges into Seti, therefore the Seti river sub-basin area includes Madi also. Similarly, Marsyangi includes Daraundi, and Trishuli sub-basin area includes all of Budhi Gandaki, Marsyangdi, and Seti rivers. The area in the Table above also includes the total drainage area of the Trishuli river, as it flows from China enters Bagmati province and flows through Gandaki Province. The Trishuli and the Kali Gandaki confluence at Devghat and become the Narayani River. The Narayani river has a drainage area of 1,793 km^2 along its main stem. The total drainage area of the Gandaki River Basin at the Indian border is 36,383 km^2.

The altitude of the river basin in Nepal ranges from 80 meter to 8167 meter, Mt. Dhaulagiri, the seventh highest mountain peak of the World. Mt. Manaslu (8163m), the eighth highest peak, and Annapurna-1 (8091m), the tenth highest peak, lie in the central part of the basin. The tributaries cut through steep slopes in the mountain and hill regions, flow through valleys and emerge from the Siwalik mountain into the Terai plains in the south.

The precipitation over Gandaki Basin exhibits extreme spatial and temporal variability. It has an average annual precipitation (within the catchment in Nepal) of 1823 mm (WECS, 2024) with a higher precipitation of about 4,000 mm around Lumle area and a low precipitation of about 200 mm in Upper Mustang. The rainfall pattern in the basin, on the southern side of the Himalayas is temporally skewed with almost 80% of the precipitation occurring in four months of July to October and the rest 20% over the remaining eight months. March and April are the driest months in the basin. The basin's river system is fed by snow melt, springs, and direct runoff originating from rainfall. In the wet season (monsoon), heavy rainfall can lead to water-induced disasters such as floods, inundations, and landslides. During winter, the dry season, the basins' rivers have relatively low discharge primarily fed by groundwater release from mountains and hill aquifers, and high-altitude snow/ice melt. All these features make the basin central to both water security and climate-risk discussions in the water sector.

The Gandak Barrage, built to regulate the Narayani river water, or the Gandak as it is called in India, is a major transboundary hydraulic structure at the Nepal-India border in Triveni built in 1963-68 under the 1959 Gandak River Agreement between Nepal and India. It primarily serves to divert water for extensive irrigation networks in India (Bihar and Uttar Pradesh) and parts of Nepal. The Western Gandak Canal system, operating with a discharge capacity of 8.5 m^3/s was designed to irrigate 8,700 hectares in East Nawalparasi (Gandaki Province) and West Nawalparasi (Lumbini Province). The Eastern Main canal and the Western main canals can divert 532.77 m^3/s and 444.77 m^3/s. The Nepal East Canal offtakes from the Eastern main Canal in India with a capacity of 24.1 m^3/s. from the barrage The Western Main Canal includes a 15 MW hydropower station at Surajpura, Nawalparasi in Lumbini Province.

6.7.2 Sub-basins of Gandaki Basin within Gandaki Province.

Kali Gandaki River

The Kali Gandaki sub-basin is one of the most important tributary systems within the Gandaki/Narayani river basin and a defining hydrological corridor of Gandaki Province, extending from the trans-Himalayan headwaters of Mustang. It originates from the Nhubine Himal Glacier in Mustang District. Another tributary A small basin portion (21 km^2) lies in China also, flowing through the Middle Hills to the lower river valleys. Its physiography is exceptionally rugged and vertically extensive spanning roughly 188 m to about 8,000 m in elevation across an area on the order of 11,797 km^2 resulting in pronounced gradients in climate, runoff processes, and accessibility.

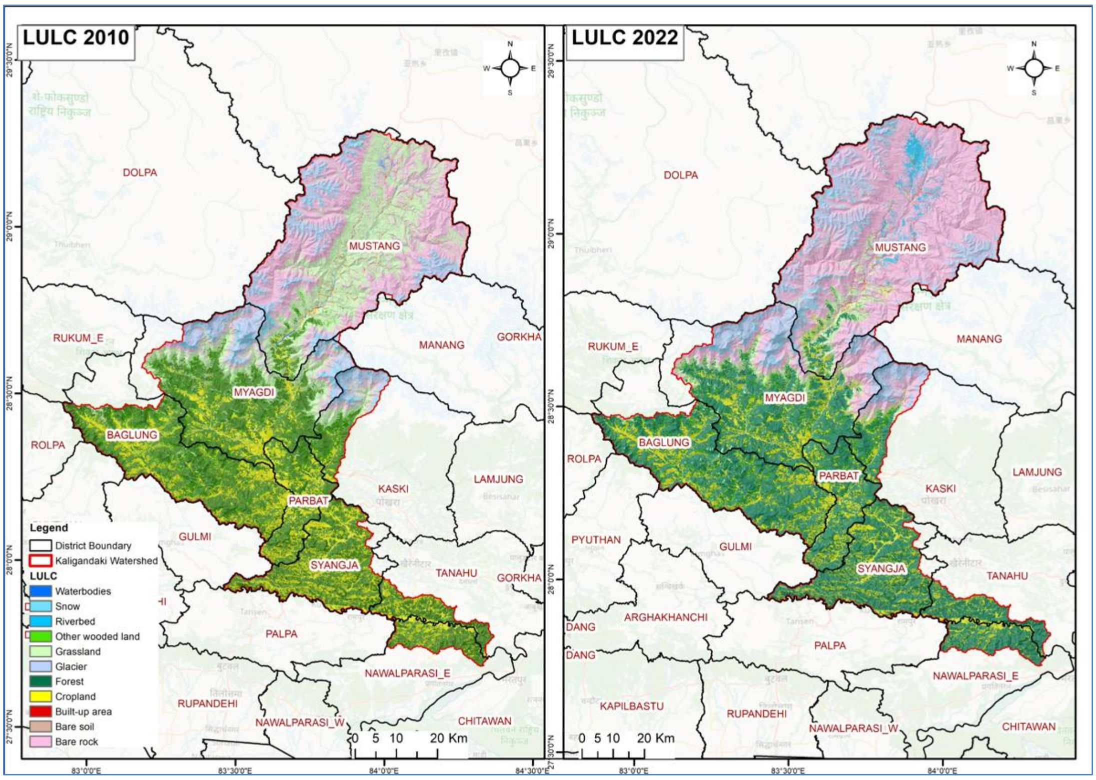


Figure 6-48. Kaligandaki River Basin and Landuse Changes in 2010 and 2022

The Kali Gandaki river cuts between the Dhaulagiri and Annapurna massifs forming the Kali Gandaki Gorge, where the river and concentrates high-energy flows, erosion, and sediment movement along a narrow valley floor. Hydroclimatic conditions vary sharply: the upper basin lies in a rain-shadow with low annual precipitation (reported around 200 mm at Lo Manthang), while the southern windward slopes receive some of Nepal's highest rainfall totals (reported above 4,000 mm at Lumle) producing strong spatial contrasts in water availability and hazard exposure. The mean annual precipitation of this basin is around 1396 mm most of which occurs between June to August and it translates to a mean monthly flow of 448 m^3/s at Kotagaun (hydraulic Station 420) upstream of Devghat, where it joins Trishuli river. The main tributaries that feed into this river, with catchment exceeding 200 km^2 are include Parung khola, Dhechyang khola, Ghami khola, Chilungpa khola, Mristi khola, Raughat khola, Modi khola, Adhi Khola, Badigad khola, Ridi khola and Nisdi khola. Trishuli river joins this at Devghat and continues on as the Narayani River.

There are a number of hydropower projects in the basin including the Kali Gandaki Hydropower Project (140 MW) as the river is snow-fed and has reliable low flow, as well as a strong gradient. The river is also said to be overall water-surplus and inter-basin transfer of water for irrigating adjoining areas are also under plan.

Seti River

The Seti River basin drains the southern flanks of the Annapurna massif and flowing through Pokhara Valley toward Damauli before joining the Trishuli at Devghat. The catchment area of the basin is about 2935 km^2 ranging from 220 m to 7,469 m in elevation. The major tributaries are Sardi, Mardi, Yamgdi, Kali, Bijayapur, Kotre, and Madi rivers. The river is widely known for its steep, gorge-forming reaches around Pokhara, where high relief and active geomorphic processes strongly shape channel form, sediment transport, and local river hazards.

Annual precipitation averages about 3710 mm with 80 % of the total rainfall is received during the monsoon season from June to September. Hydrologically, the Seti basin expresses classic monsoon-driven seasonality high flows and elevated sediment loads during the summer monsoon and much lower dry-season discharge.

The mean annual flow from this sub-basin is estimated to be 209 m³/s. There are six run of the river hydropower plants in operation with an installed capacity of 26 MW, while four more are under construction to add an additional 214 MW.

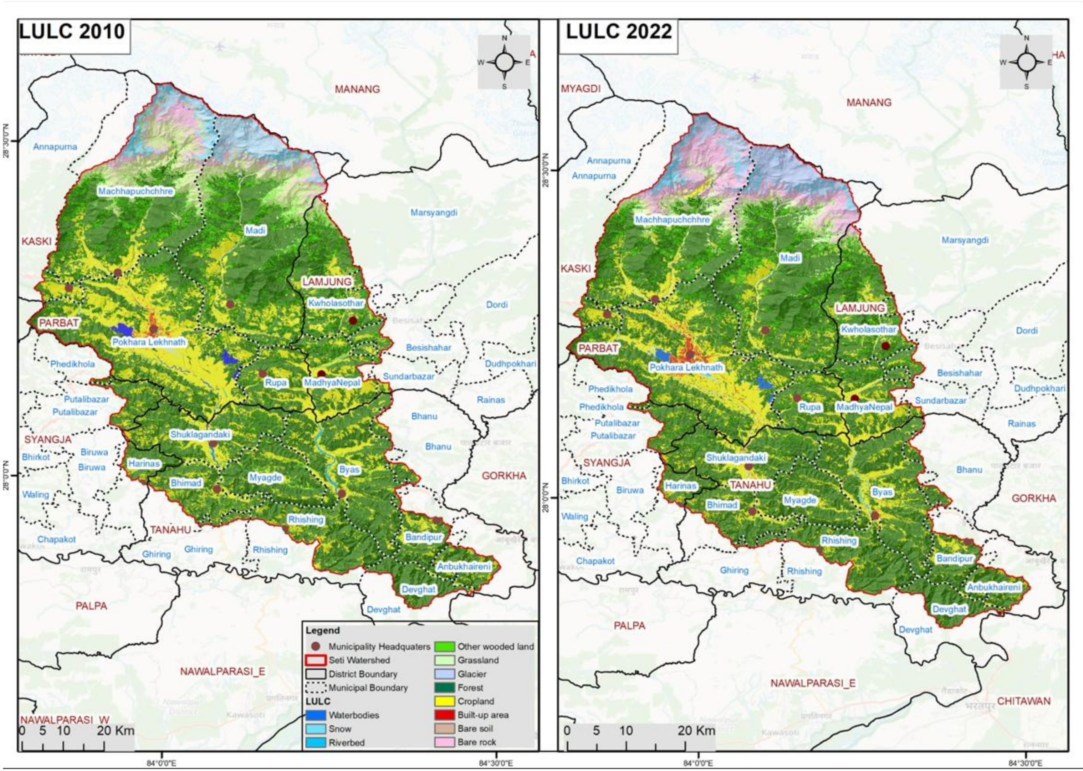


Figure 6-49. Landuse Map of Seti River Basin (2010 and 2022)

Seti basin is a critical water resource supporting river-dependent livelihoods, irrigation, recreation, and hydropower/riverbank infrastructure in and around the urban Pokhara, dense populated valleys and farmlands. It is a high-energy Himalayan system where water availability, sediment dynamics, and flood risk are tightly coupled with anthropogenic pollution and sewage disposal.

Madi River

The Madi River (Madi Khola) originates in the high Himalaya of the Annapurna region, with headwaters rising from high-elevation slopes and snow- and ice-influenced catchments north-east of Pokhara valley and flows through Kaski and Lamjung to join the Seti river near Damauli. The Madi river catchment area is about 1,117 km² with elevations ranging from 305 m to 7,915 m. Precipitation and discharge in the Madi basin are strongly seasonal and spatially variable, annual precipitation varies from about 1,684 mm at Damauli (lower basin) to 3,784 mm at Sikles (upper basin), and that roughly 74–80% of total precipitation falls during the four monsoon months' conditions that drive high wet-season flows, flashy hydrographs, and elevated sediment transport during storms.

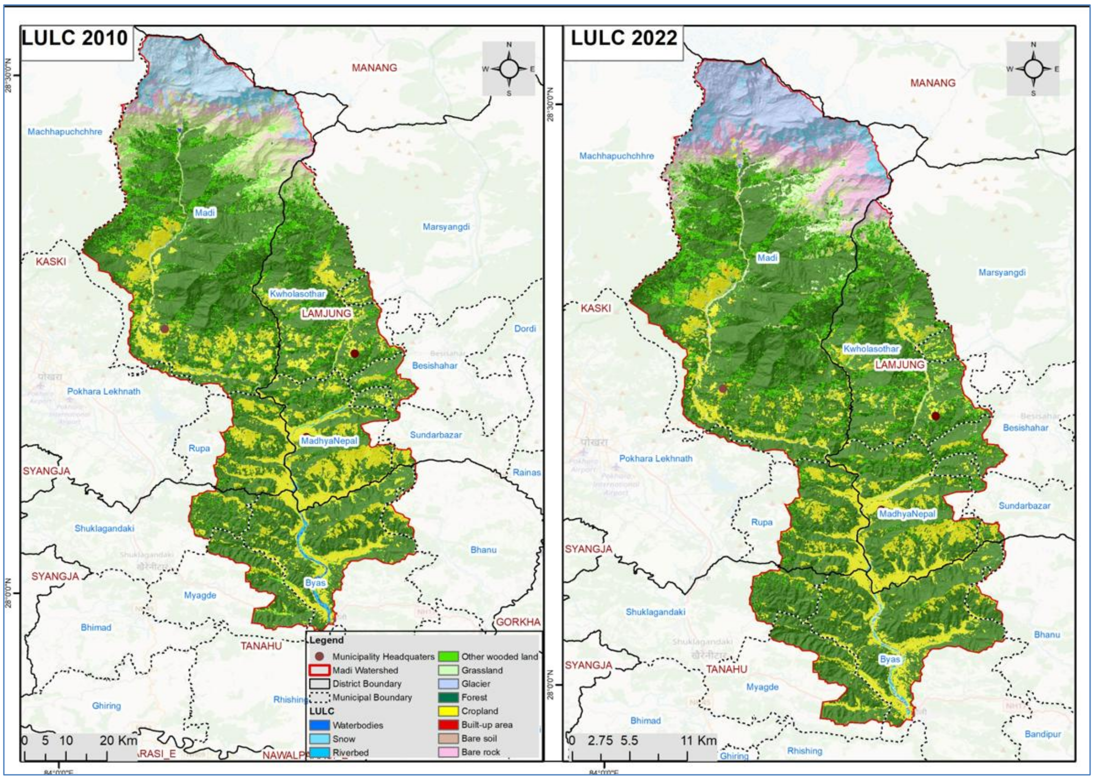


Figure 6-50. Landuse Map of Madi River Basin (2010 and 2022)

Smaller tributaries support local irrigation systems, drinking water supply and sustain livelihoods. Six hydropower plants are in operation with an installed capacity of 68 MW and seven more are under construction with 123 MW. The Madi River drains the high-relief terrain north of Pokhara and delivering both monsoon runoff and sediment to the Seti river sub-basin. This brings about dry-season water-stress risks for irrigation and ecosystems; and wet-season flood and debris-flow hazards for river-corridor settlements and infrastructure.

Daraundi river

The Daraundi river drains the Manaslu Conservation Area in central-west part of Gandaki Province, in Gorkha district. It originates snowfields and glaciers as Narad Pokahari river and flows into Marsyangdi river. It has a catchment area of about 606 km^2 with elevation ranging from 280 m to 6,036 m. The lower valleys are warm and include farmlands providing grain to the adjacent communities.

The longterm average discharge average at Naya Sangu, catchment area 224 km^2, is 17.7 m^3/s; therefore, for the whole catchment, it is estimated to be 44 m^3/s. There is an existing 6 MW hydropower plant and five more run of the river plants are under construction to add another 47 MW of generation capacity. Springs in the catchment provide crucial water supply to villagers and hydropower generation. The area also has a thriving tourism industry.

Marsyangdi River

The Marsyangdi sub-basin is a high-relief Himalayan sub-basin of the Gandaki (Narayani) system that spans from the trans-Himalayan headwaters in Manang down through Lamjung, Gorkha and Tanahu to its confluence with the Trishuli at Mugling. The Marsyangdi River originates from snow fields and glaciers northwest of the Annapurna flows south-east. The basin includes rugged and complex topography ranging from high Himalayas in the north to a mountainous basin in the south with varied hydro-climatic conditions. The average annual precipitation for the sub-basin is about 2,150 mm typical monsoon skewed rainfall characteristics of the region.

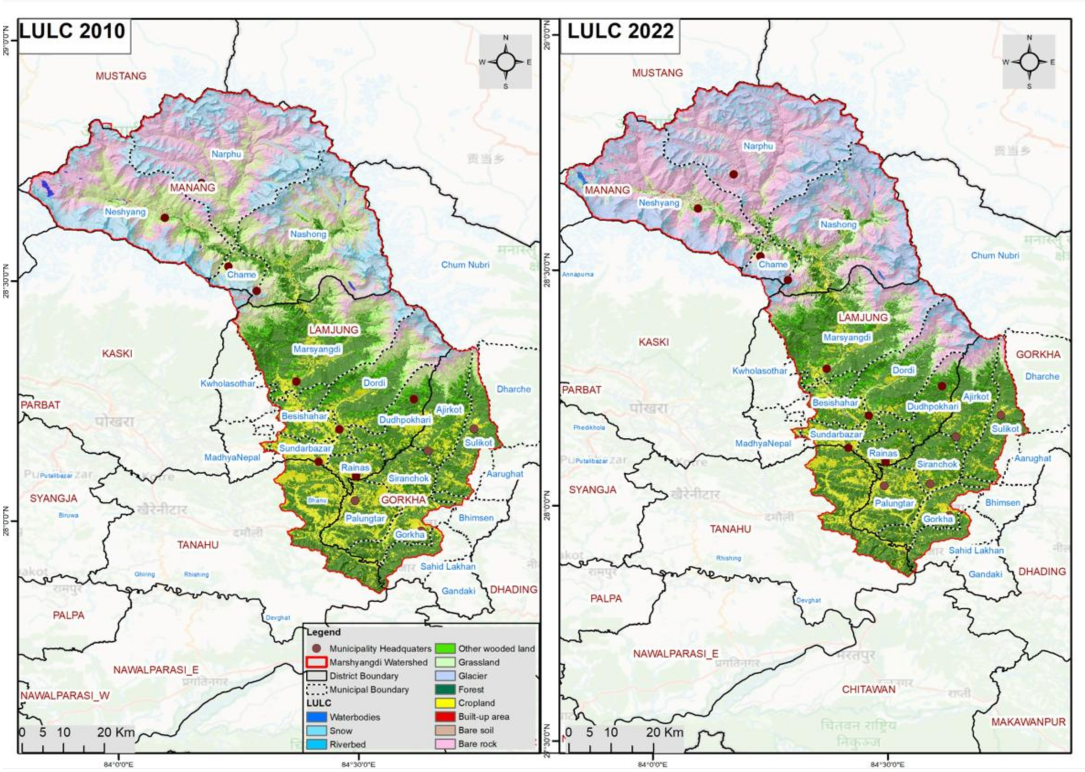


Figure 6-51. Landuse Map of Marshyangdi River Basin (2010 and 2022)

Hydrologically, the Marsyangdi is snow- and glacier-influenced in its upper reaches but remains dominantly monsoon-driven in seasonal runoff, with peak flows in the monsoon months and low flows in late winter/early spring. The main tributaries of Marsyangdi are Nar khola, Dudh khola, Nadi khola, Dordi khola and Chepe khola. Daraudi river confluences with it and flows into the Trishuli river. The average annual flow is 210 m^3/s. The main basin has 8 hydropower plants in operation with a capacity of 208 MW and 19 more are under construction to add another 887 MW. Another Hydroelectric Project 600 MW Upper Marsyangdi project is also in planning stages. It is also a destination for adventure tourism for river rafting and kayaking.

Budhi Gandaki River

The Budhi Gandaki sub basin is a major system of the Gandaki basin draining rugged terrain of Gorkha and Dhading and joining the Trishuli at Benighat. It is a transboundary river originating from China and with tributaries in Nepal arising from the Manaslu -Ganesh Himal region to the mid-hills with a catchment area of 3,607 km^2 in Nepal and 1,368 km^2 in China. The terrain elevation ranges from 320 m to 7,979 m in high Himalayas. The average annual rainfall is estimated to be 1,495 mm with distinct spatial and temporal variations typical of the region.

The sub basin combines snowmelt- and rainfall-fed headwaters with a strongly monsoon-controlled seasonal hydrograph, where high flows concentrate in the summer monsoon and low flows persist through the winter dry season. The long-term average flow is about 222 m^3/s. There are currently two hydropower station with an installed capacity of 12 MW are in operation while eight plants are under construction for about 146 MW. A large storage project with a capacity of 1200 MW has also been planned. This storage is expected to augment the low flows and provide additional benefits downstream. It is, therefore, important to follow environment overview to balance dry-season flow regulation and energy generation with downstream river ecology and sediment continuity, while also managing monsoon flood risk in a steep, landslide-prone Himalayan catchment. The upper region is relatively pristine with attractive trekking, e.g. the Tsum Valley Trek, providing scenic mountain views, hot springs and waterfalls for the nature and adventure minded tourists.

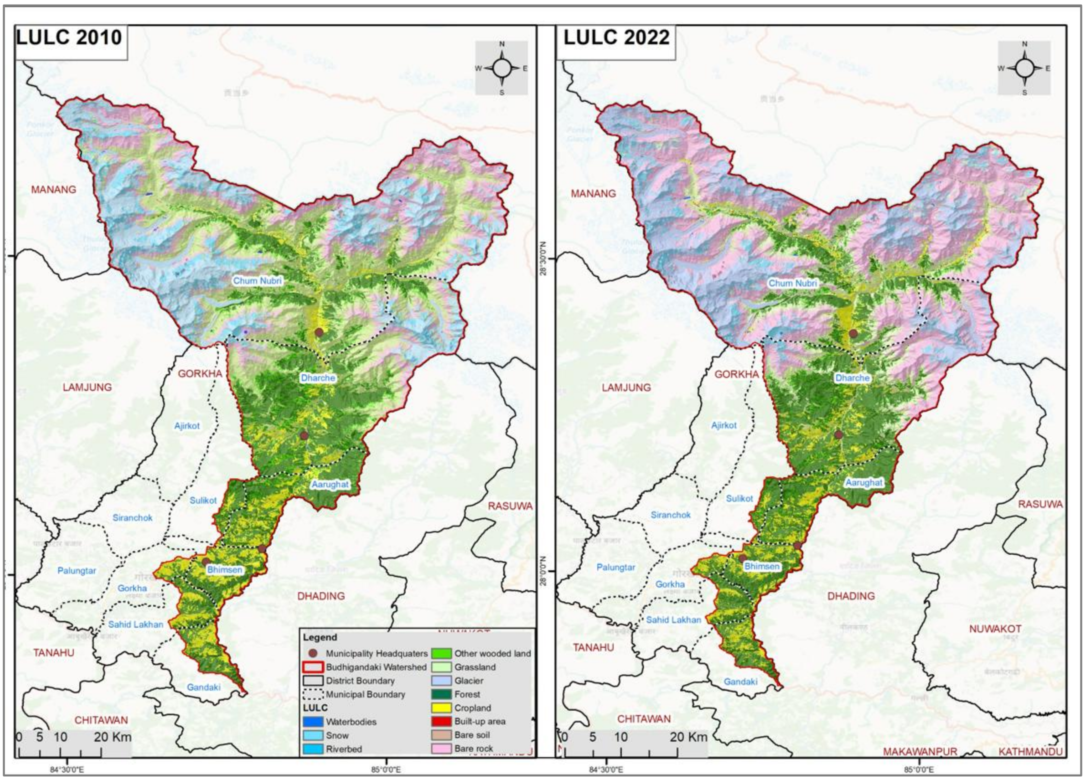


Figure 6-52. Landuse Map of Budigandaki (part of River Basin) (2010 and 2022)

Trishuli River

The Trishuli River is eastern most river sub-basin of the Gandaki Province, the headwaters of the basin lies in Bagmati Province as well as extending up north beyond Nepal-China border into China. The total catchment area is19,738 km2 of which 2,961 lies in China north of Nepal. It is formed by the confluence of the Kyirong Tsangpo (flowing south from Tibet, China) and the Lende Khola, after which the river cuts south through steep mountain gorges through Rasuwa and Nuwakot unto Dhading. It then flows eastwards, draining Budhi Gandaki, Marsyangdi and flows south meeting Seti and Kali Gandaki at Devghat, Chitwan.

Hydrologically, the Trishuli exhibits a strongly seasonal regime driven by the summer monsoon and augmented by snow/ice melt from the high Himalaya, with cold headwater zones transitioning to warmer downstream reaches as slopes reduce. A basin-wide characterization prepared for hydropower planning delineates the river into upstream, midstream, and downstream zones with progressively flatter slopes. The river starts with high mountain climatic regime followed by subtropical to temperate climatic regime in the middle and lower reaches. The upper and middle third areas of Trishuli, lying in Bagmati region sites a number of hydropower projects and some irrigation in the valley areas. The river becomes fragmented with hydropower projects, aggregate mining, urbanization and impacts on the ecosystem. The major highway connecting Kathmandu to the central and western part of the country is also located partly on the river corridor.

Lakes and Ponds

Based on the Gandaki Province Lake Inventory Final Report (LCDA, 2021), 290 lakes, including ponds, lakes, and glacial lakes, were mapped and identified across Gandaki Province. The number of these these lakes by elevation are:

- Lakes below 3,000 m: 116 lakes
- Lakes between 3,000-4,500 m: 48 lakes
- Glacial lakes (above 4,500 m): 126 lakes

The largest in Pokhara valley and the most popular one is the Phewa lake which is pivotal to Pokhara's existence as a tourist hub. The Pokhara Valley lake cluster also includes eight other cluster lakes as Ramsar sites. Apart from recreation and sight-seeing benefits, the lakes provide irrigation, fisheries and even hydropower benefits.

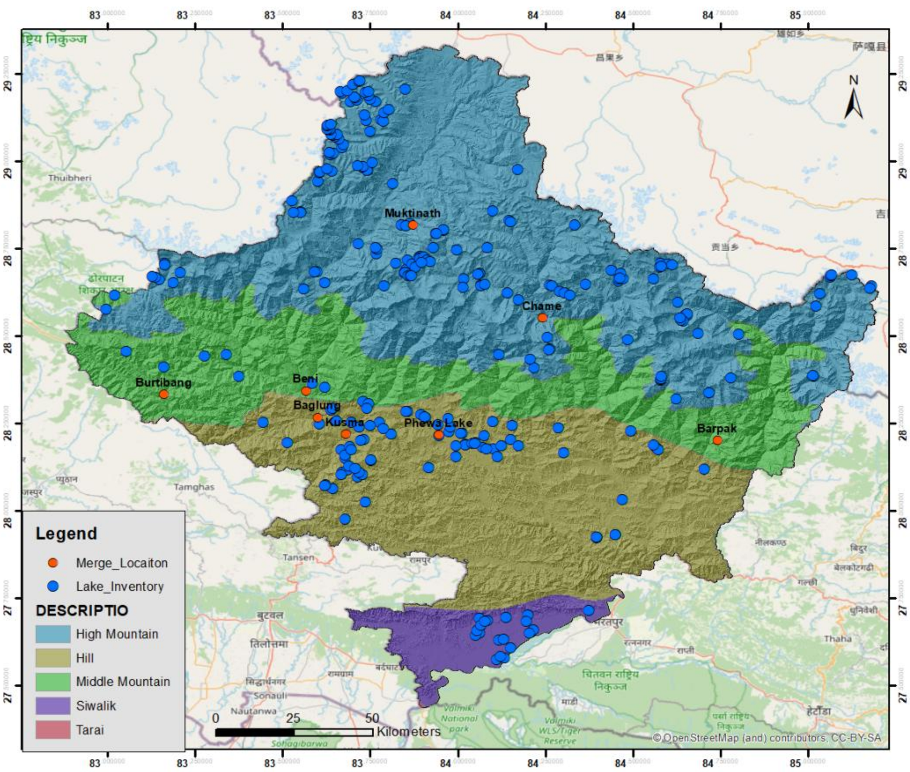


Figure 6-53. Lakes in Gandaki Province

There are a higher numbers of lakes identified in mountain districts (Mustang and Manang) while the majority of lakes below 3,000 m are in Kaski, Parbat, and Nawalpur. Tilicho lake (4 km long, 1.2 km wide, and 200 m deep) at an elevation of 4,919 m in Manang District is reportedly the highest freshwater lake in the world. Many lakes in the mid-hills are degraded and suffering from pollution, encroachment, sedimentation, and invasive species (especially water hyacinth). Glacial lakes pose a danger for outbursts and flooding due to climate change and global warming.

6.7.3 Significance of Water to Provincial Development

Water resources constitute the cornerstone of Gandaki Province's socio-economic aspirations aligned with national goals of achieving upper-middle-income status by 2030 and prosperity by 2043. The Province's second Five-Year Plan (FY 2024/25–2028/29) targets 2,500 MW from a baseline of 733 MW in 2022/23. hydropower's centrality to development vision. The aspirations of prosperous province hinges on water security and access to water as it can carry the province forward through:

1. Basic necessity and Public health preservation: Access to safe drinking water directly influences health outcomes, especially waterborne disease prevention
2. Energy Production: The Province's second Five-Year Plan (FY 2024/25–2028/29) targets 2,500 MW from a baseline of 733 MW in 2022/23. hydropower's centrality to development vision.

3. Agricultural productivity: Agriculture contributes significantly to the provincial GDP, provides job opportunities not only for sustaining livelihoods but also value addition products and income generation. Reliable irrigation improves the likelihood of a robust produce and profit to farmers.
4. Tourism and culture: Lakes and rivers anchor the province's tourism economy
5. Ecosystem Services: Water resources sustain biodiversity hotspots, including wetlands protecting plant species (Phewa watershed), migratory birds, endemic fish, and riparian forests. Environmental flows also maintain aquatic ecosystems and protect livelihoods.

6.7.4 Forces Behind Water Resource Changes

Population Growth and Distribution

Gandaki Province's population trajectory exerts fundamental pressure on water demand and infrastructure. The latest census, (CBS, 2021a) shows that the population in 2021 was 2,466,427, with an annual average population growth rate of 0.25% (2011–2021). Furthermore, the economic prosperity and modern consumption habits require higher per capita water consumption and increases water consumption footprint.

The daily per capita use rates for Nepal, as set by the DWSS, are 45 - 65 lpcd (liters per capita per day) for rural municipalities, 66 - 90 lpcd for urban municipalities, and 91 - 160 lpcd for metropolitan cities. Increase in personal income is always correlated with increased water consumption. Rapid urbanization in hubs such as Pokhara, Beni, Baglung and Nawalpur's market centers, combined with in-migration from mountain districts (Manang, Mustang, Myagdi), has sharply increased demand for domestic water supply, sanitation, solid waste services and energy – all of which require additional supply of water. The Pokhara city receives intermittent supply (few hours per day during dry seasons) causing possibilities of dysfunction. Conversely, rural hill districts face depopulation, abandoning traditional spring-fed systems complicating maintenance of dispersed infrastructure.

Population rise, consumerism leads to increased waste production, mismanagement and absence of proper disposal sites increases litter, water pollution, presence of microplastics in water body and food chains, deterioration of water bodies and water supplies.

Urbanization Trends

Rapid, often unplanned, urbanization transforms land use and hydrology. Satellite imagery analysis reveals Phewa Lake's shoreline urbanization: buildings within 200m buffer increased from 1,296 (2004) to 2,655 (2023) a 105% rise while 500m buffer structures grew 76% (Watson et al., 2023). Impervious surface expansion accelerates runoff, reduces groundwater recharge, and channels pollutants directly into water bodies reducing access to quality water.

Pokhara's urban sprawl into Phewa watershed exemplifies broader trends: forest cover declined 11.5% (2000-2020), replaced by built-up areas (+18.7%) and agriculture (+3.2%). This pattern repeats at Begnas and Rupa lakes, where road construction and settlement encroachment fragment watersheds. Urban water demand in Kaski alone totals 70,524 m^3/day drinking water, plus institutional (6,480 m^3/day) and industrial needs, stressing supply systems.

The federal restructuring after 2015, designated Pokhara as provincial capital, catalyzed infrastructure development roads, administrative complexes, commercial zones further intensifying land conversion and water service demand. Secondary towns (Gorkha, Baglung, Tanahun) undergo similar changes, albeit at smaller scales.

Agricultural Development

Agriculture remains the dominant economic sector, engaging more than 60% of the provincial workforce. Increased agriculture and intensive farming increases water requirements, most irrigation water is drawn from rain-fed rivers and streams. This disproportionately increases pressure on these sources, particularly during the dry seasons, as no irrigation is available from snow-melt driven flows in deep valleys.

The push for agricultural intensification and commercialization shifting from subsistence to market-oriented farming escalates irrigation imperatives. The provincial strategy (PPPC, 2024) targets expanding year-round irrigation from 31,841 ha (2021) toward full coverage of 173,773 ha irrigable land by 2050. This drives the water requirement. Future cropping patterns foresee modest increases in cropping intensity on suitable land (from ~155 to 164 percent) and shifts towards high-value crops and horticulture, especially in the hills and Terai pockets. High-value crops demand consistent water, increasing source depletion including groundwater extraction in Nawalpur Terai and river valleys. Pesticide and fertilizer application, aided by productivity goals, contributes nutrient loading (nitrogen, phosphorus) into rivers and lakes, exacerbating eutrophication.

Hydropower Expansion

Nation's effort to improve energy security and energy production as a means for prosperity drives large interventions along river and transmission corridors along with other associated environmental impacts. National power planning envisions hydropower capacity rising to 18,591–44,812 MW by 2050, with Gandaki contributing 8,000–12,000 MW under different scenarios. This makes Gandaki a strategic basin for national and export-oriented electricity generation, driving strong interest in storage, multipurpose and run-of-river projects.

Each project alters flow regimes. Run-of-river schemes divert water through tunnels, reducing downstream flows; storage and even peaking run-off-river projects submerge valleys, impound daily flows and modify flow dynamics. River corridors are increasingly fragmented with series of hydropower schemes, e.g. Modi, Marsyangdi rivers. The 140 MW Kaligandaki A, operational since 2002, diverts ~90 m^3/s through a 5.6 km tunnel, impacting downstream ecosystems and sediment transport turbine abrasion from high sediment loads (monsoon turbidity) necessitates annual shutdowns. Intensification of rain events and instantaneous floods, increased landslides and erosion increases siltation requirements and damages to plant components highlighting climate-hydrology-energy nexus challenges.

Industrial Growth

While limited compared to agriculture and energy, emerging industries manufacturing, processing, tourism-related services concentrate in accessible districts (Kaski, Nawalpur, Tanahu) (MoEA, 2025). Industrial water demand, though currently <1% of total consumption (Nepal-wide 0.3%), grows with economic diversification. Pokhara's beverage, textile, and construction material industries discharge effluents with inadequate treatment, contributing to Seti River pollution causing elevated BOD, chemical oxygen demand.

The provincial strategy anticipates industrial sector expansion, projecting demand increases and necessitating wastewater management infrastructure to prevent quality degradation. Cement plants, distilleries, and agro-processing units in Nawalpur and Tanahu exemplify point-source pollution risks if regulations remain unenforced.

Tourism Development

Tourism in the Pokhara–Annapurna–Manaslu corridors creates high seasonal peaks in water demand, with tourist per capita water use reported to be 3–4 times that of local residents, further stressing local streams, groundwater and lake front sources. Tourism generates seasonal water demand spikes. Phewa Lake area received 1.1 million tourists annually (pre-pandemic), with peak seasons (October-November, March-April) straining Pokhara's water supply and waste management. Hotels, restaurants, and recreational facilities discharge wastewater often untreated into lakes and rivers, elevating fecal coliform, nutrients, and solid waste burdens.

Trekking corridors within the Annapurna Conservation Area encompassing the districts of Manang, Mustang, and Lamjung support lodge-based tourism infrastructure that is largely dependent on proximal stream systems for potable water supply and wastewater disposal, thereby constituting a significant anthropogenic stressor on high-altitude aquatic ecosystems. For example, the sacred pilgrimage site of Damodar Kunda (Mustang District) exhibits recurrent episodes of solid waste accumulation and inadequate sanitation management, particularly during peak religious congregations, posing measurable risks to localized water quality and ecological integrity. Comprehensive sustainable tourism governance frameworks capable of reconciling socioeconomic development objectives with rigorous environmental protection standards remain insufficiently established across the region.

Climate Change Drivers

Climate variability and climate change also drive changes in how water resources prevail and affect their usage in the province. The climate change drive primarily emanates from temperature rise and is precipitation changes, two aspects that are readily felt by the communities.

Temperature Trends

Gandaki Province has experienced a clear and consistent warming trend over recent decades, with higher elevations warming faster than lower ones. It is estimated that historical warming continued across Nepal at 1.0–1.3°C over the 20th century, with nighttime temperatures above 4,000 m rising at nearly double the rate of those below 2,000 m (The World Bank's Climate Risk Country Profile: Nepal, 2021. At the district level, a trend analysis in lower Kaski confirmed annual increases of approximately 0.082°C in maximum and 0.08°C in minimum temperatures across all seasons from 2001 to 2017 (DHM, 2017). The Department of Hydrology and Meteorology (DHM, 2019) further reported a national maximum temperature trend of 0.056°C per year, with long-term mean temperatures projected to rise by 1.3–1.8°C, with sharper increases in the high mountains. Under the high-emissions scenario (RCP 8.5), warming could reach up to 5.5°C in the Kali Gandaki basin by the 2090s (Hi-AWARE,2018), while CMIP6 projections for the Budhi Gandaki sub-basin suggest a rise approaching 17°C under SSP5-8.5 by 2075–2100 (NDRI and APN, 2025).

These trends carry serious implications for glacier retreat, weather intensification, water resource availability, and agricultural systems across the province. Seasonal patterns show reduced cold extremes and intensified warm extremes, particularly in high mountains where glacier-fed systems dominate. Warmer temperatures drive multiple hydrological consequences - accelerated glacier/snow melt (initially boosting dry-season flows, later depleting ice reserves), altered precipitation phase (more rain, less snow at higher-altitudes), increased evapotranspiration (reducing soil moisture, crop water efficiency), and expanded GLOF and permafrost melting risks inducing landslides, floods, erosion and deposition.

Precipitation Variability

Precipitation trends across the Gandaki basin remain largely insignificant statistically, though coherent directional patterns are evident across physiographic zones. The DHM (2017) found no significant trend in All-Nepal annual or seasonal precipitation for 1971–2014; however, the High Mountain region covering much of the northern Gandaki basin recorded the highest decreasing annual precipitation trend of −3.17 mm/yr, while the Middle Mountains showed −1.58 mm/yr. Within Gandaki Province, monsoon precipitation showed significant positive trends in Syangja (9.04 mm/yr) and Parbat districts, while Kaski recorded the highest significant decreasing annual precipitation trend nationwide; post-monsoon precipitation showed a negative trend in 73 out of 75 districts across Nepal (DHM, 2017). In terms of extremes, very wet days (R95p) and extremely wet days (R99p) showed significantly decreasing trends in the northern districts of the basin, while consecutive wet days increased in the central parts of the Western Development Region (DHM, 2017). Looking ahead, CMIP6 projections suggest annual precipitation could increase by 18–45% under SSP2-4.5 in the far future, with monsoon and pre-monsoon seasons becoming wetter, while post-monsoon and winter seasons become drier (Devkota and Gyawali, 2015). The World Bank Group and Asian

Development Bank (2021) further caution that greater intra-annual variability and more intense rainfall events will elevate flood and drought risks across the basin.

Excerpts from various municipalities and government officials state an increase in intense rainfall events, more rainfall occurring in high mountain areas such as Mustang region, seasonal shifts in onsets of and retreat of rainfall, fewer rainy days but intense events were noted challenging expected patterns. Erratic rainfall undermines rainfed agriculture (90% of irrigation sources), necessitating adaptive strategies like water harvesting, reservoir storage, and diversified cropping. Extreme events cloudbursts triggering landslides, prolonged droughts reducing spring discharge increasingly characterize the "new normal.

6.7.5 Policy and Institutional Drivers

Water resources development in Gandaki Province is shaped by a multi-tiered policy architecture rooted in Nepal's Constitution, which assigns provinces direct powers over water and energy sectors. Therefore Provinces endeavor to direct development efforts to make good constitutional mandates, policy directives, and public expectations and international commitments for a prosperous and sustainable future. The Second Five-Year Plan (2024/25–2028/29) aligns with Nepal Vision 2100, the Sixteenth National Periodic Plan, and the SDG Localization Roadmap (2022–2030), ensuring that federal water commitments cascade into provincial action through annual action plans and a Medium-Term Expenditure Framework (MTEF). The following are the key policy and institutional drivers:

- Designation of River Corridors as Priority Zones: The riparian zones of the Marsyangdi, Kaligandaki, Madi, Seti, Myagdi, Chepe, and Daraundi Rivers are designated as priority investment corridors for multipurpose water resource and energy projects (Second 5-year Plan, Gandaki Province). These corridors overlap with ecologically sensitive zones including Annapurna and Manaslu Conservation Areas and Chitwan National Park buffer zones making environmental safeguarding a critical institutional challenge.
- Institutional Models for Resource Mobilization: Due to limited provincial revenue authority and heavy dependence on federal fiscal transfers, the province also relies on public-private partnerships (PPP), investment summits, public-cooperative, and public-community-NGO models to finance water infrastructure. Multiple institutional actors across project governance increases the need for coordinated environmental oversight throughout project lifecycles.
- Water Supply Coverage as a Policy Commitment: Achieving universal (100%) access to safe drinking water is a benchmark inherited from the First Five-Year Plan and continued in the current plan's Chapter 10 quantitative targets. The declaration of Pokhara as the province's Tourism Capital intensifies demand for reliable treated water supply, placing additional pressure on surface water abstraction and groundwater resources.
- Watershed Conservation as an Environmental Safeguard: Approximately 47.4% of Gandaki Province is covered by forests and shrubs; watershed conservation is designated a priority. Rural-to-urban migration and declining productive sector investment in rural areas risk degrading upstream watershed conditions that sustain downstream water supply and river flow regimes.
- Climate Risk and Environmental Vulnerability: The province policies, plans and institutions recognize Glacial Lake Outburst Floods (GLOFs), landslide blocked lake outburst floods and climate-driven disasters as key threats to water infrastructure in the province's high-mountain river systems. The second five-year plan, provincial and water sector policies and acts all attempt to mainstream climate and environmental considerations in development efforts such as to ensure that all water sector planning account for glacial retreat and shifting precipitation patterns.

6.7.6 Stresses on Water Resources

Abstraction and flow modification.

Irrigation is the dominant consumptive water use in Nepal, accounting for more than 90 percent of national withdrawals, and Gandaki reflects this pattern with extensive run-of-river and farmer-managed canals drawing from steep mid-hill streams and rivers. At the provincial scale, only about 24.5 percent of irrigable land (66,866 ha out of 272,630 ha) is currently served by modern irrigation infrastructure, creating strong incentives for further abstraction and new diversions.

Water stress is faced by farmers as the available irrigation supply is constraint at source, sources that are usually hill springs and smaller rivers. Abstraction from larger rivers is not attractive due to inappropriate cost of infrastructure and operation. Further expansion of small and medium irrigation schemes and agricultural practices, including gravity and list systems, raises dry season withdrawals in most of the sub-basins.

River corridor hydropower development such as cascade run-of-river hydropower (e.g., multiple schemes on Marsyangdi, Modi, Seti and Kali Gandaki) diverts nearly all flow through their conveyance systems leaving "dewatered reaches" with nominal releases or even none at all. Nepal's Hydropower Development Policy (2001) and subsequent guidance require projects to release at least 10 percent of minimum monthly average discharge as environmental flow, but recent national syntheses suggest that around 80 percent of projects do not effectively comply with this rule, largely due to weak guidelines and monitoring. This results in fragmented rivers with dry or low-flow stretches so that flows are for ecological and cultural needs. For example, Lower Modi 1 HEP (10 MW) and Modi Khola HEP (14.8 MW) were reported as not releasing mandatory e-flows during dry periods (JVS, 2016).

Pollution from point and non-point sources.

Water bodies are typical under pressure from point and non-point pollution. Urban centres (Pokhara, district headquarters and market towns) discharge untreated wastewater and stormwater into nearby rivers, streams and even lakes leading to high coliform levels and elevated nutrient loads in receiving water bodies. Examples include Ph Phirke Khola, Harpan Khola, Seti, Aandhi and other stream among urban centers.

Agricultural intensification increases nutrient and pesticide runoff, causing non-point pollution, which, together with sewage, drives eutrophication in aquatic systems, for example in Phea and Rupa lakes. Intensively cultivated irrigated pockets in Syangja, Kaski, Tanahun and Nawalpur adds nitrates and phosphates to draining channels and rivers and lakes.

Municipal survey respondents and documents reveal that municiaplities have no centralized sewerage systems. About 90 percent of households in Pokhara and over 97 percent in Besishahar rely on on-site septic tanks, and multiple municipalities (Galkot, Paiyun, Besishahar, Mangala, Baglung, Beni, Modi) report direct discharge of untreated effluent to rivers. Widespread reliance on on-site sanitation (septic tanks and pits) combined with limited fecal sludge management and lack of sewerage/wastewater treatment leads to leakage of sewerage, direct discharge to rivers, and microbiological contamination of groundwater, receiving surface water and even leaky distribution networks.

Industries such as cement factories, textile factories, breweries, bottling plants etc. discharge high load waste water and some with heavy metals, excessive suspended solids, and even alkaline water disrupting receiving water bodies, if unchecked.

Catchment disturbance, erosion and sedimentation.

Proliferation of poorly engineered rural roads, uncontrolled slope cultivation, sand and gravel mining and deforestation in sensitive zones accelerates hillslope erosion, gully formation and mass wasting. Runoff, some of which become increasingly intense, deliver sediments to lake inlet areas, settling basins of hydropower plants, and fill up irrigation canals. Sediments even damage turbines necessitating costly repairs.

In the Phewa watershed alone, estimated sediment deposition in Harpan Khola valley and eight sub-watersheds is about 2.784 million m^3, driving more than 50 percent reduction in lake area over five decades.

Rural roads that cut across hillsides intercept shallow aquifers and subsurface flow pathways that feed traditional springs (dhara, kuwa), causing physical disruption and long-term reduction or failure of spring discharge. These roads often act as sources of massive sediment loads, with some watersheds in the mid-hills losing over 40 tons/ha/yr of topsoil (Joshi et al., 2023). In the Chure and upstream mid-hills, deforestation and inadequate watershed management above irrigated and settled valleys exacerbate flashy runoff, gully formation and flood risks in downstream districts such as Nawalpur and parts of Tanahun and Syangja. Quarrying of riverbed material also enhances turbidity and disrupts river profiles and flow patterns.

Institutional and policy resetting.

The three-tiered governance system, as prescribed and mandated by the 2015 Constitution of Nepal has not been fully aperational in terms of policy and legal formulations, implementation and monitoring. Federal Acts and policies are still in limbo or pre-constitution Acts prevail for want of new enactments. Overlapping mandates among federal (WECS, DWRI, DoED, DoWSSM, MoFE), provincial (MoEWRD, provincial agencies) and local governments, combined with gaps in the legal framework, delayed restructuring, create fragmented decision-making and weak enforcement of environmental flows, pollution control and land-use regulations. These also create loopholes that could be exploited and be detrimental to the water sector management and development.

6.7.7 Current Condition of Water Resources

Precipitation Patterns and Trends

Gandaki Province spans all agro-ecological zones of Nepal from the Terai plains in the south to the Trans-Himalayan highlands in the north and consequently exhibits one of the sharpest precipitation gradients in the country. Annual precipitation across the Gandaki Basin ranges from as low as 152 mm in the Trans-Himalayan rain-shadow districts of Mustang and Manang to as high as 5,493 mm in the hill zone around Lumle, Kaski, owing to strong orographic forcing by the Annapurna and Dhaulagiri ranges. The summer monsoon (June–September) dominates the precipitation regime, contributing over 80% of annual rainfall; the hill zone records the highest monsoon share (~83%), while the Trans-Himalaya relies more on winter westerly disturbances and shows a bimodal pattern with peaks in May and December (DHM, 2017). The precipitation patterns across different subbasins and regions are shown in figure below.

Historical trend analyses reveal that monsoon precipitation is increasing across all agro-ecological zones while pre-monsoon and winter precipitation are decreasing significantly in most zones (Panthi et al., 2015). The Mountain zone records the steepest annual decline (−6.3 mm/year), whereas the Hill zone (Kaski, Parbat, Syangja) shows a positive annual trend, with Syangja and Parbat recording the highest significant monsoon rainfall increases nationwide (Panthi et al., 2015; DHM, 2017). A more recent station-level analysis (1990–2020) across Gandaki Province (Regmi & Acharya, 2023) confirms mixed precipitation signals: Jomsom in Mustang anomalously shows an increasing trend in both rainfall and rainy days, while maximum five-day precipitation and consecutive dry days correlate significantly with altitude pointing to heightened flood and drought risk at higher elevations.

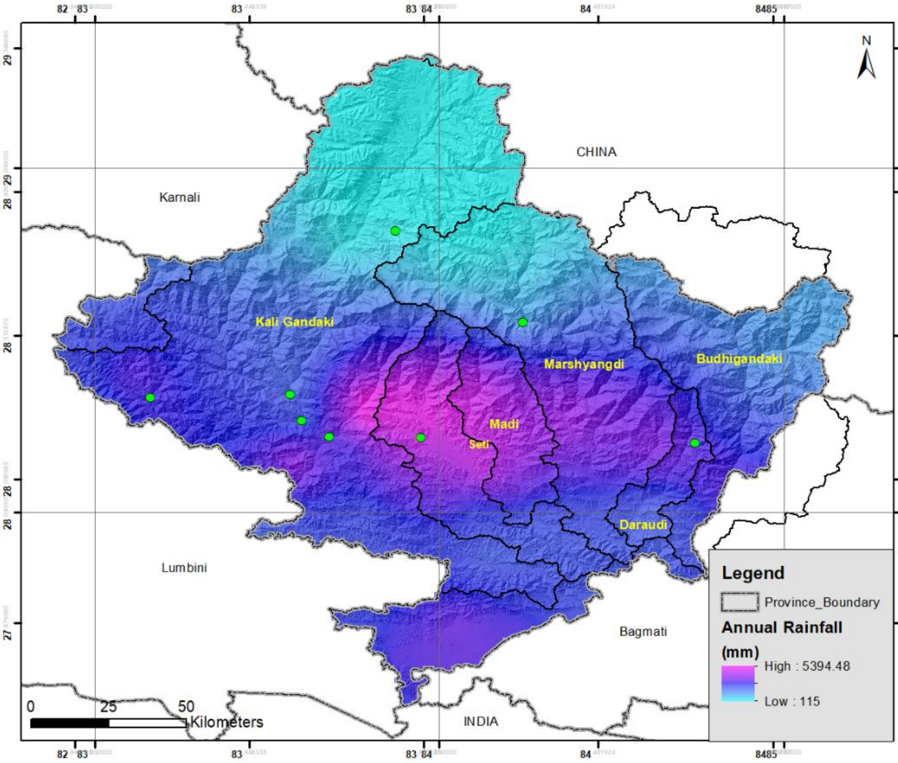


Figure 6-54. Precipitation Pattern Map Indicating Major River Basin

Extremes are also intensifying: maximum five-day precipitation and consecutive dry days show a significant positive correlation with altitude, pointing to heightened flood and drought risk at higher elevations within the province. Monsoon onset has not shifted significantly, but withdrawal is occurring later extending monsoon duration at a rate of roughly five days per decade. The skewed precipitation patterns, temporally and spatially creates surplus-to-scarcity oscillations. Dry season (December-March) flows drop to 10-20% of monsoon levels, stressing irrigation, hydropower (reduced generation), springs, groundwater and drinking water systems.

Surface Water Resources

The surface water availability of Gandaki Basins's mean annual discharge at Narayani river Devghat DHM's gauging station is 1,466 m^3/s translating to 46,232 MCM of water. This volume excludes East Nawalparasi (Nawalpur) due to absence of data. Arung Khola and Binayi Khola flow directly into the Narayani itself. The **Table 6-75** describes the river basins, estimate annual average flows and the corresponding annual volume of water available. The major uses and the qualitative summary ecological status is also indicated.

Table 6-75. River Sub-basins and Summary Uses and Status

River sub-basin	Catchment in Nepal (km²)	Estimated Mean annual flow (m³/s)	Available Annual Volume (MCM)	Major Use	Ecological status (qualitative)
Kali Gandaki	11,797	450	14,191	Hydropower, irrigation, religious rituals,	Vulnerable – siltation, fragmentation (e.g. Modi, Kali Gandaki A)
Seti	2,936	102	3,217	Urban water, tourism, Hydropower	Degraded – urban pollution

River sub-basin	Catchment in Nepal (km²)	Estimated Mean annual flow (m³/s)	Available Annual Volume (MCM)	Major Use	Ecological status (qualitative)
				aggregate mining, irrigation	
Madi	1,117	78	2,460	Hydropower, irrigation, household and livestock uses	Uplands pristine, rest at-risk
Daraudi	604	44	1,388	Hydropower, irrigation, household and livestock uses	Relatively pristine, lower reaches at-risk
Marsyangdi	4,772	211	6,654	Hydropower, tourism, rafting and adventure	Fragmented River–multiple dry loops or dewatered stretches, multi-hazard in upper reaches
Budhi Gandaki	3,607	153	4,825	Planned storage hydropower, tourism and adventure	Pristine (present) to at-risk (future projects)
Trishuli	16,777	1012	31,914	Hydropower, irrigation, local supply, aggregate mining, rafting	Mixed – from relatively healthy to at-risk

It is essential to note that water stress does occur in Gandaki Province despite having high volume of water available annually as is evident in ***Table** 6-75* above. The commonly reported high water availability is a paradox. The problem is structural, rain occurs during the four monsoon months, rivers run deep in gorges far below where people actually live and farm, and the cost of getting water from river channel to field is beyond what communities can bear. Three constraints converge timing, terrain, and economics to produce chronic scarcity inside an apparently water-rich basin. Volume is not the issue, rather access is the issue in Gandaki basin as in Nepal.

Groundwater Resources and Springs

Quantitative assessment of groundwater remains incomplete. The terai area (East Nawalparasi) and intermontane valleys (Pokhara, Gorkha) host alluvial/colluvial aquifers. Recharge estimation for Pokhara Valley is about 150-200 MCM/year (IWMI studies, 2010s). Extraction volume, currently estimated to be well below the recharge volume, is primarily via shallow wells and discharging springs, approximates 50-80 MCM/year province-wide. However, localized overexploitation is evident in Pokhara urban core area with declining water tables, drying springs and lowering groundwater table.

Throughout the mid hills and mountain areas springs exist in favorable conditions and these are traditional sources for drinking water, irrigation and other uses. Springs are natural discharge points of groundwater when the groundwater table intersects with the surface. Streams, rivers, ponds, wetlands and riverine ecosystems all feed into and from groundwater, and impacts on one are directly transferred to the other.

Baseflow of rivers are sustained by groundwater discharges, and aquifers also depend upon leakage from water bodies to build up their reserves. Detailed data on groundwater and springs in the mid-hills of Gandaki Province is severely lacking and site-specific information is limited.

In general, it is reported by most of the municipalities that the springs are drying up. Galkot's functional springs decreased from 220 to 200, and Malika's from 180 to 150. Groundwater is described as critical in Beni, Myagdi. In similar areas, across mid-hills of Nepal springs' discharges are reported to be reducing or even drying out in many parts of the country (Chapagain et al., 2020). Groundwater status is categorized as "Critical" in Galkot, Mangala, and Beni. Springs are primarily seasonal storages of water and get replenished annually unless overdraft and unsustainable extraction occur or recharge is hindered with change in precipitation patterns or drainage modifications (such as roads in hilly areas).

The groundwater potential of hills and mountains are not well researched into, but the fact remains that these are increasingly being disappearing or reducing in discharge in the recent years due to modifications to recharge areas due to urbanization, road construction and even earthquakes changing aquifer boundary properties and connectivity. The net total groundwater recharge for the southern Siwalik/Terai district is 632 MCM, though problems of drying up of shallow tube wells are reported as the shallow groundwater levels have receded beyond handpump capacity and below tube-well screens. Most water availability is at deeper aquifers.

Table 6-76. Groundwater Recharge Potential in Nawalparasi East

District	**Net total groundwater recharge [MCM per year]**			
	Bhabar Zone	Seepage Zone	Terai Zone	Total
Nawalparasi East	205	196	231	632

Sources: Irrigation Master Plan (DWIR, 2019)

Arsenic (As) contamination is the dominant groundwater quality issue in the broader Nawalparasi region with 11.69% of tested tube wells exceeding the Nepal Drinking Water Standard of 50 µg/L (NASC,2011) and all 35 samples exceeded the WHO guideline for Arsenic concentrations of 10 µg/L collected in both post-monsoon (2015) and pre-monsoon (2017) seasons. Also, nitrate contamination exceeded 20 mg/L in Nawalpur and Tanahu with e-coli bacteriological pollution in shallow dug wells near settlements indicating contamination from sewers and urea leaching in to groundwater. Earlier Pokhara valley studies on groundwater, in the 2010s, reportedly list the following (PPC,2024):

- Nitrate: 5-25 mg/L (agricultural areas), occasionally >50 mg/L near septic tanks.
- Iron/Manganese: Elevated (>1 mg/L Fe) in some deep wells, natural geogenic sources.
- Bacteriological: Shallow wells frequently contaminated (coliforms present 30-50% of samples).

Lake and Wetland Resources

There are, furthermore, 318 lakes and ponds identified and listed (LCDA, 2024) and the total aggregate area of these lakes are 33.35 km^2 during the monsoon season and shrink to 27.44 km^2 during the dry season. These lakes provide water for irrigation, water supply and bathing, recreation, religious practices and fisheries opportunities. These lakes are acutely under threat due to sedimentation, pollution, encroachment, and waste disposal. Key lakes' status (LCDA, 2024) of major lakes are as follows stating the major use of the lake:

- Phewa (3.97 km^2, 792 masl): Shrinking (-10% since 1989), eutrophic (Carlson Trophic State Index (TSI ~45-55), culturally/economically vital.

- Begnas (3.28 km², 650 masl): Stable area, moderate eutrophication (TSI ~40-50), supports aquaculture.
- Rupa (1.35 km², 600 masl): Stable, mesotrophic-eutrophic transition (TSI ~38-48), biodiversity hotspot.
- Tilicho (3.52 km², 4,919 masl): Expanding (+10% since 1976), oligotrophic, GLOF risk, tourism.
- Damodar Kunda (0.08 km², 5,000 masl): Stable, religious site, minimal data.

There is no systematic inventory of wetlands (marshes, ponds, swamps), it is estimated that there are hundreds of small systems in the province. These are increasingly being drained and facing degradation.

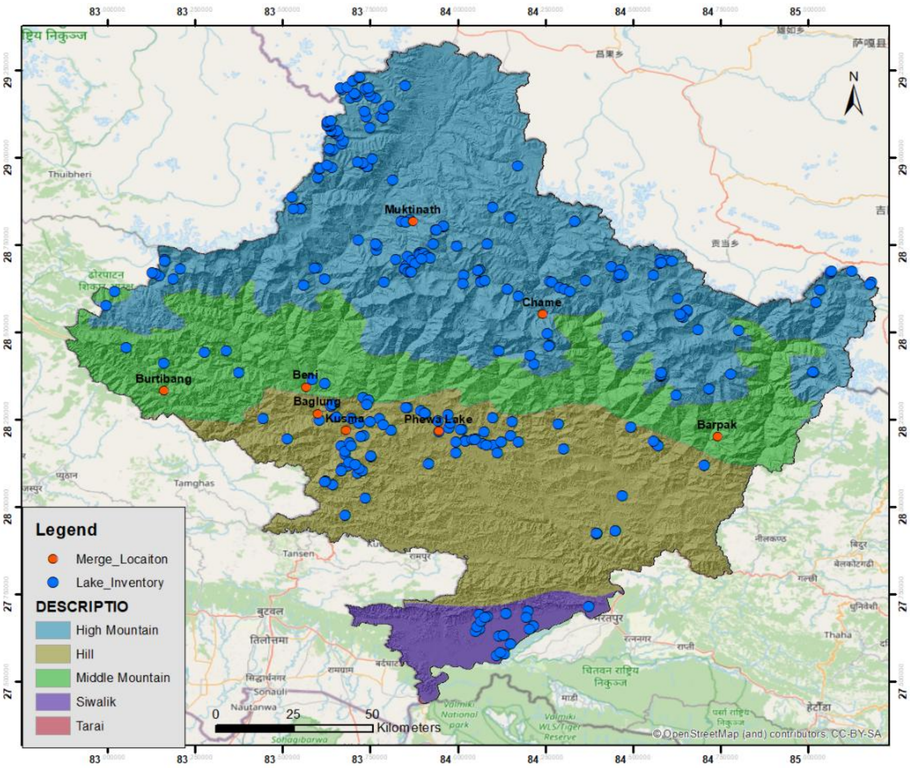


Figure 6-55. Location Lakes in Gandaki Province

6.7.8 Water Quality Status

The water quality data was not readily available as there was no regular monitoring of water quality data. The following summarizes the water quality status using information from one of disjointed studies and reports where the sampling methodologies, testing procedures may differ.

Surface Water Quality

River water quality are primarily pristine and clean in their headwaters, though these may be subject to sediment turbidity, geogenic contamination or even biological pollution if runoff accumulates from pasture land and cattle paths. When these water bodies are in proximity to anthropogenic pollution such as urban areas, then pollution levels rise up. The following is an indicative list of pollution information assimilated from various reports and studies.

River water is suitable for irrigation (all parameters within FAO guidelines), marginally acceptable for aquatic life (turbidity/hardness concerns), but are mostly unfit for drinking without treatment due to turbidity, potential pathogens and possible elevated nitrates, phosphorus near and downstream of urban centers, waste water outfalls and dumping sites. The municipal survey responses reveal that the practice of direct effluent discharge into rivers are directly contributing to the high pollution levels in Galkot, Paiyun, Besisahar, Myagdi, Kaligandaki, and Seti Rivers.

Table-6-77: Indicative Water Quality Status of Key Rivers and Lakes in Gandaki

Site	pH	DO (mg/L)	EC (µS/cm)	TDS (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Turbidity (NTU)	Key Notes / Source Type
Gandaki River (Main Stem)	7.2–8.3	6–9	80–250	70–180	<5	<0.1	Low–Moderate	Generally good chemical quality; localized turbidity near extraction/road works Basin-scale hydrochemical studies
Seti River (Pokhara)	7.0–8.2	5–8	90–220	80–170	2–8	0.05–0.2	Moderate	Urban pollution inputs; elevated nutrients and coliforms downstream of Pokhara Urban/tributary studies
Marsyangdi River	7.1–8.4	6–9	70–200	60–160	<3	<0.1	Low	Generally good, outfalls from built up areas and urban centers pollute flows, DHM & academic studies
Phewa Lake	7.0–8.4	4–8	32–104	30–80	1–6	0.05–0.3	Moderate	Clear eutrophication trend; high coliforms in inflowing Phirke Khola NepJOL / lake studies
Begnas Lake	7.2–8.5	5–8	40–120	35–90	1–4	0.03–0.2	Low–Moderate	Mesotrophic to mildly eutrophic; moderate anthropogenic influence Comparative lake WQI studies
Rupa Lake	7.1–8.3	4–7	60–150	50–120	2–7	0.1–0.4	Moderate–High	Strong eutrophication; marsh-like transitions and invasive macrophyte dominance Comparative lake WQI studies

In a water quality study (Ghezzi et al., 2019) of solutes in Marsyangdi basin, thermal springs were shown to exhibit effects of effects of CO_2 degassing and Thallium (Tl), Antimony (Sb), and Arsenic (As) were found. These are highly toxic, non-essential elements that pose severe risks to human health and the environment.

Table-6-78: Trend of Phewa Lake Water Quality (1993 – 2023)

Parameter	Median (1993-2010)	Status (2020s)	Standard/Guideline
pH	7.8-8.2	7.9-8.3	NDWQS: 6.5-8.5 ✓
DO (mg/L)	6.5-8.0	5.8-7.2	WHO: >5 ✓
BOD_5 (mg/L)	2.5-4.0	3.5-5.5	NDWQS: <5 ⚠
Total N (mg/L)	1.8-2.5	2.5-3.5	Eutrophication: >1.5 ✗
Total P (mg/L)	0.08-0.12	0.12-0.18	Eutrophication: >0.05 ✗
Secchi Depth (m)	1.5-2.2	1.0-1.6	Declining

Measurement for fecal contamination indicators, Thermotolerant Coliforms, in sample waters in Phewa Lake over October 2021 to January 2023, including monsoon, post-monsoon and winter showed that (Storey et al., 2025) dry periods concentrations were low (median 3-60 cfu/100 mL) in all lake samples and very high (median 3000-45,000 cfu/100 mL) in the urban streams. After rain, concentrations in lake samples near the urban area rose to median 400-2000 cfu/100 mL showing strong fecal contamination.

Urban water security is under stress in rapidly urbanizing areas, particularly around Pokhara, with lakes acting as pollution sinks. Urban water security risks in Gandaki Province are spatially concentrated and closely linked to lake water quality degradation rather than large river systems. Environmental water security is moderate, with lakes being the weak link rather than major rivers. Hydropower water diversion during low flow periods severely impact the river flows and the aquatic life of the rivers as practically all water is diverted and the mandatory environmental release is not practiced in diligence.

6.7.9 Future Trend in Rainfall and Water Availability

An updated study on climate change study (DHM, 2024) using CMIP6 models downscaled to 0.25° resolution, provides the most detailed and current climate projections for Nepal. The report provides the following for Nepal.

Temperature

Gandaki Province will experience significant warming across all seasons. The baseline average annual maximum temperature for Gandaki is 15.1°C, and this is projected to rise by +1.6°C in the medium term and +2.5°C by end-of-century under SSP2-4.5, escalating to +4.3°C under SSP5-8.5 (DHM, 2024). Crucially, the High Himalayan and High Mountain zones which cover Gandaki's northern districts such as Manang, Mustang, and Gorkha are projected to warm the most, with winter maximum temperatures rising by up to +4.9°C and +8.0°C respectively under SSP5-8.5 (DHM, 2024). Kaski district, the provincial hub, shows a projected winter maximum temperature rise of up to +5.2°C under SSP5-8.5 by end-of-century (DHM, 2024). Both maximum and minimum temperatures show consistently significant increasing trends throughout the projection period, with minimum temperatures rising steadily at 0.03°C/year across all future periods under both scenarios (DHM, 2024).

Precipitation

Annual precipitation in Gandaki Province (baseline: 1,425 mm) is projected to increase by 88 mm in the medium term under SSP2-4.5 and up to 479 mm by end-of-century under SSP5-8.5 a rise of over 33% (DHM, 2024). However, this overall increase masks a seasonal divergence: winter precipitation is projected to decrease by 11 mm (−8%), while monsoon precipitation could increase by up to 439 mm (+40%) under SSP5-8.5, meaning drier winters and significantly wetter monsoons (DHM, 2024). Post-monsoon precipitation for Gandaki is also projected to shift from slightly negative in the near term to a notable increase of +23 mm by end-of-century under SSP5-8.5 (DHM, 2024).

Extreme Events

Warm spell duration in Gandaki Province is projected to increase dramatically, from a baseline of 11 days to 136 days under SSP2-4.5 and 244 days under SSP5-8.5 by end-of-century, while cold spell duration declines to near zero (DHM, 2024). Consecutive dry days are projected to increase from 51 to 60 days, and extreme wet day volumes (R99p) are expected to nearly triple from 79 mm to 206 mm under SSP5-8.5, pointing to simultaneous intensification of both droughts and heavy rainfall events in the province (DHM, 2024).

6.7.10 Service Delivery Status

Drinking Water and Sanitation Service Coverage

While basic drinking water and sanitation coverage is high, large gaps remain for safely managed services, water quality compliance and wastewater treatment. Provincial indicators report that 94.25% of the population has access to basic drinking water facilities and around 18.2% has medium/high-level service. About 80% of households have improved sanitation and 99% use some form of toilet, but only about 20% of the population has access to clean and safe drinking water meeting standards, indicating major gaps in treatment, source protection and routine monitoring.

Table 6-79. Provincial WASH Coverage Indicators (Second Five-Year Plan and Ministry Data)

Indicator	2015	2022-23	2025
Population with access to basic drinking water (%)	n/a	94.25	n/a
Population with medium/high-level water supply (%)	n/a	18.2	n/a
Households with improved sanitation (%)	n/a	80	n/a
Population with clean and safe drinking water (%)	n/a	20	n/a

Table 6-80. Water Supply Sources and Scheme Counts (Ministry Submission; Household Counts for 2015 and 2020)

Category	2015	2020	2025
Households served by surface water sources	311,364	562,729	NA
Households served by spring sources	83,421	n/a	n/a

Category	2015	2020	2025
Households served by groundwater sources	27,700	28,882	n/a
Households served by other sources	5,494	20,234	n/a
No. of surface water supply schemes	2,517	n/a	n/a
No. of spring water supply schemes	6,280	n/a	n/a
No. of groundwater schemes	11	n/a	n/a
No. of other schemes	116	n/a	n/a

While basic drinking water and sanitation coverage is high, large gaps remain for safely managed services, water quality compliance and wastewater treatment. The province has made substantial progress in extending basic water supply: 94.25 percent of the population has access to basic drinking water, with 18.2 percent enjoying medium or high- level services and around 64 percent of households expected to have a household tap by FY 2023/24. Approximately 80 percent of households use improved sanitation facilities, and 99 percent use some form of toilet, following earlier open defecation free (ODF) declarations.

However, only about 20 percent of the population currently has access to clean and safe drinking water that consistently meets standards, reflecting inadequate treatment, intermittent service, contamination at source and in distribution, and limited monitoring. The problems are:

- Non-functionality: 30-50% of rural systems require rehabilitation, reconstruction, or minor repairs (leaking pipes, broken intakes, pump failures).
- Seasonal shortages: Pre-monsoon (March-May) supply drops 50-70% in hill districts as springs dry; urban areas implement rationing.
- Quality issues: Only ~25% of systems have treatment (chlorination, filtration); rest deliver raw water.
- Urban-Rural Disparity: Urban areas (Pokhara, district headquarters) achieve 90-98% piped access but intermittent supply; rural hills rely on gravity-fed community systems (85-95% coverage) with better continuity but affected by seasons.

The municipal survey responses underscores this “infrastructure–quality gap”: about 70 percent of reporting municipalities explicitly state that their schemes do not meet National Drinking Water Quality Standards, with biological contamination (coliforms, animal dung) as primary causes; in Beni, only 1 of 46 schemes meets the standard; in Galkot, about 50 percent of springs become non potable during the monsoon; and Narpa Bhumi and Dhawalagiri report widespread faecal contamination of spring sources.

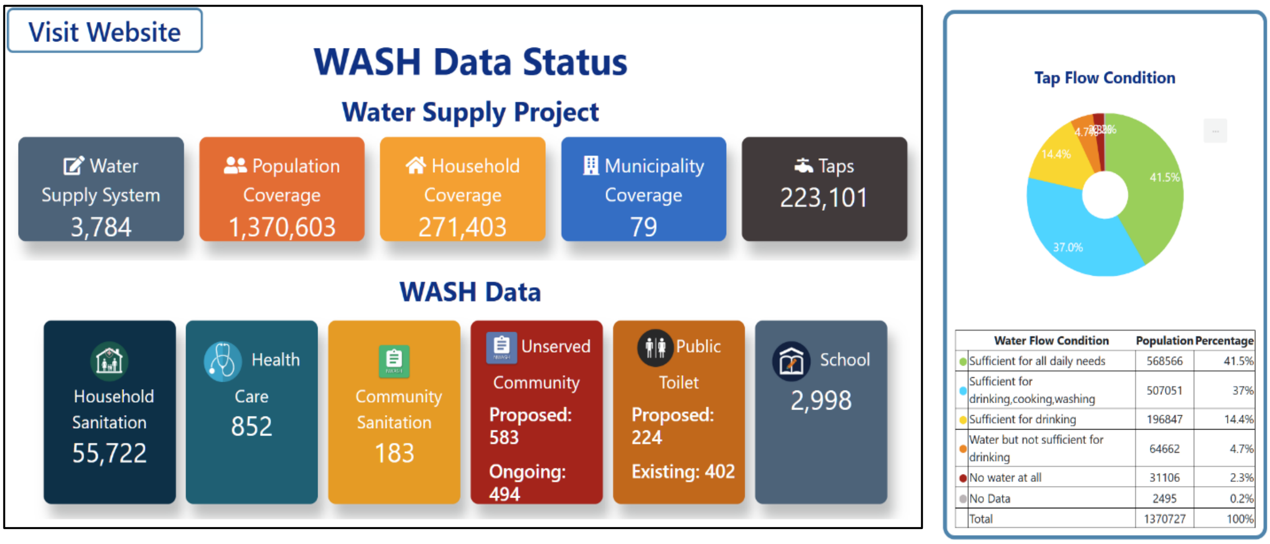


Figure 6-56: (left) Water Supply Project Status and WASH Data from NWASH Portal and (right) Tap Water Condition (10 Feb 2026)

Table 6-81: Water Supply and Sanitation Status by District (qualitative)

District	Water supply coverage & service level	Water quality & sanitation notes
Manang	Small gravity schemes and springs; sparse settlements; nominally high “access”.	Frequent biological contamination (animal dung) in spring sources; limited testing; on-site sanitation only.
Mustang	Village-level systems; some piped supplies in Jomsom/Lo Manthang areas.	Vulnerable to climate-driven source changes; septic tanks and pit latrines dominant; no centralized treatment.
Myagdi	Multiple schemes, including Beni town WSS; good nominal coverage.	Beni: only 1 of 46 schemes meets NDWQS; direct effluent discharges elsewhere in district.
Baglung	High scheme density in rural municipalities (e.g., Kathekhola 157 schemes).	Significant water-borne disease outbreaks; many schemes non-compliant with NDWQS; no dedicated environment unit/budget at municipal level.
Parbat	Mix of gravity schemes and small-town systems (e.g., Kushma WSS).	Springs declining; intermittent supply; on-site sanitation; likely bacteriological contamination during monsoon.
Gorkha	Prithvi Narayan WSS and multiple rural schemes.	Landslide risks and source instability; limited regular testing; typical reliance on septic tanks and river discharge.
Lamjung	Besishahar and rural schemes; high nominal coverage.	97% of households rely on septic tanks; direct effluent discharge to rivers reported; weak routine water quality testing.

District	Water supply coverage & service level	Water quality & sanitation notes
Kaski	Pokhara DWSC plus peri-urban and rural schemes; high private tap share.	Partial JICA-supported compliance; major microbiological and nutrient pollution in Phirke, Seti and lakes; septic tanks widespread; indirect and direct effluent discharges.
Syangja	High scheme density (e.g., Ghiring 180 schemes).	Frequent monsoon contamination; some outbreaks of water-borne disease; no sewerage; on-site sanitation and river discharge.
Tanahun	Bandipur, Damauli and rural schemes; good nominal coverage.	On-site sanitation; no centralized treatment; river pollution hotspots near settlements.
Nawalpur	Many schemes and large groundwater-based systems; high coverage in plains.	Groundwater status "critical" in Baudikali; irrigation and domestic uses competing; limited testing; monsoon turbidity and contamination issues.

All households have toilet facilities (Open Defecation Free achieved provincially), with 73.7% accessing improved sanitation such as flush/pour-flush to piped sewer or septic, ventilated improved pit latrines. Waste water treatment systems as a public utility is almost non-existent, effluent is routinely discharged untreated into rivers rivers and ponds. Waste water treatment is managed at site by users with:

- Lined septic tank (impermeable walls, open bottom): ~45%
- Unlined pit: ~25%
- Connected to sewerage: <2%
- Others (composting, bio-gas): ~3%

This poses the following challenges for waste water management.

- Low Sewerage coverage: <2% of province connected to centralized sewerage; Pokhara city has limited sewer lines (old city core), no functional wastewater treatment plant (WWTP proposed, not operational).
- Fecal sludge management: On-site systems (septic, pits) require periodic emptying; vacuum tanker services available only in Pokhara and few towns, often discharge untreated at dumpsites/rivers.
- Hygiene practices: Handwashing with soap remains suboptimal (~60% practice regularly), impacting health outcomes.

Irrigation Coverage

Gandaki has about 272,630 ha irrigable land, but modern irrigation infrastructure covers about 70,080 ha (about 25.7% of irrigable land). Dry-season irrigation remains limited in many hill areas, and some inner-Terai areas show increasing groundwater dependency.

Table 6-82: District-wise Agricultural Land With Irrigated Area Details (Source: PPPC, 2024)

District	Total Agricultural Land (ha)	Irrigated (ha)	%age area irrigated	Year-Round Irrigated (ha)	%age of Irrigated area year-round irrigated
Gorkha	26,094	7,133	27	3,456	48

District	Total Agricultural Land (ha)	Irrigated (ha)	%age area irrigated	Year-Round Irrigated (ha)	%age of Irrigated area year-round irrigated
Manang	489	91	19	72	79
Mustang	1,182	886	75	839	95
Myagdi	8,953	2,253	25	1,132	50
Kaski	19,164	10,316	54	4,313	42
Lamjung	11,083	5,524	50	2,880	52
Tanahu	26,100	7,693	29	3,629	47
Nawalpur	21,090	13,731	65	7,396	54
Syangja	24,457	6,717	27	3,898	58
Parbat	9,552	4,549	48	1,982	44
Baglung	25,609	3,509	14	2,245	64
Total	**173,773**	**62,401**	**36**	**31,841**	**51**

The Table above shows that Nawalpur has the proportion of agriculture are developed with irrigation facilities (65%) and of that area 54% has year-round irrigation. This shows that Baglung has the least agriculture area developed for irrigation, in percentage basis, and this district could be the target for developing infrastructure if economical. It is to be noted that the tabulated data is derived from older data sets and lists the agriculture land area different than previously presented. This highlights the data inconsistency and management issues in the related agencies.

Table-6-83: Irrigation Infrastructure Classification by Source of Water

Irrigation source	Area (ha)	Share (%)
Gravity (surface canals)	35,125	56%
Dam/Reservoir	7,812	13%
Pumping (river/stream)	5,975	10%
Tubewell (groundwater)	2,700	4%
Others/Mixed	10,798	17%
Total	**62,410**	

Table 6-83 above shows that surface water is the main source of irrigation in Gandaki Province and groundwater irrigation is rather low. This suggests that conjunctive use of groundwater where possible can be done to improve irrigation reliabilty.

A total of 111,363 ha (64%) of agriculture land lacks irrigation facility and only about 18% of this agriculture land is reliably irrigated limiting productivity. The rest is dependent upon rainfall for crop growth. Therefore, to enhance productivity and to improve food effective irrigation needs to be rapidly increased.

Hydropower Development

The province has 58 operational power plants larger than 1 MW generating1089.478 MW and a further 8.479 MW from plants smaller than 1 MW (DOED website, Jan 2026). The list of the HP plants are shown in **Table 6-84**.

Table 6-84: List of Hydropower Plants Greater Than 1 MW

S.N	Plant Name	District	Capacity (MW)
1	Kaligandaki 'A' HP	Syangja	144
2	Nilgiri Khola-II cascade Project	Myagdi	71
3	Middle M. HP	Lamjung	70.2
4	Marsyangdi HP	Lamjung	69
5	Super Dordi Kha	Lamjung	54
6	Upper Marsyangdi A	Lamjung	50
7	Upper Rahughat	Myagdi	48.5
8	Super Madi	Kaski	44
9	Mistry Khola	Myagdi	42
10	Nilgiri Khola	Myagdi	38
11	Karuwa Seti HPP	Kaski	32
12	Nyadi	Lamjung	30
13	Dordi Khola	Lamjung	27
14	Upper Madi	Kaski	25
15	Upper Dordi A	Lamjung	25
16	Seti Nadi hpp	Kaski	25
17	Lower Modi Khola	Parbat	20
18	Middle Modi	Parbat	18
19	Gandak HP	Nawalparasi	15
20	Modi HP	Parbat	14.8
21	Ghar Khola	Myagdi	14
22	Thapa Khola HPP	Myagdi	13.6
23	Madkyu Khola	Kaski	13
24	Namarjun Madi	Kaski	12
25	Dordi 1	Lamjung	12
26	Lower Modi-1 HP	Parbat	10.2
27	Aandikhola HP	Syangja	9.4
28	Super Chepe	Gorkha	9.05
29	Rudi A	Lamjung	8.8
30	Chepe Khola	Gorkha	8.63
31	Upper Midim Khola SHP	Lamjung	7.5

S.N	Plant Name	District	Capacity (MW)
32	Upper Mardi	Kaski	7
33	Chepe A HEP	Gorkha	7
34	Rudi Khola-B	Lamjung	6.6
35	Daraundi A	Gorkha	6
36	Rele Khola HPP	Myagdi	6
37	Siuri HP	Lamjung	5
38	Ghalemdi Khola	Myagdi	5
39	Richet Khola SHP	Gorkha	5
40	Bhim Khola Small HPP	Baglung	4.96
41	Mardi Khola	Kaski	4.8
42	Upper Machha Khola Small	Gorkha	4.55
43	Bijaypur-1 Small HP	Kaski	4.5
44	Bijaypur Khola 2 HPP	Kaski	4.5
45	Radhi Small	Lamjung	4.4
46	Khudi HP	Lamjung	4
47	Sardi Khola HPP	Kaski	4
48	Upper Chhandi Khola Small	Lamjung	4
49	Seti Khola HPP	Parbat	3.5
50	Midim Khola (Karapu) HPP	Lamjung	3
51	Daram Khola-A	Baglung	2.5
52	Upper Syange Khola Small	Lamjung	2.4
53	Tatopani HP	Myagdi	2
54	Chhandi Khola	Lamjung	2
55	Upper Richet Khola SHP	Gorkha	2
56	Seti HP	Kaski	1.5
57	Theule Khola HPP	Baglung	1.5
58	Fewa (Pokhara) HP	Kaski	1.088

These listed plants are connected to the grid, while there are a further 401 mini and micro plants with an aggregate capacity of 8.479 MW that are off-grid and serving isolated rural communities, such as the Manang's Chumanubri and Narfu villages. There are a further licensed projects as below:

- Construction license: 56 projects totalling 1,439.198 MW
- Survey license: 103 projects totaling 4242.487 MW
- Awaiting licenses: 22 projects, 1,623.87 MW

There are challenges in hydropower projects due to the following

- Sedimentation: High monsoon sediment loads (turbidity >5,000 NTU in Kaligandaki) cause turbine abrasion, reducing efficiency and necessitating costly maintenance shutdowns.
- Climate variability: Changing flow regimes (glacier melt decline, monsoon intensification) affect generation predictability. Cascading and compounding risks undermine the prospects of hydropower

projects in the mountain region with dangers of GLOF, landslide induced floods, debris flow, etc damaging the plant.

- Financing: Large projects (>50 MW) require federal approval and attract limited private investment due to regulatory complexity, PPA delays.
- Environmental compliance: EIA approvals slow; downstream impact mitigation (e-flows, fish passage) inadequately enforced, functional fish passage difficult to be operational.

Hydropower development scenarios for the Gandaki Basin indicate potential installed capacities of 4,660–7,600 MW and annual energy generation of 24,000–37,700 GWh under different investment and environmental constraint assumptions (WECS, 2024).

From an environmental state perspective, major hydropower cascades have transformed flow regimes in Marsyangdi and Kali Gandaki, introducing daily peaking, reduced minimum flows in dewatered stretches and altered sediment budgets, which together reduce habitat integrity for native riverine species, altered hydrodynamics of river channels. Longitudinal continuity in a river is disrupted by structures such as dams, weirs, diversions, etc. These impact the flow, sediment transport, fish migration, and ecosystem connectivity. These have serious implications on the aquatic species and the riverine environment.

6.7.11 Consequences of Water Resource Changes

Service reliability, health and equity

Overall service reliability, health and equity has progressed but a lot still needs to be accomplished. Water supply access has dramatically improved but poor water quality in water supply aspects yields recurrent outbreaks of diarrhoeal and other water-borne diseases in municipalities such as Baglung, Phedikhola and Galkot, and chronic exposure to unsafe water across much of the province.

Drying springs and intermittent piped supply increase collection times and coping burdens, disproportionately affecting women and children in mid-hill and Himalayan communities. It is reported that people of Dhey Valley in Mustang (Bhadra, Neupane & Khadka 2021) migrated due to lack of water and ancient homes have been abandoned. Mid hill springs in districts such as Parbat, Baglung, Myagdi and Gorkha show widespread discharge decline, with some seasonal sources having dried completely, forcing communities to shift to more distant or lower quality sources.

Urban water security is increasingly fragile, Pokhara and other growth centers face simultaneous pressures from declining lake and river health, growing groundwater abstraction, and limited treatment capacity, threatening both residents and the tourism economy.

The irrigation infrastructure facility has been enhanced by 7,679 ha in the last eight years. Rehabilitation and upgrading of traditional farmer managed systems have added another 11,537 ha with year-round irrigation. This has aided in increasing food production and income generation of farmers contributing to food security and livelihood protection. River training works of 140.45 km has been completed protecting 3,416 ha of settlements, markets, physical and cultural sites from floods and erosion.

The hydropower scene has been performing better in terms of increased production capacity of renewable energy. The impacts on environment and reduction of green house gases and improvement of quality of life metrics are yet to be adequately established and monitored.

Ecosystem Health

The overall ecosystem has been impacted by the anthropogenic interventions. These can be primarily described as the following. Environmental Flows: Cascade hydropower with poor e-flow compliance leads to long river segments with critically low flows, loss of shallow and riffle habitats, impeded fish migration and disrupted sediment transport, especially in Marsyangdi and Kali Gandaki systems. Similar cumulative assessments in Trishuli show sharp deterioration in ecosystem integrity along cascades when diversion flows are not adequately maintained, a pattern likely mirrored in Gandaki sub basins if present trends continue.

The Hydropower Development Policy, 2001, requires measures to address direct adverse impacts of water diversion from rivers by provisioning for release of environmental water at least ten percent of the minimum monthly average discharge of the river/stream or the minimum required quantum as mentioned in the EIA report (downstream ecosystem might require more water for its maintenance than 10 percent of the total discharge). Hydropower producers see the release water as a lost income, so the e-flow release has not been strictly practiced and monitored impacting environmental flows and subsequent effects.

Example: Lower Modi 1 HEP (10 MW) and Modi Khola HEP (14.8MW) were reported as not releasing the mandatory e-flow requirements during dry periods, but official reporting of missing the eflow requirement are not made. Not meeting the mandated eflow requirement impacts the following:

- Aquatic habitat degradation: Reduced wetted area, loss of pool-riffle sequences, thermal stress (higher temps in depleted reaches).
- Downstream users deprived: Communities report reduced water availability for bathing, livestock, small-scale irrigation.

Aquatic Biodiversity: Decline in diversity is reported due to dam barriers fragment populations, preventing upstream spawning migrations; flow depletion desiccates breeding grounds; pollution (urban reaches) reduces habitat quality. Gandaki rivers historically supported diverse fish assemblages snow trout (Schizothorax spp., over 8 species), mahseer (Tor spp., 3 species), catfish, carps, but these are reported by locals as becoming rare.

Tourism and recreation impacted

Lake-based tourism, centered on Lake cluster in Phewa (boating, paragliding lakeside), contributes significantly to Kaski's economy estimated 40-50% of Pokhara's tourism revenue linked to lake attractions. This has been impacted by

- **Aesthetic decline**: Algal blooms, invasive weeds, trash accumulation, shoreline encroachment reduce appeal; tourist surveys (2010s) noted declining satisfaction. Presence of plastics in lake water is unsightly, also leading to microplastics and possible health issues.
- **Recreational safety**: Eutrophic water discourages swimming; boating accidents increase with invasive plant entanglement (water hyacinth propeller jams).
- **Economic losses**: Declining visitor numbers or expenditure reductions (shorter stays) estimated at 5-10% revenue dip if degradation continues translating to tens of millions NPR annually.

Adventure tourism (river rafting on Seti, Kali Gandaki, Trishuli) depends on adequate flows and clean water; aggregate mining of rivers, hydropower diversions reducing flows in popular rafting sections (e.g., Upper Seti above Damauli) limit navigability, forcing route changes or cancellations during dry season.

Cultural/religious sites: Damodar Kunda (pilgrimage destination), Tilicho (trekker magnet) face waste management challenges—litter, human waste—degrading sacred/scenic value and risking pollution of pristine high-altitude ecosystems.

Floodplain disconnection: Reduced flood pulses prevent nutrient deposition and groundwater recharge in floodplains, converting productive wetland-agriculture mosaics to drier, less fertile lands. Traditional *char* (riverine grassland) ecosystems, supporting livestock grazing and biodiversity are reportedly diminishing.

6.7.12 Floods, Sedimentation and Infrastructure Risk

River Basin Plan flood mapping and Gandaki's climate diagnostics show increasing flood depths and extents under extreme rainfall scenarios, especially in upper Seti, Aandhi Khola, Kali Gandaki and lower Narayani reaches. Sediment-rich floods, amplified by landslides, road failures and sand–gravel mining, aggrade riverbeds and alter channels, reducing conveyance capacity and increasing future flood risk.

High sediment loads and bedload movement damage hydropower intakes, turbines and canals, clog irrigation systems and fill reservoirs and ponds, shortening infrastructure life and increasing O&M costs. Flood-induced channel migration and incision often exacerbated by over-extraction of aggregates and poorly designed river training threaten riverbank communities, roads, bridges and farmland in districts such as Nawalpur, Tanahun, Syangja and Baglung.

6.7.13 Actions and Interventions

Policy and Legal Responses

Nepal's 2015 Constitution established a three-tier federal system (federal, provincial, local) which has, fundamentally restructuring water governance. Schedule 5 to 9 of the Constitution describes exclusive and concurrent powers of the three “autonomous” governance tiers (, but current experience suggest that jurisdiction delineation has not matured yet as areas overlaps and ambiguities persist creating confusion and duplicity at times.

Table 6-85: Constitutionally Decreed Individual and Concurrent Powers of the Federal, Province and Local Governments Related to Water Resources Management

Schedule No.	Government Level	Water Resource Management and related areas
5	**Federal**	• Policies relating to conservation and multiple uses of water • Large electricity, irrigation and other projects/programs of central level, inland and interstate transmission lines • Mines excavation, national parks and wildlife reserves, forest policies, wetlands, tourism and environmental policies • Central planning, statistics, finance policies, taxes, foreign grants, aids and loans, international relations, treaties or agreements • Insurance policies, health policies, social security and poverty • Land- use policies, ports, federal civil service and security forces • Any other matter not specifically enumerated in Province and Local powers or not on concurrent lists.
6	**Provincial (State)**	• Province level electricity, irrigation and water supply services, navigation. • Use of forests and waters and management of environment within the State • Acquisition, requisitioning of and creation of right in property • Foreign grants and assistance with the consent of the Centre • House and land registration fee, agro-income tax • State civil service and other government services, State statistics • Agriculture and livestock development, trade, transportation • Exploration and management of mines
7	**Federal and Provincial**	• State boundary river, waterways, environment protection, biological diversity; Tourism, water supply and sanitation

Schedule No.	Government Level	Water Resource Management and related areas
	(Concurrent powers)	• Conservation of and utilization of forests, mountains and waters stretching in inter-State form • Industries and mines and physical infrastructures • Early preparedness for, rescue, relief and rehabilitation from, natural and man-made calamities • Land policies and laws relating thereto, insurance operation and management • Forest, mountain, protected forests water use
8	Local	• Local level development plans and projects • Water supply, small hydroelectricity projects, renewable energy • Acquisition, requisitioning of property and creation of right in property • Basic health and sanitation, Environment protection and bio-diversity • Local roads, rural roads, agriculture roads, irrigation • Agriculture and animal husbandry; Disaster management • Protection of watersheds, wildlife, mines and minerals
9	Federal, Provincial and Local (Concurrent powers)	• Agriculture, health and services like electricity, water supply, irrigation • Service fees and charges and royalty from natural resources • Forests, wildlife, water uses, environment, ecology and bio-diversity • Mines and minerals; landless squatter's management • Disaster management; Social security and poverty alleviation.

Provincial Water Sector Policies and Regulations

Gandaki Province, operationalizing devolution, enacted its First Five-Year Plan (2019/20-2023/24) and recently the second 5-year plan with water sector priorities stating energy target, irrigation expansion, drinking water coverages, and WASH improvements. However, lack of federal enabling legislation—the Water Resources Bill 2020 remains unpassed, leaving the outdated 1992 Act in force—creates legal vacuums hampering provincial action compounded by fiscal limitations.

The province has been proactive in enacting legislations and formulating strategies to streamline its business and priorities. The following are the primary highlights.

Formulation of Provincial Water Resources Strategy (2024): Gandaki Province government carried out the important task to evaluate the current state of water resources in Gandaki Province, identify existing challenges and opportunities, and propose strategic measures for sustainable water management to ensure long-term water security and socio-economic development (PPPC, 2024). The proposed strategy is defined with the following:

- Vision: "Sustainable, equitable, and climate-resilient water resource management contributing to prosperous Gandaki and happy citizens."
- Goals: (i) Universal safe drinking water and sanitation by 2035; (ii) Irrigation coverage 100% by 2050; (iii) Hydropower development 2,500 MW by 2040; (iv) Environmental flow maintenance 20%

of annual discharge; (v) Zero water-induced disaster casualties by 2030 (via early warning, infrastructure).

- Strategies: Organized under 7 thematic areas Integrated Water Resources Management, Climate Resilience and Disaster Risk Reduction, Equitable Access to WASH, Sustainable Irrigation, Hydropower Development, Environmental Conservation, Institutional Strengthening.

The strategy directs the formulation of a Provincial Water Resources Council (PWRC) chaired by Chief Minister, coordinating cross-sectoral water issues, forming River Basin Committees (RBCs), mandate water accounting and auditing; promote Public-Private Partnerships (PPPs) for hydropower (target 50% of new capacity via private investment) and water supply (performance-based contracts for service providers); integrate GESI in water resources development and management. The regulation aspect includes the following enactments.

1. Gandaki Province Irrigation Act, 2078
2. Gandaki Province Drinking Water and Sanitation Act, 2079
3. Gandaki Province Electricity Development Act, 2082
4. Gandaki Province Drinking Water and Sanitation Regulations, 2082
5. Standards for Electricity Tariff Subsidy Grants for Limited Electricity Organizations, 2082
6. Repair, Maintenance, and System Strengthening Plan Implementation Standards, 2082
7. Working Procedures for Domestic Solar Energy Installation, 2075 (2018 A.D.)

The province has also drafted the Integrated Water Resources Management (IWRM) aligning with the national policies on water resources demonstrating commitment to IWRM principles of adopting to holistic, participatory, basin-centric management. IWRM Action Plan has been drafted and is awaiting formal adoption

Improving water supply and sanitation access and coverage

- Universal drinking water access: Raise the population with access to safe drinking water from 94.25% to 100%, initiated "one house, one tap" program prioritizing underserved and remote communities
- Safe water quality assurance: Shift coverage targets from basic to safe and clean drinking water, addressing the gap where only ~20% currently have access to fully clean water
- Integrated water & sanitation programmes: Combine drinking water improvements with sanitation interventions as co-managed sectoral responsibilities under provincial law
- Repair, maintenance & system strengthening: Implement the Repair, Maintenance and System Strengthening Implementation Standards (2082) to rehabilitate deteriorating water supply systems
- Multipurpose water resource projects: Plans are ongoing to develop multipurpose projects along major rivers (Marsyangdi, Kaligandaki, Madi, Seti, Myagdi, Chepe, Daraundi) integrating irrigation, energy, and water supply to support cross-sectoral integration and optimize resources
- Starting domestic solar energy for water pumping: Expand solar installation under the *Working Procedures for Domestic Solar Energy Installation (2075)* to power rural water supply systems off-grid

Watershed & Source Protection

The provincial government has prioritized watershed conservation and reforestation is, as stated in the second 5-year plan to protect watershed areas and biodiversity zones (Annapurna, Manaslu, Chure) to sustain water source quality and flow. Priority given to lake catchments (Phewa, Begnas, Rupa). The activities include

- Reforestation: Plant 5 million seedlings (2024-2030) in degraded watersheds target species: *Alnus nepalensis* (alder), *Schima wallichii* (chilaune), *Pinus roxburghii* (pine).
- Soil conservation: Construct 1,000 km check dams (gully plugs), terracing 10,000 ha steep slopes, bioengineering (grass seeding, brush layering) on 5,000 ha
- Community forestry expansion: Handover 15,000 ha degraded forest to Community Forest User Groups (CFUGs) with management plans emphasizing watershed protection; technical support (forestry extension)
- Sedimentation control: Install sediment traps (settling basins) in 50 tributaries feeding Phewa Lake, reducing inflow sediment by 30-40%
- Monitoring: Establish 25 automatic sediment/discharge monitoring stations in key watersheds; remote sensing-based LULC change detection biannually.[ppc.gandaki.gov]
- Community participation: Engage 200 watershed committees (formed under LCDA, municipalities) in planning, implementation, benefit-sharing (payment for ecosystem services pilots

Wastewater Treatment

The policy and plan has prioritized strategic targets and already initiated the following:

- Urban sewerage: Establish/expand sewerage in 8 municipalities (Pokhara, Gorkha, Baglung, Damauli, Besisahar, Beni, Kusma, Waling); construct 5 WWTPs (aggregate 100 MLD
- Fecal sludge management: Procure 15 vacuum tankers (district coverage), establish treatment/disposal facilities (co-composting, biogas plants) in 20 municipalities; cost
- Decentralized systems: Promote constructed wetlands for institutional/community-level wastewater treatment (schools, hospitals, market centers); install 100 CWs by 2035
- Pilots: Begnas lakeside conservation wetland restoration (2023, 0.5 MLD capacity, treats hotel wastewater); Damauli municipality fecal sludge treatment plant (2024, 5 m^3/day capacity)

6.7.14 Key Issues and CHallanges

Policy Implementation Gaps

Well intended policies do not translate into intended actions and service deliveries at the local level due to implementation lags. The expected benefits do not accrue due to mismatch between policies, implementation, monitoring and corrective enforcement activities.

- Jurisdictional ambiguity: Overlap between federal-provincial-local roles especially those that are joint and collective mandates. (e.g., hydropower 1-50 MW requires provincial license but federal grid connection approval) creates bureaucratic delays, investor uncertainty).
- Budget-policy mismatch: Provincial water budget (NPR 3-5 billion/year) far below strategy requirements (NPR 15-20 billion/year needed 2024-2030 for target achievement); financing gap ~70%.
- Enforcement weakness: Environmental flow mandates, pollution standards, encroachment prohibitions exist on paper but unenforced penalties low (NPR 5,000-50,000 fines for violations), detection/prosecution rare.

While Nepal's Water Resources Act (1992), currently in force, formally recognizes drinking water and irrigation as priority uses, the economic appeal of hydropower has often overshadowed these commitments in practice leaving communities dependent on agriculture and safe drinking water at a disadvantage. This gap between policy intent and on-the-ground reality underscores the urgent need for coordinated, cross-sectoral water governance and basin-level planning that puts people and ecosystems at the center.

Data and Information Management

Absence of appropriate quality integrated water resources database for hydro-meteorological parameters, springs and groundwater, demand-side parameters, climate projections and risk assessment tools hinder planning and decision making in the provinces. There is a lack of suitable institutional set up, skillsets and capabilities to manage information and convey to decision makers. The local municipalities also lack suitable skill sets to handle the information and demands related to water sector.

Institutional Coordination

Horizontal and vertical institutional linkages among institutions working on same field or similar offices creates duplicity, ambuigities and even creates friction. This is true for offices within the province as well as those in adjacent provinces, federal and local levels. Institutions act independently unaware of other's intervention that may be impacting one's activities. Provisions to improve regular interaction and build synergies required.

For example: Federal agencies (e.g., Department of Electricity Development) bypass provincial input on licensing decisions for hydropower projects 1-50 MW (provincial jurisdiction per Constitution), causing tension and leaving out the local site stakeholders and disregarding local water priorities.

Local-provincial disconnect: 85 local governments (municipalities, rural municipalities) implement WASH, minor irrigation independently, rarely coordinating with provincial planning—resulting in duplicated efforts, incompatible systems, and missed economies of scale.

Financing and Investment

There exist severe public funding constraints, as the budgets are inadequate to address public expectations; there is over-reliance on federal transfers and outlays. Often administrative costs at multiple centers adds up recurrent costs. For example, the provincial budget shortfall is more than 70% - annual allocation NPR 3-5 billion whereas NPR 15-20 is billion needed.

Private sector participation across the water and energy sectors remains largely unrealized in Gandaki Province. In hydropower, despite a supportive PPP policy framework, investors face a maze of overlapping regulatory requirements from environmental assessments and land acquisition to power purchase agreement (PPA) negotiations that routinely stretch three to five years. Compounded by tariff disputes and political uncertainty, fewer than half of all licensed hydropower projects ever reach construction.

In the WASH sector, no Public Private Partnership as successfully taken root. Monthly water tariffs fixed between NPR 100 and 300 regardless of actual consumption fail to generate the revenue needed to attract or sustain private operators.

Irrigation presents a similar challenge: farmers contribute less than a fifth of operation and maintenance costs, with water pricing remaining a politically sensitive issue. As a result, private investment in irrigation infrastructure is virtually absent.

There is limited success in leveraging for multilateral/bilateral funds (ADB, World Bank, JICA) by the provinces as the project preparation is weak (feasibility studies, safeguards), counterpart funding unavailable, institutional absorption capacity low (slow procurement, implementation), as well as reluctance on part of the federal agencies to allow provincial bodies to link directly with external funders.

This requires exploring and identifyin innovative financing mechanisms such as Payment for Ecosystem Services (PES), green bonds, climate funds (Green Climate Fund eligibility), water funds (downstream beneficiaries paying upstream conservation), crowd funding, etc.

6.7.15 DPSIR Analysis and Synthesis on Water Resources

Water resources in Gandaki Province are shaped by strong seasonal variability, complex topography, and increasing human pressure. Although the province is water-rich at basin scale, growing demand, infrastructure expansion, and climate variability are placing stress on both water quantity and quality, particularly during the dry season and in urbanizing corridors.

The main drivers include population concentration in urban and tourism hubs, agricultural intensification, hydropower and river-corridor development, and climate change. These drivers translate into pressures such as increased abstraction, flow alteration, untreated wastewater discharge, watershed degradation from roads and slope disturbance, and rising sediment loads in rivers and lakes.

The state of water resources reflects this interaction: seasonal water scarcity, declining reliability of springs and small systems, deteriorating water quality in populated downstream reaches, and increasing sedimentation and eutrophication in lakes. These conditions generate impacts on public health, livelihoods, hydropower reliability, irrigation efficiency, tourism value, and aquatic ecosystems, with disproportionate effects on poorer and more remote communities.

Policy responses are evolving toward integrated water governance, emphasizing basin-level planning, environmental flow compliance, improved water quality monitoring, watershed protection, and ecosystem-based solutions. However, implementation remains uneven and fragmented across sectors, highlighting the need for stronger coordination and enforcement.

Table 6-86. DPSIR Synthesis for Water Resources and Quality (Gandaki Province)

DPSIR Element	Description
Drivers	Urban growth and rising domestic demand; agricultural intensification; hydropower and river-corridor development; tourism expansion; climate warming and rainfall variability
Pressures	Increased abstraction and flow modification; untreated municipal wastewater and fecal sludge discharge; agricultural runoff; erosion and sediment from roads and slope disturbance; riverbed extraction
Baseline Indicators	• Strong rainfall seasonality (majority of rainfall concentrated in monsoon months) • Large spatial contrast in precipitation (humid mid-hills vs arid trans-Himalaya) • Extensive lake system with strong seasonal fluctuation in surface area • Limited modern irrigation coverage relative to irrigable land
Current State	• Dry-season water stress in many settlements • Widespread microbiological contamination in drinking water schemes • Sedimentation and eutrophication in major lakes (e.g., Phewa, Begnas, Rupa) • Increasing turbidity and sediment loads in river systems
Impacts	Public health risks and household coping costs; reduced irrigation and hydropower efficiency; loss of lake-based tourism and fisheries value; increased flood and infrastructure damage risk
Responses	Basin-based water governance initiatives; environmental flow provisions; watershed and spring-shed protection; eco-safe roads and nature-based solutions; expansion of water quality monitoring and sanitation systems

6.7.16 Baseline, and State Indicators

The baseline condition of water resources in Gandaki Province is defined by high seasonal variability and spatial inequality rather than absolute scarcity. Monsoon-dominated rainfall provides abundant water over a short period, while dry-season flows remain limited, especially in hill and mountain settlements dependent on springs and small sources. The province's extensive lake system shows strong seasonal contraction, indicating sensitivity to both climate variability and watershed condition.

Current state indicators reveal growing stress on water safety and ecosystem health. Despite relatively high service coverage, many drinking water schemes do not consistently meet national quality standards, primarily due to biological contamination. Lakes and downstream river reaches increasingly experience sedimentation, nutrient loading, and turbidity, reflecting upstream land disturbance, inadequate wastewater management, and infrastructure-related erosion.

Table 6-87. Baseline Indicators, State and Synthesis

Indicator / Dimension	Baseline (Reference)	Current State (2022–24)	Observed Change / Trend	Synthesis
Hydro-climatic regime	Monsoon-dominated system; ~80% of annual rainfall concentrated in July–October; historically predictable seasonal flows	Increasing rainfall intensity with fewer rainy days; longer dry-season stress periods	Shift from evenly distributed rainfall to high-intensity events	Water availability is becoming more variable, increasing both dry-season scarcity and wet-season hazard
Spatial water availability	Strong physiographic contrast (humid mid-hills vs arid trans-Himalaya); local reliance on springs and small streams	Localized water stress in hill and mountain settlements despite basin-level abundance	Growing spatial inequality in water security	Basin-scale "water richness" masks growing local scarcity and inequity
River flow condition	Perennial rivers with seasonal fluctuation; limited abstraction historically	Altered flows in many river reaches due to irrigation diversions and hydropower intakes	Increasing flow modification and dry-season depletion	Environmental flow management is becoming a critical governance issue
Lakes and wetlands	318 lakes/ponds; total area ~33.35 km² (monsoon) and ~27.44 km² (dry season)	Major lakes (Phewa, Begnas, Rupa) show sedimentation and eutrophication stress	Progressive lake shrinkage and declining water quality	Lake health reflects cumulative upstream watershed and pollution pressures
Sediment and turbidity	Naturally high sediment loads during monsoon in steep catchments	Elevated sediment delivery linked to roads, slope disturbance, and intense rainfall	Increasing sediment pulses and inlet aggradation	Sediment is now a system-level water quality and infrastructure risk
Drinking water services (quantity)	Expansion of piped schemes focused on coverage	Intermittent supply common in dry season	Reliability declining despite infrastructure expansion	Water security challenge is shifting from access to reliability
Drinking water services (quality)	National standards exist, but limited monitoring historically	Many schemes fail to meet NDWQS, mainly due to biological contamination	Persistent water safety gap	Unsafe water remains a major public health concern
Irrigation development	Large irrigable potential; limited modern irrigation (24.5% coverage)	Continued dependence on traditional and seasonal systems	Pressure to expand abstraction	Irrigation growth risks increasing competition with domestic and ecological needs
Watershed condition	Historically forested slopes with localized erosion	Road-induced erosion and landslides increasingly dominant	Degradation accelerating in road corridors	Roads have become a primary driver of water-related degradation

Indicator / Dimension	Baseline (Reference)	Current State (2022–24)	Observed Change / Trend	Synthesis
Governance & monitoring	Sectoral management with limited basin integration	Growing emphasis on basin approaches, LCDA monitoring, and provincial planning	Gradual institutional strengthening	Governance reform is progressing but implementation remains uneven

The synthesis below highlights that Gandaki's water challenge is not solely about availability, but about reliability, safety, and system resilience. Addressing these issues requires treating watersheds, roads, settlements, lakes, and rivers as interconnected components of a single water system rather than as separate sectors.

6.7.17 Observed Trends, Risks, and Targeted Actions

Observed evidence across the Province suggests a clear "quantity–quality–hazard" interaction. Water availability is increasingly shaped by dry-season stress (declining spring reliability and intermittent supply) while wet-season extremes intensify turbidity, erosion, and infrastructure damage. Climate signals described in the sector draft highlight warming and increasing rainfall intensity characteristics, which amplify runoff energy and sediment movement, with implications for flood risk, lake sedimentation, and damage to intakes, canals, and local WASH systems.

Risks therefore cluster around four practical problem areas: (i) unsafe water and inadequate wastewater management, (ii) watershed degradation and erosion driven by roads and land disturbance, (iii) flow fragmentation and water competition driven by river corridor development, and (iv) multi-hazard exposure of vulnerable households. Targeted actions need to be framed as cross-sectoral because water outcomes depend on roads, settlements, tourism, agriculture, and hydropower behaving differently, not only on "water projects" behaving better.

Table 6-88. Observed Trends, Risks, and Targeted Actions

Dimension	Observed trends in Gandaki	Key risks for water & DRR	Targeted/proposed actions
Changing rainfall & drought	85% of households report delayed monsoon onset; 86% report increased drought; winter rainfall has declined markedly over recent decades.	More frequent agricultural drought, crop failure, reduced recharge of springs and shallow aquifers, and greater competition for domestic and irrigation water.	Scale up climate-smart agriculture, expand year-round irrigation, and integrate seasonal forecasts into farm and water-allocation decisions.
Heavy rainfall & flood intensity	Number of days with ≥100 mm rainfall has increased, with more intense cloudbursts and frequent heavy rains.	Higher incidence of flash floods, debris flows and riverine floods, damaging irrigation systems, WASH infrastructure, hydropower, roads and settlements.	Implement risk-sensitive land-use planning, enforce building codes in floodplains, construct and maintain protective works using bio-engineering, and expand flood early-warning systems and evacuation protocols.

Dimension	Observed trends in Gandaki	Key risks for water & DRR	Targeted/proposed actions
Glacier retreat & GLOF risk	Himalayan temperatures rising faster than national and global averages; glaciers and glacial lakes in the Gandaki basin are increasingly unstable.	Glacial lake outburst floods threatening upstream communities, hydropower plants, bridges, roads and irrigated valleys downstream.	Implement GLOF risk assessments and mitigation (lake-level lowering, monitoring), install GLOF-specific early-warning systems (target 3–8 by 2028/29), and integrate GLOF scenarios into hydropower, road and settlement planning.
Permafrost thaw & slope instability	Warming in high-mountain districts like Manang and Mustang (≈3 °C over 35 years) is accelerating permafrost melting.	Destabilization of steep slopes, damage to high-altitude roads, trekking routes and lifeline infrastructure, increased rockfall and landslide hazard.	Map permafrost and high-risk slopes, climate-proof mountain infrastructure (alignment, drainage, slope protection), and integrate monitoring into provincial hazard-mapping and early-warning programmes.
Drying of hill springs	About 84.5% of households report drying water sources; ~70% of monitored mid-hill springs show declining discharge, with some drying completely.	Rural drinking-water insecurity, time and labour burdens (especially on women and children), loss of traditional irrigation and livestock water, and climate-induced out-migration.	Protect and restore recharge zones, construct recharge ponds, regulate road cuts in recharge areas, and prioritize watershed conservation.
Landslides & erosion linked to roads	Poorly engineered hill roads and weak enforcement of environmental safeguards are increasing landslide and gully erosion across steep terrain.	Loss of agricultural land, damage to rural roads, irrigation canals and water intakes, higher sediment loads in rivers and lakes, and blockage of drainage and WASH systems.	Make environment and watershed management mandatory within infrastructure projects, apply NbS, bio-engineering and slope-stabilization measures, and require environmental impact assessments and risk audits for new roads.
Multi-hazard exposure of vulnerable households	147,985 households are identified as highly disaster-vulnerable; mortality and injury remain low but risk is rising with climate extremes.Gandaki-Province-Second-Five-Year-Plan-English-Translation.pdf	Disproportionate impacts on poor, marginalized, women-headed and remote households from floods, landslides, droughts and climate-sensitive diseases.	Expand social protection, agriculture/livestock insurance (target 70–80% coverage), community-based DRR training, and inclusive early-warning and contingency planning at local level.

6.7.18 Future Outlook of Water Resources

The future of water resources in Gandaki Province will be shaped less by absolute scarcity and more by increasing variability, uneven distribution, and cumulative watershed pressures. Although the province lies within one of Nepal's major river basins and receives substantial annual rainfall, its hydrological system is highly seasonal. Around 80 percent of rainfall occurs during the monsoon months, while dry-season flows remain limited, particularly in hill and mountain settlements that depend on springs and small streams. This structural seasonality means that even small shifts in rainfall timing or intensity can significantly affect water reliability.

Climate projections for Nepal indicate continued warming and an increase in high-intensity rainfall events. In Gandaki's steep terrain, more intense rainfall translates into stronger runoff pulses, higher sediment transport, and greater damage to intakes, canals, and local infrastructure. At the same time, longer dry spells are likely to increase competition among domestic supply, irrigation, hydropower, and ecological flow requirements. The coexistence of wet-season excess and dry-season stress will become a defining feature of provincial water management.

Lake systems are expected to remain particularly sensitive. Gandaki hosts 318 lakes and ponds, with total surface area fluctuating from approximately 33.35 km^2 in the monsoon to 27.44 km^2 in the dry season. This seasonal contraction already indicates vulnerability. Without strengthened watershed management, sedimentation and nutrient loading in major lakes such as Phewa, Begnas, and Rupa may intensify, reducing ecological health and affecting tourism and fisheries. The experience of inlet sedimentation in Phewa demonstrates how upstream land-use decisions directly shape downstream lake conditions.

Water safety will also remain a central challenge. Despite expansion of drinking water infrastructure, many schemes continue to face microbiological contamination. As temperatures rise and rainfall events become more intense, contamination risks may increase unless source protection, treatment systems, and routine monitoring are strengthened. Future investment therefore needs to shift from expanding coverage to ensuring safety and reliability.

Agricultural water demand is also likely to grow. Currently, only about 24.5 percent of irrigable land is covered by modern irrigation systems. Expansion of irrigation could improve food security, but without efficient water use and conjunctive management, it may intensify dry-season abstraction and ecological stress in smaller rivers and springs.

Infrastructure development will play a decisive role in shaping the water future. If rural roads continue to expand without eco-safe drainage and slope stabilization, erosion and sediment delivery will likely increase regardless of improvements within the water sector itself. Conversely, mainstreaming watershed safeguards into infrastructure planning could significantly reduce sediment-related risks and long-term maintenance costs.

Institutionally, the future outlook depends on whether Gandaki Province can strengthen basin-level governance, enforce environmental flow provisions, and integrate water, roads, sanitation, and land management policies. A coordinated monitoring system linking watershed condition, river flow, lake health, and drinking water safety would improve early detection of stress and allow adaptive management.

In summary, Gandaki's water future will not be determined solely by hydrology, but by governance choices. With integrated watershed protection, eco-safe infrastructure, improved water quality management, and climate-resilient planning, the province can enhance water security despite increasing variability. Without such integration, pressures on lakes, rivers, and drinking water systems are likely to intensify over the coming decades.

6.7.19 Recommendations

Gandaki Province faces compounding pressures on its water resources from fragmented river governance and unregulated mining to declining springs and safety gaps in drinking water services. Addressing these requires targeted, cross-sectoral action across five priority areas.

1. **Establish basin-level governance and e-flows:** Develop Narayani/Gandaki basin plans that define hydropower corridors, ecological "no-go" stretches, and river-specific environmental flow rules. Codify these in hydropower licensing and link e-flow compliance to power purchase agreements and license renewals.
2. **Control watershed degradation:** Enforce EIA/IEE standards for roads and quarrying in high-risk watersheds. Designate no-mining zones near confluences and critical intakes, and treat sediment management as integral to flood risk reduction not an afterthought.
3. **Shift WASH investment from coverage to safety:** Establish a province-wide water quality monitoring regime prioritizing high-risk municipalities. Redirect resources from new scattered schemes toward rehabilitating failing systems, and scale up fecal sludge treatment plants (FSTPs) beyond Beni to key urban nodes with clear cost-recovery mechanisms.
4. **Build climate-resilient irrigation and spring management:** Prioritize conjunctive use of surface and groundwater in critical irrigated valleys, and restore spring-sheds in Parbat, Baglung, Myagdi, and Gorkha through recharge structures and land-use controls linked where possible to payment for ecosystem services.
5. **Strengthen data systems and municipal capacity:** Establish an integrated provincial water information system covering hydrology, water quality, groundwater, and flood hazards. Strengthen dedicated water and environment units in municipalities, using performance-based grants tied to measurable improvements in water safety, spring health, and flood risk.

6.8 Cross Cutting: Gender Equality and Social Inclusion

6.8.1 Background

Environmental change in Gandaki Province does not affect all people equally. Gender, caste and ethnicity, age, disability status, geographic location, and livelihood shape people's exposure to environmental risks, access to natural resources, and capacity to respond to climate variability and disasters. Integrating

GESI into the SoE therefore strengthens the analytical foundation of environmental assessment and supports more equitable and effective policy responses.

Gandaki is characterized by significant ecological, social, and cultural diversity, ranging from high mountain ecosystems to river valleys and rapidly growing urban centres. This diversity is reflected in differentiated patterns of resource dependence, environmental pressure, and vulnerability. Women, Dalits, Indigenous communities, elderly persons, and persons with disabilities often experience disproportionate environmental burdens due to unequal access to land, services, information, and decision-making processes.

This chapter adopts GESI as a cross-cutting analytical lens, examining how social structures interact with environmental change across sectors such as agriculture, forestry, energy, water, urban services, and disaster risk management. Using census data (2011 and 2021), sector statistics, and policy analysis, the chapter identifies key trends, risks, and response pathways relevant to inclusive and sustainable environmental governance in the Province.

6.8.2 Population and GESI Dynamics

Population dynamics in Gandaki Province over the last decade reflect gradual demographic change combined with strong social differentiation. According to the national censuses of 2011 and 2021, the province's total population increased marginally, from 2.40 million in 2011 to 2.47 million in 2021, indicating a slow annual growth rate of about 0.25 percent (CBS, 2011; CBS, 2021a). This low growth is closely linked to long-term out-migration, declining fertility, and changing household structures. From a GESI perspective, these demographic shifts have important implications for labour availability, care responsibilities, environmental resource management, and local adaptive capacity.

Sex Composition and Gender Balance

Gandaki Province has a distinct gender composition compared to many other provinces. In 2021, women constituted 52.5 percent of the total population, while men accounted for 47.5 percent (CBS, 2021a). The sex ratio improved from 83 males per 100 females in 2011 to 90 males per 100 females in 2021, yet women continue to outnumber men. This pattern is strongly associated with male labour migration, particularly from rural and mountain districts (Springer and Almeida, 2015).

The environmental implications of this gender imbalance are significant. With men absent for long periods, women increasingly shoulder responsibility for:

- agricultural production and livestock management,
- collection of water, fuelwood, and fodder,
- participation in community forestry, irrigation, and disaster response activities,
- household-level recovery after floods, landslides, and climate shocks.

While women's responsibilities have increased, their access to land ownership, financial services, technology, and decision-making authority has not expanded at the same pace, creating a mismatch between responsibility and power.

Age Structure and Dependency

The population age structure of the Province shows a dominant working-age population (15–59 years) at 62.8 percent, with 23.9 percent below 15 years and 13.3 percent aged 60 years and above. Compared to 2011, the proportion of elderly people has increased, reflecting population ageing alongside youth out-migration. From a GESI and environmental lens:

- Women bear a disproportionate share of care work for children, elderly family members, and persons with disabilities.
- Ageing populations in rural and mountain areas increase vulnerability to climate-induced hazards, especially where access to health services, clean water, and transport is limited.
- Labour shortages in agriculture and natural resource management contribute to land abandonment in some areas and overexploitation in others.

The combination of ageing, feminization of agriculture, and environmental stress places additional pressure on women, particularly in subsistence farming households.

Household Structure and Female Headship

The number of households in Gandaki increased from 578,219 in 2011 to 662,480 in 2021, (CBS, 2011; CBS, 2021a) an increase of nearly 15 percent. This reflects both population redistribution and a trend toward smaller household sizes.

A striking GESI feature is the high share of female-headed households, which reached 41 percent in 2021, increasing since 2011. Female headship arises from multiple factors, including male migration, widowhood, separation, and women's increasing role in household management. From an environmental perspective:

- Female-headed households often rely more heavily on local natural resources due to limited cash income.
- They may face greater constraints in accessing irrigation, agricultural inputs, clean energy technologies, and post-disaster compensation.
- At the same time, women heading households often demonstrate strong local environmental knowledge and resource stewardship, particularly in community forestry and water user groups, when institutional barriers are reduced.

Migration, Vulnerability, and Environmental Pressure

Although census data capture migration only indirectly, population stagnation combined with rising female headship strongly indicates sustained male out-migration (IOM, 2023). Migration has mixed environmental effects:

- Reduced labour availability can lead to declining agricultural productivity and land abandonment in upland areas.
- Remittance income may enable investment in housing, education, and clean energy, but access is uneven across caste, ethnicity, and income groups.
- Women left behind often face increased workloads and decision-making responsibilities without commensurate institutional support.

In climate- and disaster-prone areas, households with absent male members may face additional risks during floods, landslides, and extreme weather events, especially where early warning systems, evacuation infrastructure, and relief mechanisms are not gender- and disability-responsive.

Disability, Inclusion, and Access to Services

The 2021 census reports that 2.9 percent of Gandaki's population lives with some form of disability. Disability intersects strongly with gender, age, and poverty. Women and elderly persons with disabilities often face multiple barriers to accessing:

- safe water and sanitation facilities,
- health and reproductive services,
- disaster preparedness information and evacuation support,
- participation in community institutions managing forests, water, and local infrastructure.

Environmental planning that does not explicitly consider accessibility and inclusive design risks reinforcing exclusion, particularly in urban services, public infrastructure, and disaster response systems.

6.8.3 Dalits and Ethnic Communities

Gandaki Province is one of the most socially and culturally diverse provinces in Nepal. According to census and provincial planning documents, the province is home to more than 100 caste and ethnic groups, with wide variation in language, culture, livelihoods, and geographic settlement. This diversity is a defining feature of Gandaki's social landscape, but it also shapes unequal relationships with land, natural resources, services, and environmental risks.

Caste and Ethnic Composition

Major caste and ethnic groups in Gandaki Province include Brahmin, Magar, Chhetri, Gurung, and Bishwakarma, alongside many smaller Dalit and Indigenous communities. Dalits such as Bishwakarma, Pariyar, Nepali (Sarki), and other groups constitute a significant share of the population, while Indigenous Nationalities (Janajati) such as Magar and Gurung are particularly concentrated in hill and mountain districts.

This composition has direct implications for environmental governance. Indigenous communities in Gandaki often maintain strong cultural and livelihood links to forests, pasturelands, rivers, and mountain ecosystems. Dalit communities, by contrast, have historically faced restricted access to land, water sources, and forest resources due to caste-based exclusion, shaping long-term patterns of vulnerability.

Spatial Distribution and Environmental Exposure

Caste and ethnic groups in Gandaki are not evenly distributed across space. Many Indigenous communities reside in upland and mountain areas, where livelihoods depend on rain-fed agriculture, livestock, and forest resources (Sujakhu et al., 2019). These areas are highly exposed to climate variability, landslides, drought, and ecosystem degradation. Dalit households are more commonly found in:

- marginal lands with lower agricultural productivity,
- riverbanks and flood-prone areas,
- informal or unplanned settlements in peri-urban and urban areas.

As a result, Dalits often experience higher exposure to environmental hazards, including floods, landslides, poor sanitation, and pollution, while having fewer assets and coping mechanisms to manage these risks.

Livelihoods, Natural Resources, and Social Exclusion

Livelihood patterns differ sharply across caste and ethnic groups:

- Indigenous communities traditionally rely on subsistence farming, animal husbandry, forest products, and seasonal migration, making them sensitive to environmental degradation and climate change.
- Dalit households are disproportionately represented among landless or near-landless populations, informal labourers, and wage workers, limiting their ability to benefit from natural resource-based livelihoods.

Restricted access to land ownership and productive assets means Dalit households are often excluded from irrigation systems, agricultural extension services, and compensation mechanisms related to land acquisition or disaster recovery (Aryal and Holden, 2013). Even where formal access exists, social norms and power relations may limit effective participation in community forestry user groups, water user associations, and local planning forums.

Gender, Caste, and Intersectional Vulnerability

Within Dalit and Indigenous communities, women face layered disadvantages. Dalit women, in particular, experience intersecting discrimination based on gender, caste, and economic status (Sharma and Geetha, 2021). This intersectionality is visible in:

- heavier workloads related to fuelwood and water collection,
- limited access to education and skills training,
- exclusion from leadership roles in environmental institutions,
- higher vulnerability during disasters due to mobility constraints and social marginalization.

Indigenous women possess rich ecological knowledge related to seed systems, forest management, and traditional coping strategies. However, this knowledge is often underrepresented in formal environmental planning and climate adaptation programmes.

Institutional Participation and Voice

Although legal frameworks promote inclusion, meaningful participation of Dalits and Indigenous peoples in environmental decision-making remains uneven. Representation in community forestry user groups, conservation committees, and local planning processes has improved numerically, but leadership and influence over decisions often remain concentrated among socially dominant groups.

For Indigenous communities, conservation and protected area management have sometimes restricted traditional resource use without adequate consultation or benefit-sharing (Springer and Almeida, 2015). For Dalits, participation barriers are compounded by historical exclusion, low literacy levels, and limited access to information (Karuga et al., 2023).

6.8.4 Education, Health, and Employment

Education, health, and employment are central to understanding how different social groups in Gandaki Province experience environmental change and climate risks. These dimensions' shape people's ability to access information, adopt new technologies, participate in decision-making, and recover from environmental shocks. From a GESI perspective, persistent disparities across gender, caste/ethnicity, location, and disability status continue to influence environmental outcomes (Karuga et al., 2023).

Education and Environmental Capacity

Census data show that Gandaki Province has made notable progress in education, with an overall literacy rate of 81.7 percent in 2021 (CBS, 2021a). However, this progress masks substantial gender and social gaps. Male literacy stands at 88.8 percent, while female literacy is 75.3 percent, reflecting long-standing inequalities in access to education (CBS, 2021a).

Educational disparities have direct environmental implications. Lower literacy and educational attainment among women and marginalized groups limit:

- access to climate and disaster early warning information,
- understanding and adoption of improved agricultural practices,
- uptake of clean energy technologies and water treatment methods,
- participation in local planning and environmental governance processes.

In rural and mountain areas, where environmental dependence is high, limited education constrains households' ability to diversify livelihoods and adapt to climate variability. Girls' education is particularly important for long-term environmental resilience, as it influences health outcomes, family size, and intergenerational transmission of environmental knowledge.

Health, Environment, and Unequal Burdens

Health outcomes in Gandaki are closely linked to environmental conditions such as water quality, sanitation, air pollution, waste management, and exposure to climate-related hazards. While provincial-level health indicators have improved over time, environment-related health burdens are unevenly distributed. Women and children are disproportionately affected by:

- indoor air pollution from biomass-based cooking,
- unsafe water and inadequate sanitation,
- increased care burdens during disease outbreaks and disasters.

Marginalized communities, including Dalits and residents of informal settlements, face higher exposure to polluted environments and lower access to quality health services. For persons with disabilities and elderly populations, environmental barriers such as inaccessible water points, toilets, and health facilities further increase vulnerability, particularly during floods, landslides, and extreme weather events.

Climate change is expected to intensify these health risks through heat stress, vector-borne diseases, and more frequent disasters, placing additional strain on households with limited adaptive capacity (WHO, 2023).

Employment Structure and Gendered Labour Patterns

The structure of employment in the Province reflects a transition from traditional agriculture toward services and foreign employment, but agriculture remains a key livelihood for a large share of the population.

Women's labour participation is high, yet it is often concentrated in unpaid family labour and informal work (Karuga et al., 2023). Women are heavily involved in:

- subsistence agriculture and livestock care,
- post-harvest processing,
- collection of fuelwood, fodder, and water,
- household-based enterprises.

These activities are highly sensitive to environmental change. Climate variability, declining soil fertility, water scarcity, and forest degradation directly affect women's workloads and productivity. At the same time, women's contributions are frequently undervalued in economic statistics and policy planning.

Men's employment is more likely to be linked to wage labour, construction, transport, and migration, exposing them to different environmental and occupational risks, including workplace hazards and climate-induced disruptions.

Occupational Health and Environmental Risk

Employment-related environmental risks vary by sector and social group (Amadio et al., 2023). Agricultural workers face exposure to:

- extreme weather events,
- agrochemicals,
- water scarcity and crop failure.

Urban and peri-urban workers, particularly those in informal sectors such as waste picking, construction, and small-scale manufacturing, are exposed to:

- air and water pollution,
- unsafe waste handling,
- heat stress.

These risks are often compounded for Dalits, women, and migrants, who are overrepresented in hazardous and informal occupations and have limited access to occupational health and safety measures.

Education, Skills, and Green Transitions

As Gandaki Province moves toward cleaner energy, sustainable agriculture, and climate-resilient infrastructure, education and skills development become critical. Without targeted interventions, green transitions risk benefiting those who are already better educated and resourced. GESI-sensitive education and employment strategies are therefore essential to:

- ensure women and marginalized groups can access green jobs,
- support skills development in renewable energy, waste management, and climate-smart agriculture,
- prevent widening inequality during environmental and economic transitions.

6.8.5 Women in Agriculture and Household Activities

Women play a central role in agriculture, household management, and natural resource use in Gandaki Province. Over the last decade, demographic change, male out-migration, and environmental stress have intensified the feminization of agriculture and household environmental responsibilities (CBS, 2021a). Census and sector data clearly show that women's contribution to food production, resource management, and household resilience has increased, while structural constraints on access to land, technology, finance, and decision-making largely persist.

Feminization of Agriculture

Agriculture remains a major livelihood in Gandaki Province, particularly in rural and mountain areas. Census and agricultural statistics indicate that a significant proportion of economically active women are engaged in agriculture, largely as own-account workers or unpaid family workers, rather than as formal employees. The 2021 census (CBS, 2021b) shows that women are disproportionately represented among (Brown, 2020; CBS, 2021a):

- contributing family workers, and
- subsistence agricultural labourers, while men are more likely to be categorized as employees, employers, or migrants.

This pattern reflects sustained male migration from rural areas, which has transferred responsibility for farming, livestock management, and natural resource use to women. In many hill and mountain communities, women now manage:

- land preparation and planting,
- seed selection and storage,
- livestock feeding and health,
- irrigation scheduling,
- harvesting and post-harvest processing.

Despite this responsibility, women's control over productive assets remains limited. Census data on asset ownership indicate that a large majority of households report no female ownership of land or housing, while only a smaller share report female ownership of land, housing, or both. This imbalance directly affects women farmers' access to agricultural credit, extension services, insurance, and compensation following climate-related losses.

Women, Land, and Tenure Security

Land ownership is a critical determinant of agricultural decision-making and climate resilience. In Gandaki, women's land ownership has improved gradually over time, but remains far below parity. Where women cultivate land without formal ownership or joint titles, they face:

- limited access to subsidized agricultural inputs,
- exclusion from formal irrigation and water user associations,
- weaker bargaining power in household and community decisions,
- reduced eligibility for post-disaster relief and reconstruction support.

For Dalit and Indigenous women, land tenure insecurity is often compounded by caste-based exclusion and geographic marginality, reinforcing cycles of vulnerability and environmental dependence.

Household Environmental Responsibilities and Time Poverty

Beyond agriculture, women carry primary responsibility for household-level environmental management (Abdulsalam et al., 2024). This includes:

- collection of water for drinking, cooking, and livestock,
- collection of fuelwood and fodder,
- waste management within and around the home,
- maintenance of household sanitation.

Census and sector studies consistently show that women and girls spend significantly more time than men on unpaid care and domestic work. In rural Gandaki, this time burden increases during:

- dry seasons, when water sources become distant,
- periods of forest degradation or restricted access,
- climate shocks such as droughts and landslides.

Time poverty limits women's ability to participate in education, skills training, paid employment, community leadership, and local environmental governance, even where formal inclusion policies exist.

Climate Change, Agricultural Risk, and Women's Workload

Climate variability is already affecting agricultural systems in Gandaki Province through:

- erratic rainfall patterns,
- prolonged dry spells,
- increased incidence of landslides and soil erosion,
- pest and disease outbreaks.

Women farmers are often the first to experience these impacts, as they are responsible for daily farm management and food provisioning. Crop failure or livestock loss translates directly into increased labour demands, reduced household nutrition, and heightened stress. Studies on gender and climate solutions emphasize that women farmers possess substantial local knowledge related to:

- crop diversity and seed conservation,
- soil and water management,
- coping strategies during climatic stress.

However, this knowledge is rarely integrated systematically into agricultural extension services or climate adaptation planning.

Energy Use, Cooking, and Health Implications

Household energy use is another domain where women's roles intersect with environmental and health outcomes. A large share of households in Gandaki particularly in rural and mountain areas continue to rely on biomass fuels such as firewood and agricultural residues for cooking (WECS, 2024). Women are the primary cooks and fuel collectors, exposing them to:

- indoor air pollution,
- respiratory and eye diseases,
- musculoskeletal strain from fuel collection.

Although clean cooking and renewable energy programmes exist, access remains uneven, particularly for poor, remote, Dalit, and female-headed households. Where climate and energy financing mechanisms are not explicitly gender-responsive, they risk bypassing the women who bear the greatest costs of traditional energy systems.

Women as Environmental Managers and Change Agents

Despite these challenges, women in Gandaki Province play a critical role as environmental stewards and agents of change (Abdulsalam et al., 2024; Karuga et al., 2023). Women's participation in community forestry user groups, irrigation committees, and savings groups has expanded over time, and evidence shows that women-led or women-inclusive institutions often demonstrate stronger outcomes in forest protection and resource sustainability.

However, participation does not automatically translate into influence. Women especially Dalit and Indigenous women remain underrepresented in executive positions and technical decision-making roles, limiting their ability to shape resource allocation and adaptation strategies.

6.8.6 Implications of Climate Change for GESI

Climate change and environmental degradation in Gandaki Province interact strongly with existing gender and social inequalities, shaping who is most exposed to risk and who has the capacity to adapt. Evidence across population dynamics, livelihoods, environmental services, and governance shows that environmental change is not socially neutral; rather, it tends to reinforce pre-existing disparities unless explicitly addressed.

Census data indicate that Gandaki already exhibits a strong feminisation of responsibility**.** In 2021, 41% of households were female-headed, reflecting sustained male out-migration. As climate hazards such as floods, landslides, droughts, and heat stress intensify, women are increasingly responsible for managing households, agriculture, and natural resources, often with limited access to assets and institutional support.

Adaptive capacity is further constrained by persistent asset inequalities. Female ownership of land and housing remains low, despite gradual improvement since 2011. This limits women's access to credit, agricultural services, climate finance, insurance, and post-disaster compensation, reducing their ability to recover from environmental shocks.

Unequal access to environmental services amplifies these vulnerabilities. While basic service coverage appears high at the provincial level, significant gaps remain in water quality, sanitation, clean cooking energy, waste management, and disaster protection particularly in Dalit and marginalized ethnic settlements. These gaps translate into higher health burdens, increased time poverty (especially for women), and lower resilience under climate stress.

Education and information access also shape climate resilience. Although literacy has improved, a substantial gender gap persists, limiting women's access to early warning information, climate-smart technologies, and emerging green livelihood opportunities. As climate adaptation increasingly relies on technical knowledge and digital systems, such gaps risk widening inequalities.

Demographic ageing and disability further compound climate vulnerability. A growing share of elderly persons and persons with disabilities face heightened risks during disasters where infrastructure, evacuation systems, and services are not accessible or inclusive.

For Dalits and Indigenous communities, climate impacts intersect with long-standing exclusion from land, services, and decision-making. Environmental degradation and conservation measures can reinforce social hierarchies when customary rights, traditional knowledge, and equitable benefit-sharing are not adequately recognized. Participation alone is insufficient; power, voice, and control over resources are critical.

The evidence underscores that GESI is central to climate resilience and environmental sustainability in the Province. Environmental and climate policies that focus only on biophysical outcomes risk being ineffective or inequitable. Integrating GESI through disaggregated data, inclusive services, tenure security, and responsive governance is essential to ensure that climate and environmental actions strengthen resilience rather than reproduce inequality.

6.8.7 GESI Policy Instruments

Over the past two decades, Nepal has developed a relatively strong policy and legal framework for gender equality and social inclusion. Gandaki Province operates within this national framework while also advancing its own provincial-level plans and sectoral strategies. However, evidence from environmental and climate-related sectors shows that policy commitments have not yet translated consistently into gender-transformative and socially inclusive outcomes, particularly at the implementation level.

Constitutional and National Policy Framework

The Constitution of Nepal establishes equality, social justice, and inclusion as fundamental state principles. It explicitly guarantees:

- non-discrimination on the basis of gender, caste, ethnicity, disability, and geography,
- women's rights to proportional inclusion in state structures,
- rights of Dalits, Indigenous peoples, persons with disabilities, senior citizens, and marginalized communities,
- the right to a clean and healthy environment.

Building on this constitutional mandate, national policies such as the GESI Policy, National Women's Policy, Climate Change Policy, and Disaster Risk Reduction and Management Act incorporate inclusion as a core principle. These instruments emphasize participation, access to resources, benefit-sharing, and protection of vulnerable groups in development and environmental governance.

From an SoE perspective, these policies provide a strong normative basis for integrating GESI across environment-related sectors such as forestry, water resources, energy, agriculture, and urban development.

GESI in Climate Change and Environmental Policies

Nepal's climate change policies recognize that climate impacts are socially differentiated and that women, the poor, and marginalized communities are disproportionately affected. Gender-responsive adaptation, local participation, and community-based approaches are highlighted as priority strategies. However, assessments of climate finance and programme implementation indicate that:

- GESI is often treated as a cross-cutting requirement rather than a core design principle,
- gender considerations are frequently limited to participation targets rather than outcomes,
- social inclusion dimensions (caste, disability, indigeneity) receive less attention than gender alone.

This pattern is also reflected in climate budgeting and project documentation, where gender markers are present but not always linked to clear, measurable changes in women's agency, access, or control over resources.

Provincial Policy and Planning Instruments

At the provincial level, Gandaki's periodic plans and sector strategies explicitly acknowledge GESI as a development priority. The provincial development plans emphasize:

- inclusive economic growth,
- women's empowerment,
- protection of marginalized groups,
- climate resilience and environmental sustainability.

GESI is mainstreamed across thematic areas such as agriculture, forestry, energy, tourism, and infrastructure. The province has also adopted gender-responsive budgeting principles aligned with federal guidelines. Despite this formal integration, several gaps remain evident:

- GESI commitments are often broad and aspirational, with limited operational guidance for sector agencies,
- monitoring indicators focus more on inputs and participation than on outcomes and impacts,
- coordination between social development, environmental, and climate-related institutions is weak.

Gender-Responsive and Climate Budgeting

Nepal's gender-responsive budgeting (GRB) system is internationally recognized, and climate budget tagging has been introduced to track public expenditure related to climate change. In theory, these tools offer strong leverage to advance GESI in environmental sectors. In practice, analysis of climate and gender budget documents shows that:

- a large share of climate-related spending is classified as "gender-neutral" or "indirectly gender-responsive,"
- budget tagging does not always reflect actual benefits reaching women and marginalized groups,
- local governments often lack technical capacity to design and track genuinely gender-transformative climate investments.

As a result, financial flows do not consistently align with the stated objective of prioritizing the most vulnerable populations in climate and environmental programmes.

Institutional Arrangements and Capacity Constraints

Institutionally, responsibility for GESI is often assigned to specific units or focal persons within ministries and local governments. While this helps ensure visibility, it can also lead to compartmentalization, where GESI is seen as the responsibility of a single desk rather than a shared mandate. Common challenges include:

- limited technical capacity to apply intersectional analysis,
- inadequate use of sex- and caste-disaggregated data,
- insufficient training of sector staff on GESI in environmental planning,
- weak accountability mechanisms linking GESI commitments to performance evaluation.

These constraints are particularly evident at the local level, where environmental decisions are increasingly being made, but resources and expertise remain limited.

Civil Society and Community-Level Instruments

Civil society organizations, community groups, and user committees play an important role in translating policy into practice. In Gandaki, women's groups, community forestry user groups, cooperatives, and Indigenous organizations have contributed to:

- inclusive forest management,
- community-based adaptation,
- awareness on climate and environmental rights.

However, reliance on community institutions alone cannot substitute for systemic reform. Without supportive policies, secure financing, and strong accountability, community-level gains remain fragile and uneven.

6.8.8 GESI baseline Indicators

This section presents a set of core GESI indicators relevant to environmental conditions, vulnerability, and governance in Gandaki Province. Indicators are selected based on data availability, policy relevance, and their direct or indirect links to environmental management, climate resilience, and sustainable development. Where possible, Census 2011 is used as the baseline and Census 2021 as the current state.

Table 6-89. Core GESI Indicators for Gandaki Province

Indicator	Baseline (2011)	State (2021)	Change (2011–2021)	GESI & Environmental Synthesis
Total population (million)	2.40	2.47	Slow growth	Low population growth combined with migration reshapes labour availability and local environmental management, especially in rural areas.
Sex ratio (males per 100 females)	83.1	90.4	Improved, but still female-skewed	Persistent feminisation of rural households increases women's responsibility for agriculture, natural resource use, and climate adaptation.
Female-headed households (%)	~39.7	41.0	Moderate increase	Female-headed households face higher exposure to environmental risk due to limited asset ownership and access to services, despite increased responsibility.

Indicator	Baseline (2011)	State (2021)	Change (2011–2021)	GESI & Environmental Synthesis
Working-age population (15–59 years, %)	~63	62.8	Slight decline	Out-migration and ageing reduce labour availability for agriculture and environmental management, increasing women's workload.
Population aged 60+ (%)	~9–10	13.3	Significant increase	Ageing population raises care burdens (mostly on women) and vulnerability to climate and disaster risks.
Literacy rate – total (%)	~66	81.7	Strong improvement	Higher literacy supports adaptive capacity, but uneven gains limit inclusive participation in environmental governance.
Literacy rate – male (%)	~75	88.8	Large improvement	Men benefit more from educational gains, reinforcing gender gaps in access to information and skills.
Literacy rate – female (%)	~57	75.3	Improvement, gap persists	Gender gap in literacy constrains women's access to climate information, technology, and leadership roles.
Population with disability (%)	~1.9	2.9	Increase (better reporting)	Persons with disabilities face heightened environmental vulnerability due to inaccessible infrastructure and disaster systems.
Female ownership of land/house	Very limited	Improved but still low	Slow progress	Limited asset ownership restricts women's access to agricultural services, climate finance, and post-disaster compensation.
Women in unpaid family/agricultural work	High	High	Minimal structural change	Environmental degradation and climate stress disproportionately affect unpaid and informal women's labour.
Median age at first marriage – female (years)	<18	18	Improvement	Delayed marriage improves education and adaptive capacity, but early marriage remains a social risk in some groups.

Overall, GESI indicators for Gandaki show clear social progress since 2011, particularly in education and demographic balance. However, structural inequalities persist in asset ownership, unpaid labour, decision-making power, and exposure to environmental risk. These inequalities shape who bears the costs of environmental degradation and climate change, and who benefits from environmental investments.

6.8.9 Dalit and Ethnic Community Related GESI Indicators

This sub-section presents selected indicators relevant to Dalits and ethnic (Indigenous Nationalities) communities in the Province. Due to limitations in caste- and ethnicity-disaggregated environmental datasets, the indicators draw primarily on Census 2011 (baseline) and Census 2021 (state) social structure variables that strongly influence environmental exposure, access to resources, and adaptive capacity. These indicators are used as proxies for environmental vulnerability and inclusion, consistent with international GESI and environment assessment practice.

Table 6-90. Dalit and Ethnic Community Related Indicators

Indicator	Baseline (2011)	State (2021)	Change / Trend	GESI & Environmental Synthesis
Share of Dalit population (%)	~13–14%	Similar proportion	Largely stable	Dalit households remain disproportionately exposed to environmental risk due to land poverty, settlement in marginal or hazard-prone areas, and limited access to services.
Share of Indigenous Nationalities (Janajati) (%)	~38–40%	Similar proportion	Stable	Indigenous communities' close dependence on forests, rangelands, and mountain ecosystems makes them highly sensitive to climate change and biodiversity loss.
Literacy rate – Dalit (%)	Significantly below provincial average	Improved but still lower than non-Dalit groups	Persistent gap	Lower literacy limits access to climate information, early warning systems, extension services, and participation in environmental decision-making.
Literacy rate – Indigenous groups (%)	Below or near provincial average (varies by group)	Improved, uneven	Uneven progress	Education gains are not uniform across groups, affecting adaptive capacity and access to green livelihood opportunities.
Land ownership among Dalits	Very limited	Marginal improvement	Structural constraint persists	Landlessness restricts access to irrigation, agricultural subsidies, climate finance, insurance, and post-disaster compensation mechanisms.
Employment type (Dalits)	High share in wage labour and informal work	Continued dominance	Limited structural change	Informal and hazardous occupations increase exposure to pollution, waste, heat stress, and climate-related health risks.
Housing quality (Dalit households)	Higher share of temporary or low-quality housing	Improved, but gap remains	Partial improvement	Poor housing quality increases vulnerability to floods, landslides, heat stress, and earthquakes.
Access to basic services by caste/ethnicity	Unequal access	Gradual improvement	Gaps remain	Dalit and marginalized ethnic settlements continue to lag in safe water, sanitation, waste management, and clean energy access.
Participation in community institutions	Limited effective participation	Numerical participation increased	Influence remains constrained	Representation does not consistently translate into decision-making power or benefit-sharing in forest, water, and local development institutions.

Caste- and ethnicity-disaggregated environmental indicators are limited in official datasets. This State of Environment therefore uses social and livelihood indicators from the national censuses as proxies to assess differential environmental vulnerability and inclusion among Dalits and ethnic communities.

The indicators reveal that social identity remains a key determinant of environmental vulnerability in Gandaki. While overall social indicators have improved since 2011, Dalits and many Indigenous communities continue to face structural disadvantages related to land ownership, housing quality, education, and employment. These disadvantages shape who is most exposed to environmental hazards and who has the least capacity to adapt.

Improvements in service access and participation are evident, but they have not yet translated into equitable control over resources or decision-making authority. Environmental and climate programmes that do not explicitly address caste- and ethnicity-based inequalities risk reinforcing existing patterns of exclusion, even when overall environmental outcomes improve.

6.8.10 Future Outlook of GESI

The future trajectory of gender equality and social inclusion in Gandaki Province will be shaped by the interaction of demographic change, environmental stress, climate change, economic transformation, and governance responses**.** Current trends suggest that while social indicators are likely to continue improving gradually, inequalities in exposure, access, and adaptive capacity may persist or deepen unless explicitly addressed through targeted and inclusive environmental policies.

Demographic and Social Trends

Population growth in Gandaki Province is expected to remain slow, with continued male out-migration and an increasing share of women, elderly persons, and female-headed households. These trends point toward a further feminization of agriculture and natural resource management, particularly in rural and mountain areas.

At the same time, population ageing will increase care demands and health vulnerabilities, placing additional pressure on women's unpaid care work. Without supportive services and gender-responsive infrastructure, these demographic changes may reduce household resilience to environmental and climate shocks.

Climate Change and Differential Vulnerability

Climate projections for Gandaki indicate increased variability in rainfall, rising temperatures, and higher frequency of extreme events such as floods, landslides, droughts, and heat waves. These changes are likely to affect different social groups in unequal ways. Women, Dalits, Indigenous communities, elderly persons, and persons with disabilities are expected to face:

- higher exposure to climate-induced hazards due to settlement patterns and livelihood dependence,
- greater sensitivity because of reliance on natural resources and limited access to services,
- lower adaptive capacity linked to asset poverty, education gaps, and exclusion from decision-making.

Unless adaptation measures are explicitly inclusive, climate change risks reinforcing existing social inequalities.

Agriculture, Livelihoods, and Environmental Change

Agriculture in Gandaki Province will continue to face pressure from climate variability, labour shortages, and land-use change. Women farmers are likely to play an even more central role in sustaining food systems, yet they remain constrained by limited land ownership, technology access, and institutional support. Without targeted investment in:

- climate-smart agriculture,
- women-friendly extension services,
- secure land tenure and access to finance,

The gap between responsibility and capacity is likely to widen, undermining both gender equity and agricultural sustainability.

Urbanization and Emerging GESI Risks

Urbanization in Gandaki Province is expected to accelerate, bringing new GESI challenges. Informal settlements, often inhabited by migrants, Dalits, and low-income households, are likely to expand in flood-prone and environmentally degraded areas.

Urban environmental risks such as air pollution, poor waste management, heat stress, and unsafe water may disproportionately affect women, children, elderly persons, and persons with disabilities. If urban planning does not integrate GESI considerations, environmental services may improve overall while exclusion persists in specific neighbourhoods.

Governance, Data, and Institutional Capacity

The effectiveness of future GESI outcomes will depend heavily on governance choices. Improved data systems, particularly sex-, caste-, and location-disaggregated environmental data, will be critical for tracking progress and targeting interventions.

Without strengthened institutional capacity at provincial and local levels, GESI risks remaining a rhetorical commitment rather than a transformative practice. Conversely, if inclusion is embedded in planning, budgeting, and monitoring, Gandaki Province has the opportunity to model inclusive and climate-resilient environmental governance. In summary:

- Incremental social progress is likely to continue,
- Climate and environmental pressures are expected to intensify,
- GESI gaps may persist or widen without targeted action.

The future outlook underscores the urgency of aligning environmental sustainability with social equity. Gender equality and social inclusion are not only social goals, but preconditions for effective climate adaptation, disaster risk reduction, and sustainable resource management in the province.

6.8.11 DPSIR Analysis: GESI

The DPSIR framework provides a structured way to understand how social inequalities interact with environmental change in Gandaki Province. Applying a GESI lens to DPSIR highlights that environmental degradation and climate impacts are not gender- or socially neutral. Instead, they are shaped by existing power relations, access to resources, and institutional arrangements, which influence who contributes to environmental pressures, who is most affected by environmental change, and who benefits from policy responses.

Drivers

Underlying drivers shaping GESI–environment interactions in Gandaki Province include:

- demographic change, particularly male out-migration and population ageing,
- persistent gender inequality and caste-based exclusion,
- poverty and unequal access to land, assets, education, and services,
- economic transitions from subsistence agriculture to migration- and service-based livelihoods.

These drivers shape livelihood choices and resource dependence, influencing how different groups interact with the environment.

Pressures

Social drivers translate into environmental pressures through:

- overreliance on biomass energy due to limited clean energy access,
- intensified use of land, forests, and water by households dependent on natural resources,
- expansion of informal settlements in environmentally sensitive and hazard-prone areas,
- increased waste generation and unmanaged disposal, particularly in urban and peri-urban areas.

Women, Dalits, and marginalized communities often bear responsibility for managing these pressures at the household level, despite limited control over resources and decisions.

State

These pressures contribute to changes in the state of the environment, including:

- degradation of forests and pasturelands,
- declining soil fertility and water availability,
- air and water pollution affecting household and community health,
- uneven access to environmental services such as safe water, sanitation, and clean energy.

Environmental degradation disproportionately affects socially excluded groups, whose livelihoods and well-being are more directly tied to local ecosystems.

Impacts

Environmental change produces differentiated social impacts:

- increased time poverty for women due to longer hours spent collecting water and fuelwood,
- heightened health risks from indoor air pollution, unsafe water, and waste exposure,
- reduced agricultural productivity and food security for subsistence households,
- greater disaster-related losses among Dalits, Indigenous communities, elderly persons, and persons with disabilities.

These impacts reinforce existing inequalities, creating feedback loops between social exclusion and environmental vulnerability.

Responses

Policy and institutional responses include:

- constitutional and legal commitments to GESI and environmental rights,
- gender-responsive and climate budgeting frameworks,
- community-based natural resource management and adaptation programmes,
- provincial and local development plans emphasizing inclusion and resilience.

However, responses often focus on participation rather than power, and on projects rather than systemic change. As a result, benefits are uneven, and transformative outcomes remain limited.

Table 6-91. DPSIR Synthesis for GESI and Environment in Gandaki Province

DPSIR Element	GESI–Environment Linkages
Drivers	Gender inequality, caste-based exclusion, poverty, male out-migration, ageing population, unequal access to land and assets
Pressures	Biomass dependence, land and forest overuse, informal settlement growth, unmanaged waste, climate stress on livelihoods
State	Degraded forests and soils, water scarcity, air and water pollution, unequal access to environmental services
Impacts	Time poverty for women, health burdens, food insecurity, disaster losses concentrated among marginalized groups
Responses	GESI policies, climate and gender budgeting, community forestry, local adaptation initiatives, social protection measures

Key DPSIR Insights

- Environmental pressures in Gandaki Province are closely linked to social structure and inequality, not only to population growth or technology.

- Women and marginalized groups are central actors in managing environmental resources, yet have limited influence over policy and investment decisions.
- Current responses reduce some vulnerabilities but do not fully address structural drivers, limiting long-term effectiveness.

A GESI-sensitive DPSIR analysis reinforces the need for environmental governance that addresses both ecological sustainability and social justice.

6.8.12 Recommendations Advancing GESI through Environmental Action

The GESI analysis for Gandaki Province emphasizes that environmental sustainability and social inclusion are mutually reinforcing. Environmental degradation and climate risks disproportionately affect women, Dalits, Indigenous communities, persons with disabilities, and elderly populations. Without addressing underlying social inequalities, environmental and climate interventions risk being ineffective and inequitable. The recommendations focus on eight strategic areas:

1. Inclusive Environmental Governance: Strengthen meaningful participation and leadership of marginalized groups in environmental decision-making institutions, supported by clear accountability mechanisms.
2. Land, Resource, and Tenure Security: Improve women's and marginalized groups' access to land and productive resources through joint ownership, inclusive land registration, and integration of tenure security into adaptation and recovery programmes.
3. Climate-Resilient Livelihoods and Agriculture: Promote climate-smart agriculture and green livelihoods that explicitly target women farmers and socially excluded communities, supported by GESI-sensitive extension services.
4. Reduction of Women's Time Poverty: Expand access to water, sanitation, clean energy, and waste services to reduce unpaid care and environmental labour burdens, improving health and economic participation.
5. GESI-Responsive Climate and Environmental Financing: Strengthen gender-responsive and climate budgeting to ensure that financial resources reach the most vulnerable groups and deliver measurable inclusion outcomes.
6. Data, Monitoring, and Learning: Improve disaggregated data systems and integrate GESI indicators into environmental monitoring to support evidence-based planning and accountability.
7. Inclusive Disaster Risk Reduction and Climate Adaptation: Design disaster preparedness, early warning, and recovery systems that are accessible and responsive to diverse social needs, linked with social protection mechanisms.
8. Cross-Sectoral Coordination and Institutional Capacity: Enhance coordination across sectors and build technical capacity of provincial and local institutions to implement GESI-responsive environmental policies effectively.

Gandaki Province has a strong policy foundation for GESI, but achieving transformative change requires sustained institutional commitment, targeted investment, and robust accountability. Integrating GESI into environmental governance is essential not only for social equity, but also for resilient ecosystems, effective climate adaptation, and sustainable development.

Table 6-92. GESI – Observed Trends, Risks, and Targeted Actions in Gandaki Province

Observed Trend	Associated Risks	Targeted Actions (GESI-responsive)
Increasing feminisation of agriculture due to male out-migration	Growing gap between women's responsibilities and access to land, finance, technology, and services; declining agricultural productivity	Target women farmers with climate-smart agriculture, extension services, secure land tenure (joint titles), and access to climate finance
High and increasing share of female-headed households	Higher exposure to climate shocks and limited recovery capacity due to asset poverty	Prioritise female-headed households in adaptation, disaster recovery, clean energy, and livelihood support programmes
Persistent gender gap in literacy and skills	Limited access to climate information, early warnings, and green livelihood opportunities for women	Strengthen education, skills training, and climate information dissemination tailored to women and marginalized groups
Continued dominance of women in unpaid and informal labour	Time poverty, health stress, and reduced participation in decision-making	Expand access to water, sanitation, clean cooking energy, and labour-saving technologies
Limited female ownership of land and housing	Exclusion from credit, insurance, subsidies, and post-disaster compensation	Promote joint land ownership, simplify registration processes, and link tenure security with adaptation programmes
Dalits concentrated in land-poor, hazard-prone, and informal settlements	Disproportionate exposure to floods, landslides, pollution, and service deficits	Target Dalit settlements for basic services, disaster risk reduction, and climate-resilient infrastructure
Indigenous communities highly dependent on forests and ecosystems	Increased vulnerability to climate change and biodiversity loss; risk of exclusion from benefits	Recognize customary rights, integrate Indigenous knowledge into conservation and adaptation planning
Ageing population, especially in rural areas	Increased care burdens on women and higher disaster vulnerability among elderly	Design age- and disability-responsive infrastructure, early warning systems, and social protection
Low accessibility of environmental infrastructure for persons with disabilities	Exclusion from water, sanitation, health, and disaster response systems	Apply universal design standards in environmental and disaster-related infrastructure
Participation of women and marginalized groups improving numerically	Limited influence over decisions and resource allocation	Move from quota-based participation to leadership roles and accountability mechanisms
GESI mainstreamed in policy but weakly implemented	Symbolic inclusion without measurable outcomes	Strengthen institutional capacity, monitoring, and outcome-based GESI indicators
Gender and climate budget tagging in place	Limited alignment between budget labels and real benefits	Improve quality of tagging and link budgets to measurable GESI outcomes
Rapid urbanisation and informal settlement growth	Increased exposure to urban environmental hazards and exclusion from services	Integrate GESI into urban planning, waste management, air quality, and housing policies

The alignment of GESI indicators with the DPSIR framework and the Sustainable Development Goals demonstrates that progress on environmental sustainability in Gandaki is inseparable from progress on gender equality and social inclusion. Indicators related to gender roles, caste and ethnicity, land ownership, education, energy use, and access to services influence not only SDG 5 and SDG 10, but also outcomes under SDGs 1, 6, 7, 11, 13, and 15. The analysis shows that environmental pressures and impacts are socially differentiated, while inclusive governance, gender-responsive financing, and community-based resource management represent critical response pathways. Strengthening GESI-responsive environmental action will therefore accelerate multi-SDG progress, enhance climate resilience, and ensure that environmental gains in the Province are equitable and sustainable.

6.8.13 Concluding Remarks

The GESI analysis of Gandaki Province demonstrates that environmental sustainability and social equity are deeply interconnected. Census trends and sector evidence show gradual improvements in education, service access, and participation, alongside persistent structural inequalities related to land ownership, unpaid labour, decision-making power, and exposure to environmental risk.

Women, Dalits, Indigenous communities, elderly persons, and persons with disabilities play a central role in managing natural resources and responding to environmental change, yet they continue to face constraints that limit their adaptive capacity. Climate change, demographic ageing, and urbanization are likely to intensify these challenges unless environmental governance explicitly addresses social differentiation.

Embedding GESI across environmental planning, financing, and monitoring is therefore not only a matter of social justice, but a prerequisite for effective climate adaptation, disaster risk reduction, and sustainable resource management. By aligning GESI-responsive action with the DPSIR framework and the Sustainable Development Goals, Gandaki Province can strengthen resilience while ensuring that environmental progress is inclusive and durable.

6.9 Cross Cutting: Tourism

6.9.1 Background

Tourism is one of the most important economic and environmental sectors in Gandaki Province (PPPC, 2077 (2021)). The province hosts some of Nepal's most iconic natural and cultural destinations, including high mountain landscapes, trekking routes, protected areas, lakes, rivers, and heritage towns. As a result, tourism plays a critical role in provincial income generation, employment, and local livelihoods, while also exerting growing pressure on natural resources and ecosystems.

Tourism in the Province is inherently nature-dependent. Mountain scenery, biodiversity, forests, rivers, and cultural landscapes form the core attraction for domestic and international visitors. This strong dependence on environmental quality means that tourism both benefits from and contributes to environmental change. Degradation of ecosystems, unmanaged waste, water scarcity, and climate impacts directly affect tourism viability, while tourism activities can intensify environmental pressures if not well managed.

From a environment perspective, tourism must therefore be examined not only as an economic sector, but as a cross-cutting driver of environmental change. Tourism influences land use, infrastructure development, water and energy demand, waste generation, and ecosystem integrity. At the same time, tourism can support conservation and sustainable resource management when benefits are equitably shared and environmental safeguards are in place.

Gandaki exhibits strong spatial concentration of tourism activities, with high pressure in trekking corridors, urban tourism hubs, lake basins, and protected areas, while other areas remain relatively underdeveloped. This uneven distribution creates localized environmental stress, particularly in fragile mountain and lake ecosystems, and raises concerns about carrying capacity, waste management, and service provision.

Tourism is also closely linked with social dimensions, including employment opportunities, migration patterns, and community participation. While tourism provides livelihoods for many households, benefits are not evenly distributed across gender, caste, ethnicity, or geography. Without inclusive planning, tourism development risks reinforcing social inequality alongside environmental degradation.

This section of the report adopts tourism as a cross-cutting theme in the State of Environment, examining how tourism interacts with ecosystems, climate change, infrastructure, and social systems in the Province.

Using available statistics, policy analysis, and sector evidence, the chapter identifies key trends, pressures, and response options to support environmentally sustainable and socially inclusive tourism development.

6.9.2 Tourism dynamics of Gandaki Province

The Province sits at the heart of Nepal's "mountain–lake–culture" tourism brand. Pokhara Valley works as the main gateway for Annapurna and other mid-hill/mountain destinations, while sacred landscapes (e.g. Muktinath corridor and associated heritage sites), adventure hubs (e.g. trekking, rafting, paragliding, etc.), and community-based homestays spread benefits into rural municipalities. This geography makes tourism one of the province's most visible economic sectors but also one of the most climate- and disaster-sensitive.

Long-term tourism trend

National tourism numbers provide a useful backdrop for interpreting Gandaki's trajectory because it is strongly linked to national arrival patterns such as air connectivity, and travel facilities (PPPC, 2077 (2021)). According to Nepal Tourism Statistics (MoCTCA, 2023) international tourist arrivals increased from 602,867 (2010) to 614,869 (2022). While the two years look similar in absolute arrivals, the pathway between them was not steady: Nepal experienced major disruptions such as the 2015 earthquake and the COVID-19, 2022 reflects a recovery phase rather than a "new peak" especially when compared with 2018–2019, when arrivals exceeded one million. This is important because Gandaki's trekking/adventure economy depends heavily on international seasons, global perceptions of safety, and transport reliability. A recovery year tends to concentrate demand in a few well-known circuits (e.g. Pokhara–Annapurna Circuit) and among a narrower market segment, which can intensify pressure on hotspots while leaving peripheral destinations behind.

Tourism – Economics and Employment Drivers

Tourism in Gandaki Province operates within Nepal's national tourism system, as international visitors enter the country through national gateways and then distribute across provinces. Provincial records for FY 2022/23 indicate that Gandaki received approximately 245,000 international tourists and over one million domestic tourists (PPPC, 2077 (2021)). This pattern highlights a defining feature of Gandaki's tourism economy: domestic tourism dominates in visitor numbers, while international tourism remains particularly important for higher-value activities such as trekking, guiding, and longer stays. The Province hosts around 12,200 hotel beds and more than 300 registered community homestays, reflecting a diversified tourism service base that spans formal hotels, small enterprises, and community-based tourism initiatives (PPPC, 2077 (2021)).

Tourism contributes to the provincial economy primarily through visitor expenditure on accommodation, food, transport, guiding and pottering services, retail trade, and local products. National tourism statistics show that in 2022, international tourists in Nepal stayed for an average of about 13 days and spent approximately USD 40–41 per person per day (MoCTCA, 2023). Although spending patterns vary by destination and visitor type, these national averages provide a reasonable proxy for understanding the economic footprint of tourism in Gandaki, particularly given the Province's role as a major tourism destination.

The economic significance of tourism therefore extends well beyond hotels and travel agencies. Tourism spending supports a broad value chain that includes agriculture (food supply), transport services, construction and maintenance, handicrafts, and local retail. In addition, tourism is an important source of foreign exchange earnings for Nepal, indirectly supporting provincial development through national revenue flows and public investment. From an environmental perspective, this dual role is important: tourism growth increases demand for environmental services such as clean water, energy, waste management, transport infrastructure, and landscape quality while also generating income that can support environmental management if governance and planning are effective.

Tourism is also a major source of employment in Gandaki Province, creating jobs across a wide range of skills and locations. Provincial reporting for FY 2022/23 estimates approximately 25,500 tourism-related jobs, including employment in hotels and restaurants, trekking and guiding services, transport, homestays, and a wide range of associated informal activities (NSO, 2025). These jobs are concentrated in urban hubs such as Pokhara, but also extend into rural and mountain areas through trekking routes, pilgrimage tourism, and community-based tourism.

Evidence from the Nepal Labour Force Survey (NLFS) 2017/18 (NSO, 2025) provides important context for understanding the structure and quality of tourism employment. The survey shows that Gandaki Province had about 606,000 employed people aged 15 years and above, of whom roughly 240,000 were in formal employment and 366,000 in informal employment. This dominance of informal work is particularly relevant for tourism, where many jobs such as seasonal hotel workers, restaurant staff, porters, informal guides, homestay operators, street vendors, and transport workers are casual, seasonal, or semi-formal. Such employment arrangements allow households to combine tourism with agriculture and other livelihoods, but they also expose workers to income instability and limited social protection, especially during shocks such as earthquakes, pandemics, road disruptions, landslides, or sudden declines in tourist arrivals.

National-level labour force data further illustrate how tourism employment has expanded over time. The NLFS 2008 (CBS, 2008) reported about 197,000 employed people in the "Hotels and restaurants" sector nationwide. By 2017/18, employment in the comparable category "Accommodation and food service activities" had increased to about 371,000 people. While the sector classifications are not perfectly identical, the trend clearly indicates that tourism-linked services have become a much larger employer over the decade. Women's participation has also been notable; even in 2008, female employment in hotels and restaurants slightly exceeded male employment, underlining tourism's role as an entry point for women into the paid labour force.

For the Province where Pokhara and major trekking corridors form a dense tourism economy this national expansion aligns with observed local dynamics. Tourism increasingly functions as a service-sector employment engine, supporting thousands of livelihoods. At the same time, its heavy reliance on informal and seasonal work means that tourism-related employment remains structurally vulnerable to environmental degradation, climate hazards, and external shocks. This makes tourism not only an economic opportunity, but also a critical area for integrating employment quality, social protection, and environmental sustainability within provincial planning.

6.9.3 Tourism Employment – Inclusion and Risk Dimensions

Tourism can generate jobs quickly, but who accesses those jobs and under what conditions often reflects broader patterns of social inclusion. The TAAN Tourism Employment Study (GOV, 2014) shows that tourism labour markets in Nepal are strongly male-dominated, with about 80% of workers being men, and are unevenly distributed across social groups: 58% Janajati, 33% Brahmin/Chhetri, 5% Dalit, and 3% Terai/Madhesi. These patterns point to both the sector's inclusion potential for Indigenous communities and a persistent exclusion of Dalits from tourism livelihoods.

For the Province where tourism intensity is high and Janajati populations are prominent these national findings are directly relevant. While provincial and sector surveys indicate that women are economically active in tourism-facing establishments, especially in accommodation and food services, most tourism jobs remain informal, seasonal, and weakly protected. Combined with limited routine disaggregation by caste and ethnicity, this makes it difficult to assess who benefits most from tourism growth and who remains exposed to risk. ***Table 6-93*** therefore examines tourism employment in Gandaki through an inclusion and risk lens, linking patterns of participation (gender, caste, migration) with employment conditions and environmental and climate-related vulnerabilities that shape the sustainability of tourism livelihoods.

Table 6-93. Tourism Employment – Inclusion and Risk Dimensions in Gandaki Province

Dimension / Indicator	Current Evidence (Gandaki / National Context)	Inclusion Implications (GESI & Migration)	Environmental & Climate Risk Linkages
Employment scale	~25,500 tourism-related jobs in Gandaki (FY 2022/23); ~371,000 in accommodation & food services nationally (NLFS 2017/18)	Tourism is a major entry point for women, youth, and internal migrants	Jobs depend on environmental quality and visitor flows
Gender participation	High female participation in hotels, restaurants, homestays, and informal services	Expands women's income opportunities, especially in urban and community tourism	Women often work in low-paid, service roles sensitive to seasonality
Type of employment	Predominantly informal or semi-formal (guides, porters, homestays, vendors)	Low entry barriers but limited job security and benefits	Informal workers are highly exposed to shocks and disasters
Seasonality	Employment peaks during trekking and holiday seasons	Seasonal income gaps affect women and migrant workers most	Climate variability directly affects work availability
Migrant labour	Strong presence of internal migrants in urban tourism hubs	Tourism provides alternatives to foreign migration	Migrant workers often lack local safety nets during crises
Dalit participation	Concentrated in service, construction, and informal roles	Employment access exists, but upward mobility is limited	Poor housing and work conditions increase hazard exposure
Indigenous communities	Strong involvement in trekking, guiding, and homestays	Supports local livelihoods and cultural continuity	Ecosystem degradation directly threatens jobs
Occupational risk	Pottering, trekking, waste handling, transport	Higher physical risk for low-income workers	Landslides, extreme weather, pollution increase vulnerability
Social protection	Limited coverage in tourism-related informal work	Workers lack insurance, paid leave, or compensation	Shocks (pandemics, disasters) cause rapid livelihood loss
Climate sensitivity	Tourism employment fluctuates with climate and disasters	Vulnerable households revert to subsistence coping	Climate change threatens long-term job stability

6.9.4 Tourism–Environment Linkages

Tourism in Gandaki Province is closely connected to environmental quality and the sustainability of natural resources that underpin tourism experiences. The Province's tourism economy depends heavily on its mountain landscapes, lakes, rivers, forests, and cultural environments, making it both a beneficiary of environmental assets and a source of environmental pressure. Several research studies and reports highlight the emerging environmental challenges associated with tourism growth in Nepal and in areas similar to Gandaki (MoCTCA, 2023).

Tourism's Dependence on Natural and Cultural Assets

Gandaki's tourism products especially trekking and nature-based activities rely on healthy forests, reliable water bodies, scenic landscapes, and protected areas. Trekking corridors such as the Annapurna and Manaslu regions depend on well-maintained trails, abundant water sources, and intact ecosystems. Any degradation of these assets can directly affect tourism demand and local livelihoods, as visitor satisfaction and safety are influenced by environmental conditions.

Pressure on Water and Waste Systems

Environmental assessments in Pokhara, show that tourism has contributed to water pollution, waste accumulation, and congestion in lake areas. A community-based impact assessment found that tourism activities were associated with *air, water, soil, and noise pollution* and *over accumulation of non-biodegradable waste*, including plastic bottles and metal cans, particularly around *Phewa, Begnas, and Rupa lakes*. These pressures can degrade water quality and diminish the scenic and recreational value of water bodies that attract visitors (Bhattarai, 2025).

Water demand itself is also subject to strain from tourism growth. In the Province, approximately 91% of households have access to drinking water**,** but tourism growth during peak seasons places additional pressure on limited local supply systems and can exacerbate competition between tourism services and community needs for water resources (PPPC, 2024).

Solid Waste Generation and Land Impacts

Rural tourism destinations within the Province, such as Ghandruk in the Annapurna Conservation Area, produce significant amounts of solid waste, which in some cases is comparable to rates found in urban areas. Field studies show that waste generation in high-tourism rural areas can reach around 261 grams per person per day**,** with a rising share of recyclable and non-recyclable materials that local waste systems struggle to manage (Adhikari et al., 2024). Open burning of non-recyclables has been identified as a growing concern, with direct implications for air quality and soil contamination.

Over-tourism and Cumulative Impacts

Recent literature on sustainable tourism in Nepal emphasizes that rapid tourism expansion, without adequate environmental safeguards, can lead to unequal benefits, environmental degradation, and cultural pressures (Adhikari et al., 2024). Studies show that unmanaged tourism growth can challenge natural resources, dilute cultural traditions, and create tension between economic goals and conservation objectives.

Climate Change as a Risk Multiplier

Climate variability and extreme weather events act as **risk multipliers** for tourism–environment interactions. Changing precipitation patterns and warming temperatures affect water availability, trail safety, seasonality of tourism, and the overall reliability of key tourism destinations. Research on climate resilience highlights the need for targeted policies that integrate environmental protection with tourism planning to reduce vulnerability and enhance long-term sustainability.

Governance and Pathways to Sustainability

The environmental impacts associated with tourism are shaped by governance quality. Where municipal authorities, conservation bodies, and community institutions manage waste, water, and land use effectively, tourism can support conservation and local well-being. For example, community forestry, participatory waste management, and protected area benefit-sharing mechanisms contribute to balancing tourism growth with environmental protection. However, gaps in infrastructure, planning, and enforcement often mean that tourism externalizes environmental costs onto ecosystems and residents, especially those with limited resources.

Environmental Pressures from Tourism

Tourism in Gandaki Province generates multiple environmental pressures that are spatially concentrated, seasonal, and closely linked to infrastructure capacity and governance quality. While tourism contributes significantly to local livelihoods and the provincial economy, unmanaged growth risks undermining the environmental assets on which the sector depends. The most significant pressure pathways relate to solid waste and wastewater, water use, energy demand, land use change, and ecosystem disturbance.

Solid Waste Generation and Management Pressure

Solid waste is the most visible environmental pressure associated with tourism in Gandaki Province. Tourism hubs and trekking corridors experience sharp increases in waste generation during peak seasons, often exceeding local collection, transport, and disposal capacity.

Pokhara Metropolitan City is the province's primary tourism hub generates an estimated 123 tons of municipal solid waste per day, with hotels, restaurants, markets, and lakefront activities contributing substantially to the waste stream. Seasonal tourism surges increase plastic packaging, food waste, and disposable materials, raising the risk of littering, open dumping, and leakage into drainage systems, rivers, and lake basins.

In mountain tourism areas, waste management challenges are more acute. Evidence from the Annapurna Conservation Area indicates that trekkers generate approximately 0.28 kg of solid waste per person per day, including plastics, glass, tins, and multilayer packaging. Even small per-visitor quantities accumulate rapidly in destinations where removal is costly and logistically difficult. Persistent non-biodegradable waste poses long-term risks to fragile alpine ecosystems and scenic landscapes.

Wastewater, Water Quality, and Aquatic Ecosystems

Tourism growth increases wastewater generation from hotels, lodges, restaurants, and recreational facilities. In urban and peri-urban tourism zones, incomplete sewerage coverage and limited treatment capacity heighten the risk of untreated or partially treated wastewater entering rivers and lakes.

Lake and river systems key tourism assets in Gandaki are particularly vulnerable. Degradation of water quality affects not only ecosystem health but also destination image, recreational use, and public health. In trekking corridors and rural destinations, wastewater is often discharged into soak pits or nearby streams, increasing cumulative pollution loads during peak tourist seasons.

Water Demand and Local Resource Stress

Tourism establishments significantly increase water demand, particularly in accommodation, food services, and recreational facilities. In hill and mountain settlements with limited water supply systems, tourism demand can compete directly with domestic and agricultural use, especially during the dry season.

Climate variability and changing rainfall patterns further exacerbate water stress. Where tourism growth is not matched with water-efficient technologies, source protection, and demand management, local shortages and conflict over water use may intensify.

Energy Use and Biomass Pressure

Energy demand from tourism contributes to environmental pressure through electricity consumption, fossil fuel use, and reliance on biomass in remote destinations. In trekking corridors and rural tourism areas, hotels and lodges often depend on firewood, LPG, or diesel for cooking and heating.

Where clean energy alternatives are limited, tourism can increase pressure on local forests and contribute to indoor and outdoor air pollution. Although electrification has expanded, peak tourism seasons can strain local energy systems and increase reliance on backup generators.

Land Use Change and Infrastructure Development

Tourism-related infrastructure hotels, roads, viewpoints, parking areas, and recreational facilities drives land use change, particularly in urban fringes, lake basins, and along access routes to trekking destinations. Poorly planned development can increase:

- soil erosion and slope instability,
- landslide and flood risk,
- habitat fragmentation,
- visual landscape degradation.

These pressures are especially concerning in environmentally sensitive areas where carrying capacity assessments and zoning controls are weak or inconsistently enforced.

Ecosystem Disturbance and Biodiversity Impacts

Tourism activities can disturb wildlife and degrade habitats through noise, waste accumulation, trail expansion, and unregulated visitor movement. High visitor density in protected areas and buffer zones increases pressure on forests, grasslands, and alpine ecosystems.

At the same time, tourism can support conservation through revenue generation and community stewardship when management systems are effective. The balance between pressure and protection depends on enforcement capacity, benefit-sharing mechanisms, and visitor management practices.

Climate Change as a Pressure Multiplier

Climate change acts as a multiplier of tourism-related environmental pressures. Extreme rainfall, landslides, floods, forest fires, and heat stress affect waste containment, water systems, road access, and energy reliability. Disruptions often concentrate tourism activity in fewer accessible destinations, intensifying localized pressure rather than reducing overall impact.

Implications for the State of Environment

The evidence indicates that tourism in Gandaki Province:

- generates localized but significant environmental pressures,
- places increasing demand on waste, water, and energy systems,
- interacts strongly with climate risk and disaster vulnerability, and
- can either exacerbate or help manage environmental degradation depending on governance quality.

For the State of Environment, tourism should therefore be treated as a key pressure sector, requiring integrated planning, destination-specific management, and stronger alignment between tourism development and environmental protection.

6.9.5 Climate Change and Tourism Vulnerability

Tourism in Gandaki is highly sensitive to climate variability and climate-induced hazards because it depends directly on mountain landscapes, stable access routes, water availability, and seasonal weather conditions. Climate change therefore represents a systemic risk to the tourism sector, affecting destinations, livelihoods, infrastructure, and environmental quality simultaneously.

Climate Hazards Relevant to Tourism

Gandaki Province is exposed to a range of climate-related hazards that directly affect tourism operations and visitor safety, including:

- Intense and erratic rainfall, leading to floods and landslides;
- Slope instability along mountain roads and trekking trails;
- Heat stress in valley and urban tourism areas;
- Forest fires, particularly during dry pre-monsoon periods;
- Changing snowfall and glacier dynamics in high mountain areas.

These hazards are projected to increase in frequency and intensity, with implications for tourism seasonality, infrastructure reliability, and destination attractiveness.

Vulnerability of Key Tourism Destinations

Tourism vulnerability varies across the Province depending on location, accessibility, and ecosystem sensitivity.

- Mountain and trekking destinations such as Annapurna, Manaslu, Mustang corridors are particularly vulnerable to landslides, trail damage, extreme weather, and changing snow conditions. Even short-term disruptions can halt trekking activity, reduce visitor confidence, and affect income for guides, porters, lodge operators, and local suppliers.
- Urban and lake-based destinations (i.e. Pokhara Valley) face increasing risks from flooding, water pollution, heat stress, and infrastructure damage. Climate-related degradation of lakes and surrounding landscapes poses direct reputational risks for tourism.
- Pilgrimage and cultural tourism sites, often accessed by steep roads or located along river corridors, are vulnerable to climate-induced access disruptions during peak seasons.

Because tourism activity is spatially concentrated, climate shocks tend to create localized but severe impacts, rather than uniform effects across the province.

Impacts on Tourism Infrastructure and Services

Climate change affects tourism infrastructure in multiple ways:

- Road and trail damage from landslides and erosion disrupts access to destinations and increases maintenance costs.
- Water supply systems face stress during dry periods and contamination during floods, affecting accommodation and food services.
- Waste and wastewater systems are vulnerable to overflow and failure during extreme rainfall events.
- Energy systems, especially in remote areas, may be disrupted during storms or supply interruptions.

Infrastructure failures not only affect visitor experience but also place additional pressure on local governments and communities responsible for emergency response and repairs.

Livelihood and Employment Vulnerability

Tourism livelihoods in Gandaki are highly climate-sensitive. Many workers depend on seasonal tourism income, including guides, porters, lodge staff, transport workers, and small entrepreneurs. Climate-induced disruptions can result in:

- loss of income during peak seasons,
- increased economic insecurity for households with limited alternative livelihoods,
- heightened vulnerability for informal workers and micro-enterprises.

Women, Dalits, and marginalized communities often concentrated in informal, low-wage, or service roles may have less capacity to absorb climate-related shocks, reinforcing existing inequalities.

Climate Change as a Multiplier of Environmental Pressures

Climate change also amplifies tourism-related environmental pressures:

- Heavy rainfall increases the risk of waste leakage into rivers, lakes, and ecosystems.
- Water scarcity during dry seasons intensifies competition between tourism, domestic, and agricultural uses.
- Forest fires and vegetation stress degrade landscape quality and air quality, affecting tourism appeal.

These feedback loops highlight the interconnected nature of climate risk, tourism pressure, and environmental degradation.

Adaptive Capacity and Resilience Gaps

While Gandaki has strong tourism assets and experience in community-based management, adaptive capacity remains uneven. Key gaps include:

- limited climate-risk integration in destination planning,
- weak early warning and communication systems for tourists and operators,
- insufficient climate-resilient standards for tourism infrastructure,
- limited access to insurance, finance, and safety nets for tourism workers.

Without targeted adaptation measures, climate change is likely to increase volatility in tourism income and exacerbate pressure on fragile environments.

6.9.6 Tourism Policy and Institutional Framework

Tourism governance in Gandaki operates within Nepal's federal structure, involving federal, provincial, and local governments, alongside protected area authorities and private and community actors. While policy frameworks increasingly recognize sustainability, inclusion, and resilience, institutional coordination and operationalization remain uneven, particularly in managing environmental and climate risks associated with tourism.

National Policy Framework

At the federal level, tourism development is guided by national strategies and sectoral policies that emphasize tourism as a driver of economic growth, employment, and international visibility. Key policy directions include:

- promotion of nature-based, adventure, and cultural tourism,
- diversification of destinations and products,
- improvement of tourism infrastructure and services,
- emphasis on sustainable and responsible tourism.

National environmental and climate policies such as climate change, disaster risk reduction, forest, biodiversity, and environmental protection frameworks also apply to tourism activities, particularly in protected areas and ecologically sensitive zones. These policies provide a normative foundation for environmentally responsible tourism but are not always translated into destination-specific operational guidelines.

Provincial Policy and Planning Instruments

Gandaki Province has identified tourism as a priority sector in its periodic plans and development strategies, highlighting the province's comparative advantage in mountain landscapes, lakes, cultural heritage, and pilgrimage routes. Provincial plans emphasize:

- tourism-led employment generation,
- expansion of homestays and rural tourism,
- promotion of adventure and eco-tourism,
- infrastructure development to improve access.

Environmental sustainability and climate resilience are increasingly referenced in provincial planning documents. However, these references often remain broad and aspirational, with limited articulation of carrying capacity, waste management standards, water use efficiency, or climate-resilient infrastructure requirements specific to tourism destinations.

Institutional Roles and Responsibilities

Tourism governance in Gandaki involves multiple institutions:

- Provincial tourism agencies responsible for policy formulation, promotion, and coordination;
- Local governments responsible for destination management, basic services (waste, water, sanitation), local infrastructure, and regulation;
- Protected area authorities (e.g. Annapurna and Manaslu Conservation Areas) responsible for conservation, visitor management, and community engagement;

- Private sector and tourism associations (hotels, trekking agencies, guides, transport operators);
- Community institutions, including user groups and homestay committees.

This multi-actor system creates opportunities for shared responsibility but also poses coordination challenges. Overlapping mandates and capacity gaps particularly at the local level often limit effective environmental regulation and climate-responsive tourism management.

Environmental Regulation and Compliance

Environmental regulation relevant to tourism includes requirements for environmental assessment, waste management, water use, and conservation compliance, especially in protected areas (ICIMOD, 2025). In practice, enforcement is uneven due to:

- limited technical and financial capacity of local governments,
- weak monitoring of small and informal tourism enterprises,
- pressure to prioritize short-term economic gains over environmental safeguards,
- lack of tourism-specific environmental standards and indicators.

As a result, environmental pressures from tourism such as unmanaged waste, wastewater discharge, and land use change are often addressed reactively rather than preventively.

Climate Change and Disaster Risk Integration

Although climate change and disaster risk reduction are recognized in national and provincial policy frameworks, systematic integration into tourism planning remains limited. Destination-level climate risk assessments, early warning systems tailored to tourists and operators, and climate-resilient design standards are not yet consistently applied.

Tourism operators and workers often rely on informal coping mechanisms when climate shocks disrupt access or operations, highlighting gaps in insurance, safety nets, and institutional preparedness.

Inclusion and Community Participation

Policy frameworks increasingly promote community-based and inclusive tourism, including homestays and local entrepreneurship. These approaches offer potential co-benefits for livelihoods and conservation. However, participation does not always translate into decision-making power or equitable benefit-sharing, particularly for women, Dalits, and marginalized communities.

GESI considerations are rarely mainstreamed explicitly within tourism policy instruments, despite their relevance for employment quality, working conditions, and community resilience.

Key Gaps and Challenges

Across governance levels, several recurring challenges emerge:

- limited coordination between tourism, environment, and climate institutions;
- absence of destination-specific carrying capacity and environmental thresholds;
- weak integration of climate risk into tourism investment and planning;
- insufficient data and monitoring on tourism-related environmental impacts;
- capacity constraints at local government level.

Implications for the State of Environment

From a State of Environment perspective, the policy and institutional review indicates that the challenge is not the absence of policy intent, but the gap between policy and practice. Strengthening environmentally sustainable and climate-resilient tourism in Gandaki Province will require:

- clearer operational standards linking tourism development with environmental protection,
- stronger coordination across governance levels,

- enhanced local capacity for destination management,
- systematic integration of climate risk and inclusion considerations into tourism policy and planning.

6.9.7 Baseline Indicators: Tourism

This section presents key tourism-related indicators relevant to environmental pressure, vulnerability, and management capacity in Gandaki Province. Due to limited long-term, province-disaggregated tourism datasets, a combination of national tourism trends, protected area visitation, and provincial service indicators is used. 2010 (CBS, 2011) is treated as an approximate baseline and 2022/23 (MoCTCA, 2023; NPC, 2019; NSO, 2025) as the current state (***Table 6-94***).

Table 6-94.Tourism–Environment Indicators for Gandaki Province

Indicator	Baseline (≈2010)	State (≈2022/23)	Change / Trend	Environmental & SoE Synthesis
International tourist arrivals (Nepal)	~603,000 (2010)	~615,000 (2022)	Recovery after major shocks	Tourism pressure is not linear; recovery phases concentrate visitors in established hubs like Pokhara–Annapurna, intensifying localized environmental stress.
Domestic tourism (Gandaki)	Limited documentation	~1.03 million internal visitors	Strong growth	Domestic tourism now drives peak-season pressure on waste, water, and services, especially in urban and road-accessible destinations.
External tourists (Gandaki)	Not well documented	~245,000 visitors	Increasing (post-COVID)	Growth in international tourism increases demand for high-quality environmental services and destination management.
Hotel bed capacity (Gandaki)	Lower, fragmented	12,201 beds	Significant expansion	Increased accommodation capacity raises water use, wastewater generation, and energy demand.
Community homestays (Gandaki)	Very limited	324 homestays	Rapid increase	Expands rural tourism and inclusion but creates new waste, water, and sanitation challenges if unmanaged.
Tourism-related employment	Smaller, informal base	~25,546 jobs	Growth with informality	Employment growth strengthens livelihoods but increases indirect environmental pressure through settlement and service demand.
Municipal solid waste generation (Pokhara)	Lower (no systematic data)	~123 tons/day	Strong increase	Tourism intensifies municipal waste loads; leakage threatens rivers and lakes central to tourism appeal.
Trekker waste generation (ACA)	Not quantified	~0.28 kg/person/day	Now measured	Even low per-capita waste accumulates rapidly in fragile mountain ecosystems.
Protected area visitation (ACA)	~120,000 (2009/10)	~130,000 (2022)	Recovery and growth	Increased footfall raises trail erosion, waste, and habitat disturbance risks.

Indicator	Baseline (≈2010)	State (≈2022/23)	Change / Trend	Environmental & SoE Synthesis
Wastewater treatment coverage (tourism hubs)	Limited	Partial, improving	Insufficient for demand	Inadequate treatment threatens lake and river water quality, a core tourism asset.
Climate-related access disruptions	Episodic	Increasing frequency	Rising risk	Landslides, floods, and extreme weather increase vulnerability of tourism infrastructure and services.

Note: Tourism-related environmental indicators at provincial and destination level remain limited. This SoE uses national tourism trends, protected area visitation, municipal waste studies, and provincial planning data as proxies. Strengthening routine, disaggregated tourism–environment monitoring is essential for future assessments.

Tourism indicators show that the Province is experiencing renewed growth and diversification of tourism activity, driven largely by domestic visitors and recovery of international tourism. Expansion of accommodation capacity, homestays, and employment reflects tourism's economic importance, but also signals rising pressure on waste management, water resources, energy systems, and sensitive ecosystems.

Environmental pressures are spatially concentrated particularly in Pokhara Valley and major trekking corridors while climate change increases the volatility of tourism demand and infrastructure reliability. Data gaps remain significant, especially regarding routine monitoring of tourism-related waste, water use, and environmental impacts at destination level.

Overall, the indicator set suggests that tourism is transitioning from an opportunity-dominant phase to a pressure-sensitive phase in Gandaki Province. Without improved destination management, monitoring systems, and climate-resilient planning, continued tourism growth risks undermining the environmental assets on which the sector depends.

6.9.8 Future Outlook for Tourism and Environment

The future of tourism in Gandaki Province will be shaped by the interaction of visitor growth, climate change, infrastructure development, environmental management capacity, and governance choices. Current trends suggest that tourism will remain a key economic sector, but its sustainability will increasingly depend on how effectively environmental pressures and climate risks are managed.

Tourism Growth Trajectory and Spatial Concentration

Tourism demand in Gandaki Province is expected to continue growing, driven primarily by domestic tourism and the gradual recovery and diversification of international markets. However, growth is likely to remain spatially concentrated in a limited number of destinations, including Pokhara Valley, major trekking corridors in the Annapurna and Manaslu regions, and key pilgrimage sites. Without intervention, this concentration is expected to:

- intensify pressure on waste, water, energy, and transport systems in hotspot areas,
- increase environmental degradation in lakes, river corridors, and fragile mountain ecosystems,
- widen disparities between high-pressure destinations and under-developed areas.

The outlook therefore, points to increasing mismatch between tourism demand and environmental carrying capacity in selected locations.

Climate Change and Increasing Uncertainty

Climate change is projected to introduce greater uncertainty and volatility into Gandaki's tourism sector. Increased frequency of extreme rainfall, landslides, floods, heat stress, forest fires, and changing snowfall patterns will affect:

- accessibility and safety of roads and trekking routes,
- reliability of tourism seasons,
- water availability and quality for tourism services,
- destination image and visitor confidence.

Climate disruptions are likely to cause short-term shocks followed by concentrated recovery, where tourists gravitate toward perceived “safer” destinations. This dynamic may reduce overall visitor numbers temporarily but increase localized environmental pressure during recovery periods.

Environmental Pressure Outlook

If current practices persist, tourism-related environmental pressures are expected to increase, particularly in:

- solid waste and wastewater generation, especially plastics and food waste,
- water demand and competition during dry seasons,
- energy use, including continued reliance on biomass and fossil fuels in remote areas,
- land use change linked to unplanned infrastructure expansion.

Climate change will further amplify these pressures by stressing waste containment systems, reducing water availability, and increasing erosion and disaster risk.

Livelihoods, Employment, and Resilience

Tourism will continue to provide important employment and income opportunities, particularly for urban workers, trekking communities, and small entrepreneurs. However, the outlook suggests:

- continued seasonality and income volatility,
- higher vulnerability for informal workers and micro-enterprises,
- uneven access to climate-resilient infrastructure, finance, and insurance.

Without diversification and safety nets, climate-related disruptions may increase livelihood insecurity, especially for women and marginalized groups who are over-represented in lower-paid and informal tourism roles.

Governance and Management Capacity as a Decisive Factor

The future environmental sustainability of tourism in Gandaki Province will depend less on tourism growth itself and more on governance choices. Key determining factors include:

- whether destination-specific carrying capacity and environmental thresholds are defined and enforced,
- the effectiveness of waste, wastewater, and water-resource management systems,
- integration of climate risk into tourism planning and infrastructure design,
- coordination between tourism, environment, climate, and local government institutions.

Where governance capacity improves, tourism has the potential to support conservation, climate adaptation, and local development. Where it does not, environmental degradation may undermine tourism viability.

- Tourism in Gandaki Province is likely to grow and diversify, but in a spatially uneven manner.
- Environmental pressures and climate risks are expected to intensify, particularly in tourism hotspots.
- The sector’s long-term viability will increasingly depend on environmentally sustainable and climate-resilient destination management.

From a State of Environment perspective, the future outlook underscores the need to shift from expansion-focused tourism development to management-focused tourism governance, where environmental limits, climate risks, and community resilience are central considerations.

6.9.9 DPSIR Analysis: Tourism

The DPSIR framework is used to synthesize how tourism development in Gandaki Province interacts with environmental systems and climate change. Tourism acts both as a driver of economic activity and a source of environmental pressure, while climate variability and governance quality shape resulting environmental states and impacts.

Drivers

Tourism growth in Gandaki Province is driven by:

- increasing domestic travel and post-pandemic recovery of international tourism;
- the province's comparative advantage in mountain landscapes, lakes, biodiversity, and cultural heritage;
- infrastructure expansion (roads, accommodation, connectivity);
- policy emphasis on tourism-led employment and local economic development.

Climate change functions as an external driver, altering hazard patterns, seasonality, and accessibility, and shaping both tourism demand and environmental stress.

Pressures

Tourism-related drivers generate multiple pressures on the environment, including:

- increased solid waste and wastewater generation, particularly in tourism hubs and trekking corridors;
- rising water demand and competition with domestic and agricultural uses;
- increased energy consumption, including reliance on biomass and fossil fuels in remote destinations;
- land use change and infrastructure expansion in sensitive areas;
- ecosystem disturbance from high visitor density, trail erosion, and unmanaged access.

These pressures are spatially concentrated and seasonal, intensifying during peak tourism periods.

State

The cumulative effect of tourism pressures and climate stress influences the environmental state, reflected in:

- localized degradation of water quality in lakes and river systems;
- accumulation of solid waste in urban and mountain destinations;
- stress on forests and fragile alpine ecosystems;
- increasing vulnerability of tourism infrastructure to climate hazards;
- declining environmental quality in high-pressure destinations.

Environmental state changes are not uniform across the province, but are most evident in Pokhara Valley and major trekking and pilgrimage corridors.

Impacts

Changes in environmental state result in multiple impacts:

- reduced ecosystem health and biodiversity integrity;
- increased disaster risk and infrastructure damage;
- declining aesthetic and recreational value of destinations;
- economic losses due to reduced visitor satisfaction and repeat visitation;
- heightened livelihood insecurity for tourism-dependent communities.

Environmental degradation directly undermines tourism competitiveness, creating feedback loops where declining environmental quality threatens the sector's long-term viability.

Responses

Current responses include:

- protected area management and visitor regulation in conservation areas;
- municipal waste management initiatives in tourism hubs;
- promotion of community-based tourism and homestays;
- infrastructure investments to improve access and services.

However, responses remain fragmented and often reactive. Integration of climate risk, carrying capacity, and environmental thresholds into tourism planning is limited, and monitoring systems are weak.

Table 6-95. DPSIR Synthesis for Tourism and Environment in Gandaki Province

DPSIR Element	Key Tourism–Environment Interactions
Drivers	Growth of domestic and international tourism; nature-based tourism demand; infrastructure expansion; tourism-led development policy; climate change
Pressures	Solid waste and wastewater generation; increased water and energy demand; land use change; ecosystem disturbance; seasonal visitor concentration
State	Degradation of water quality; waste accumulation in urban and mountain areas; stress on forests and alpine ecosystems; increased infrastructure vulnerability
Impacts	Biodiversity loss; reduced destination quality; higher disaster risk; livelihood and income insecurity; weakened tourism competitiveness
Responses	Protected area management; municipal waste systems; community-based tourism; tourism promotion policies (often weakly integrated with environment and climate)

Tourism in Gandaki Province functions as a high-impact cross-cutting sector, where economic drivers generate localized but significant environmental pressures that are amplified by climate change. Without stronger, integrated responses, tourism growth risks degrading the environmental assets on which it depends. Strengthening climate-resilient, environmentally responsible tourism governance is therefore essential to break negative feedback loops and sustain both environmental quality and tourism-based livelihoods.

6.9.10 Recommendations

The analysis shows that tourism in Gandaki is transitioning from a growth-driven opportunity to a management-intensive sector where environmental limits and climate risks increasingly shape sustainability. The recommendations (***Table 6-96***), therefore, focus on containing environmental pressures, strengthening resilience, and improving governance, while safeguarding tourism-based livelihoods.

Table 6-96. Tourism–Environment Recommendations-Observed Trends, Risks, and Targeted Actions

Observed Trend	Key Environmental and Climate Risks	Targeted Actions (Tourism–Environment)
Rapid growth of domestic and recovering international tourism, concentrated in hotspots	Overloading of waste, water, and sanitation systems in Pokhara and trekking corridors	Develop destination-specific tourism management plans with defined environmental thresholds and service capacity limits

Observed Trend	Key Environmental and Climate Risks	Targeted Actions (Tourism–Environment)
Increasing solid waste generation in tourism hubs and trekking routes	Pollution of lakes, rivers, and landscapes; loss of destination quality	Introduce mandatory waste segregation, plastic reduction measures, and back-haul systems in trekking areas; strengthen municipal waste systems in tourism zones
Expansion of accommodation capacity and homestays	Rising wastewater discharge and water pollution	Enforce minimum sanitation and wastewater treatment standards for tourism establishments, including homestays
Rising tourism water demand during peak seasons	Local water scarcity and competition with domestic use	Promote water-efficient technologies, rainwater harvesting, and source protection in tourism facilities
Continued reliance on biomass and fossil fuels in remote destinations	Forest degradation and air pollution	Scale up clean energy solutions (electric cooking, solar heating) for lodges and homestays in trekking areas
Infrastructure expansion in fragile landscapes	Increased erosion, landslide risk, and habitat fragmentation	Apply risk-sensitive land-use planning and environmental screening for tourism infrastructure development
Climate change increasing frequency of landslides, floods, and heat stress	Disruption of tourism seasons and access routes	Integrate climate risk assessments into destination planning and tourism infrastructure design
Seasonal and informal tourism employment	Livelihood insecurity during climate shocks	Support livelihood diversification, skills upgrading, and access to insurance and safety nets for tourism workers
Weak monitoring of tourism-environment interactions	Reactive rather than preventive management	Establish routine monitoring of tourism-related waste, water use, and environmental indicators at destination level
Limited coordination across tourism, environment, and local governments	Fragmented responses to tourism pressure	Strengthen inter-sectoral coordination mechanisms for tourism–environment–climate governance

Implementation Priorities

To ensure effectiveness, the following priorities should guide implementation:

- Focus on hotspots first: Pokhara Valley, Annapurna and Manaslu trekking corridors, and major pilgrimage routes.
- Strengthen local government capacity for destination management, enforcement, and monitoring.
- Link tourism promotion with environmental compliance, rather than treating them as separate agendas.
- Embed climate resilience and inclusion into all tourism investments and programmes.

Sustainable tourism in Gandaki Province will depend less on expanding visitor numbers and more on how well environmental pressures and climate risks are managed. The recommended actions emphasize a shift toward destination-based management, environmental safeguards, and climate-resilient planning. By aligning tourism development with environmental capacity and governance strength, Gandaki can protect its natural assets while sustaining tourism-based livelihoods in the long term.

6.10 Cross Cutting: Migration

6.10.1 Background and Context

Migration is a defining socio-economic process shaping environmental conditions, resource use, and development pathways in Gandaki Province. Both internal migration (rural–urban, hill–Tarai, and inter-district movement) and international labour migration have increased over recent decades, influencing population distribution, land use patterns, labour availability, and household livelihoods.

Gandaki Province exhibits one of the highest levels of labour migration in Nepal, with a large proportion of households reporting at least one member living away from home, primarily for employment. Migration has become a key household strategy for income generation, risk management, and social mobility. At the same time, it has far-reaching implications for environmental management and sustainability. From an environmental perspective, migration affects:

- land use and agricultural practices, including land abandonment and changes in cropping systems;
- forest regeneration and resource pressure, particularly in out-migration areas;
- urban growth and environmental stress, as migrants concentrate in towns and cities;
- water, waste, and energy demand, especially in rapidly growing municipalities;
- vulnerability to climate and disaster risks, both at origin and destination areas.

Migration is also closely linked with climate change. Environmental degradation, declining agricultural productivity, and climate-related hazards are increasingly influencing migration decisions. Migration itself reshapes adaptive capacity at household and community levels through remittances, labour shortages, and changing social structures.

This section of the SoE treats migration as a cross-cutting driver of environmental change, examining how population mobility interacts with ecosystems, climate risks, urbanization, and livelihoods in Gandaki Province. Using census data (2011 and 2021), provincial statistics, and sector evidence, the chapter analyses migration trends, environmental implications, and response options relevant for sustainable and resilient development.

6.10.2 Migration Profile and Trends in Gandaki Province

Migration is a defining demographic and socio-economic feature of Gandaki Province. Census evidence shows that both international labour migration and internal migration toward urban centres have increased over the past decade, reshaping population distribution, labour availability, land use, and environmental pressure patterns.

Scale and Direction of Migration

Data from the National Population Census 2011 and 2021 indicate that Gandaki Province has a high proportion of households with absent members, primarily due to labour migration (CBS, 2021b; IOM, 2023).

- In 2021, approximately 31% of households in Gandaki reported at least one absent household member, reflecting a continued rise from 2011.
- Among absent persons, more than four-fifths are male, confirming that international labour migration remains strongly gendered.

International destinations dominate labour migration, with most migrants moving to Gulf countries and Malaysia, while internal migration flows are directed mainly toward urban centres within the province and major cities outside the province. Migration has become a structural feature of Gandaki's labour system, rather than a temporary phenomenon, with long-term consequences for environmental management and service demand.

Gender and Age Dimensions

Migration in Gandaki is highly selective by gender and age (IOM, 2023):

- Young adult males (20–39 years) constitute the majority of international migrants.
- This has resulted in a growing share of female-headed households, which reached about 41% in 2021, increasing from 2011.

Women, elderly persons, and children increasingly manage households, agriculture, and local resources in migrant-sending areas. This demographic shift has implications for labour availability, agricultural practices, and community-level environmental stewardship.

Internal Migration and Urban Concentration

Alongside international migration, Gandaki has experienced significant internal migration, particularly from rural and mountain areas toward urban and peri-urban municipalities, most notably Pokhara Valley and emerging market towns. Census data show:

- A steady increase in the urban population share between 2011 and 2021.
- Population growth concentrated in municipalities with better access to employment, education, health services, and transport infrastructure.

Internal migration contributes to urban expansion and densification, increasing pressure on land, water supply, sanitation, waste management, and energy systems in destination areas, while reducing population density in some rural and mountain settlements.

Migration and Rural Depopulation

In several hill and mountain areas of Gandaki, sustained out-migration has led to:

- declining rural populations,
- labour shortages in agriculture, and
- partial or full abandonment of cultivated land.

While reduced human pressure has allowed forest regeneration in some locations, unmanaged land abandonment also increases risks of invasive species spread, forest fires, and landscape change. The environmental outcomes of rural depopulation are therefore mixed and context-specific.

Temporal Trend: 2011–2021

Comparing the two census periods highlights several clear trends:

- Increase in households with absent members, confirming intensification of labour migration.
- Rising feminisation of household responsibility, linked to male out-migration.
- Growing urban concentration, driven by internal migration.
- Persistent dependence on remittances, which shape consumption patterns, housing construction, and resource use.

These trends suggest that migration will continue to be a major driver of demographic and environmental change in Gandaki Province. Understanding migration patterns is therefore essential for interpreting environmental pressures, adaptive capacity, and sustainability pathways across the province.

Drivers of Migration and Environmental Linkages

Migration in Gandaki is driven by a combination of economic, environmental, demographic, and structural factors. Census data and sector evidence indicate that migration is not the result of a single trigger, but rather a cumulative response to livelihood constraints, environmental stress, service access gaps, and climate-related risks (IOM, 2023).

Livelihood Constraints and Agricultural Change

Agriculture remains a key livelihood base in Gandaki Province, yet its capacity to absorb labour has declined over time. Census and agricultural statistics show (CBS, 2021b; IOM, 2023):

- a declining share of the population primarily dependent on agriculture, and
- increasing fragmentation of landholdings and labour shortages due to out-migration.

Male-dominated labour migration has reduced the availability of agricultural labour in many hill and mountain areas, contributing to:

- reduced intensity of cultivation,
- shifts toward subsistence or low-input farming, and
- partial or complete land abandonment in marginal areas.

While reduced cultivation pressure has enabled forest regeneration in some locations, unmanaged abandonment has also increased risks of invasive species spread, forest fires, and changes in landscape structure. Thus, migration reshapes land–environment interactions rather than simply reducing pressure.

Environmental Stress and Resource Degradation

Environmental conditions influence migration decisions, particularly where livelihoods are closely tied to natural resources. In parts of Gandaki:

- declining soil fertility,
- localized water scarcity during dry seasons, and
- increasing frequency of landslides and floods

Because of the unexpected phenomena such as climate-induced disasters (e.g. floods, landslides, rainstorms, forest fire, etc.), agricultural reliability and household vulnerability have increased. Although census data do not directly attribute migration to environmental causes, environmental stress acts as a risk multiplier, making migration a more attractive coping strategy when combined with limited livelihood alternatives.

Climate Change as a Driver and Amplifier

Climate change increasingly interacts with migration drivers in Gandaki Province. Rising climate variability manifested through erratic rainfall, prolonged dry spells, extreme rainfall events, and landslides affects:

- crop productivity and food security,
- safety and accessibility of rural settlements, and
- reliability of local infrastructure and services.

Climate change does not typically trigger immediate migration on its own, but it accelerates existing migration trends by undermining rural livelihoods and increasing uncertainty. Households with prior migration experience or social networks are more likely to use migration as an adaptation strategy.

Access to Services and Infrastructure

Internal migration toward urban and peri-urban centres in Gandaki is strongly influenced by access to services, including:

- education and health facilities,

- employment opportunities,
- transport connectivity, and
- electricity, water, and communication services.

Census evidence indicates that population growth is increasingly concentrated in municipalities with better service provision, particularly in the Pokhara Valley and emerging urban centres. This movement shifts environmental pressure from rural to urban systems, increasing demand for land, housing, water, sanitation, waste management, and energy in destination areas.

Remittances, Consumption, and Environmental Change

International labour migration has increased household access to remittances. While remittances improve income security, they also influence consumption and land-use patterns, including:

- expansion of housing construction (often using concrete and energy-intensive materials),
- increased demand for modern energy, water, and consumer goods,
- reduced reliance on subsistence agriculture in some households.

These changes can reduce pressure on local forests (e.g. lower fuelwood dependence) but may increase urban sprawl, material consumption, and waste generation, especially in growing towns.

Demographic Change and Social Drivers

Migration is strongly shaped by demographic factors:

- young adults (20–39 years) dominate migration flows,
- male out-migration has increased the share of female-headed households (about 41% in 2021), and
- ageing populations are emerging in high out-migration areas.

Changes in household composition affect who manages land, forests, and water. Women and elderly persons often assume greater responsibility for natural resource management, sometimes with limited labour and institutional support.

6.10.3 Socio-economic Dimensions of Migration

Migration is not only a demographic trend in Gandaki Province it is a major force shaping household economies, local labour markets, inequality patterns, and the pace of urban growth. The 2021 census confirms that international labour migration remains widespread and strongly gendered, which has direct implications for who works, who stays behind, and how livelihoods and resources are managed.

Household economies, remittances, and welfare change

Census 2021 shows that 207,910 households (31.4%) in Gandaki have at least one member living abroad, with 286,593 people recorded as absent abroad. Most absent persons are men (83.7% male; 16.3% female). This scale indicates that migration-linked income (particularly remittances) is structurally important for a large share of households. At the national level, workers' remittances have remained a major part of the economy over the last decade (commonly above one-fifth of GDP in recent years), highlighting the macro-economic importance of migration income. For Gandaki, this translates into household-level changes such as:

- improved ability to meet daily needs, education and health spending;
- housing investment and durable goods purchase;
- reduced dependence on subsistence farming for some households.

At the same time, remittance benefits are not evenly shared: households without migrants often face higher livelihood stress, and many migrant households remain vulnerable because income can be unstable and migration costs can be high.

Labour markets, workforce gaps, and local production

The census indicates that the dominant reason for being abroad is salary/wage employment, showing migration is primarily labour-driven rather than education- or marriage-driven. This creates visible socio-economic effects within the province:

- Labour shortages in agriculture and local enterprises (especially in hill and mountain areas), contributing to shifts in farming practices and increased reliance on hired labour where available.
- Rising work burdens on women and older people in migrant-sending communities, because day-to-day farming, livestock care, and household resource management continue even when working-age men are absent.

This labour restructuring also interacts with environmental systems (e.g., changing land management, fallowing, and forest use), which the SoE should interpret as a socio-economic pathway shaping environmental outcomes.

Gendered impacts: feminization of responsibility

Because migration is heavily male-dominated (over four-fifths of absent persons are men), the social economy of many communities is increasingly supported by women-managed households, with expanded responsibilities for:

- household decision-making and budgeting,
- agriculture and livestock management,
- water, fuel, and fodder collection,
- disaster response and recovery at household level.

The socio-economic significance is that responsibility increases faster than power women may manage more work and risk, while still facing barriers in land ownership, finance, and formal market access (a pattern also consistent with broader provincial development planning concerns about inclusion in labour systems).

Poverty, inequality, and "two-speed" development

Provincial planning sources show that Gandaki's poverty has reduced compared to many contexts, but it has not disappeared. The Nepal Living Standards Survey (NSO, 2024c) figure cited in the provincial plan reports poverty in Gandaki at 11.8%, with a Gini coefficient of 0.29 (inequality persists even where average welfare improves). Migration contributes to this "two-speed" development:

- Remittance-receiving households can invest more in education, health, housing, and sometimes cleaner energy options.
- Non-migrant and poorer households may fall behind, remain resource-dependent, and have fewer options during climate and economic shocks.

Urbanization, consumption patterns, and service demand

Migration influences not only incomes but also where people live. Internal migration and returnee settlement often concentrate in municipalities and market centres, increasing demand for:

- housing and land,
- water supply and sanitation,
- waste management and energy,

- transport and public services.

Migration can reduce pressure in some rural localities while shifting pressure to urban systems, where environmental services may already be constrained.

Return migration, skills, and productive use of remittances

Provincial planning frameworks emphasize the need to mobilize remittances in productive sectors and to better use skills gained from foreign employment. This is socio-economically important because without pathways for investment and decent local work, migration can become a long-term cycle rather than a transitional strategy. Migration is a core socio-economic system of Gandaki that shapes livelihoods, labour availability, gender roles, inequality, and the spatial pattern of development. With 31.4% of households linked to overseas absence and a strongly male-skewed migration profile, the province experiences both welfare gains and new vulnerabilities. Therefore, migration should be treated as a cross-cutting factor that redistributes environmental pressures often away from some rural systems and toward urban service systems while also changing who has the capacity to manage land, water, forests, and climate risks.

6.10.4 Migration, Environment, and Climate Change

Migration in Gandaki Province is increasingly shaped by interactions between environmental change, climate variability, and livelihood vulnerability. While economic factors remain the primary drivers of migration, climate change and environmental stress are playing a growing role in influencing migration decisions, adaptive strategies, and environmental outcomes at both origin and destination areas.

Climate Change as a Stress Multiplier in Migration Decisions

Evidence from census and sector studies indicates that climate change rarely acts as a single, direct trigger for migration. Instead, it amplifies existing livelihood stresses, making migration a more viable or necessary option for households already facing economic or environmental constraints. Gandaki Province is exposed to a range of climate-related hazards, including:

- erratic and intense rainfall,
- landslides and floods,
- prolonged dry spells,
- heat stress in valleys, and
- changing snowfall patterns in high mountain areas.

These hazards affect agricultural productivity, water availability, settlement safety, and infrastructure reliability. For households dependent on climate-sensitive livelihoods particularly rain-fed agriculture such changes increase income uncertainty and reduce the capacity to cope locally, encouraging labour migration as a risk management strategy.

Environmental Degradation, Livelihoods, and Out-Migration

Environmental conditions influence migration primarily through their impact on livelihoods. In parts of Gandaki Province, declining soil productivity, localized water scarcity, and recurrent landslides have reduced the reliability of agriculture and rural income sources.

Census data show that migration is highest among working-age adults, particularly men aged 20–39, indicating that migration is used to compensate for limited local employment opportunities. As climate variability increases, environmental degradation and hazard exposure further weaken already fragile rural livelihoods, reinforcing migration trends. Environmental stress does not replace economic drivers of migration but strengthens their effect, especially where households lack access to irrigation, alternative livelihoods, or climate-resilient infrastructure.

Migration as an Adaptation Strategy

For many households in Gandaki Province, migration functions as an adaptation mechanism to climate and environmental risk. Remittances from migrant workers help households:

- smooth income during climate shocks,
- invest in improved housing and services,
- diversify livelihoods away from climate-sensitive agriculture.

Census 2021 indicates that 31.4% of households in Gandaki have at least one member living abroad, demonstrating the scale at which migration contributes to household coping capacity. However, adaptation through migration is uneven and conditional, depending on access to migration networks, finance, and opportunities.

Environmental Impacts at Migration Origin Areas

Out-migration reshapes environmental conditions in rural areas. Reduced population pressure and labour availability can lead to:

- declining intensity of land cultivation,
- abandonment of marginal agricultural land, and
- natural regeneration of forests in some locations.

At the same time, unmanaged land abandonment increases the risk of invasive species spread, forest fires, and landscape change, particularly under warmer and drier conditions. Environmental outcomes therefore vary depending on land management practices, institutional presence, and community capacity.

Environmental Pressure at Migration Destination Areas

Migration also shifts environmental pressure spatially. Internal migration toward urban and peri-urban areas, combined with return migration and settlement of migrant households, increases demand for:

- housing and land,
- water supply and sanitation,
- waste management and energy,
- transport and urban infrastructure.

In Gandaki Province, population concentration in municipalities especially Pokhara Valley has increased pressure on urban environmental systems. Climate change further stresses these systems through flooding, heat stress, and water scarcity, increasing the environmental footprint of migration-driven urban growth.

Differential Vulnerability and Inequality

Not all households benefit equally from migration as an adaptation strategy. Women, elderly persons, and households without migrants often face higher exposure to climate and environmental risks, with limited access to remittance income or alternative coping mechanisms.

Similarly, poor and marginalized communities may experience climate-induced displacement or distress migration without the protective benefits of stable remittance flows, increasing vulnerability rather than resilience. Effective environmental and climate policy therefore needs to recognize migration as a structural component of adaptation and development, rather than a temporary or isolated phenomenon. Integrating migration considerations into land use planning, urban management, climate adaptation, and natural resource governance is essential for sustainable outcomes.

6.10.5 Impacts of Migration on Natural Resources and Urban Systems

Migration in Gandaki Province has produced spatially differentiated impacts on natural resources and urban systems. While out-migration has altered land use and resource management in rural and mountain areas, internal migration and return migration have intensified pressure on urban and peri-urban environments. These impacts are closely linked to demographic change, livelihood restructuring, and climate stress.

Land Use Change and Agricultural Landscapes

Sustained out-migration from rural and mountain areas has reduced agricultural labour availability, contributing to:

- declining intensity of cultivation,
- fallowing or abandonment of marginal farmland,
- shifts from labour-intensive crops to low-input or subsistence farming.

In some locations, reduced human pressure has allowed natural regeneration of forests and vegetation, contributing to increased forest cover. However, unmanaged land abandonment has also led to:

- spread of invasive plant species,
- increased risk of forest fires,
- loss of maintained terraces and irrigation systems, increasing erosion risk.

These mixed outcomes highlight that migration alters land–environment relationships rather than simply reducing pressure on natural resources.

Forest Use and Resource Extraction

Migration influences forest use patterns in multiple ways. In migrant-sending communities:

- reduced household size and labour availability may lower direct pressure on forests for fuelwood and fodder,
- remittance income can enable a shift toward alternative energy sources, reducing reliance on biomass.

At the same time, reduced local presence can weaken community-based forest management, particularly where active participation is required for protection, thinning, and fire control. In such cases, forest regeneration may coexist with increased vulnerability to fire and illegal extraction, especially under drier and warmer conditions associated with climate change.

Water Resources and Irrigation Systems

Out-migration affects the operation and maintenance of local irrigation systems, drinking water schemes, and traditional water management practices. Labour shortages and ageing populations can limit routine maintenance, leading to:

- reduced irrigation coverage,
- declining efficiency of water distribution,
- increased vulnerability to climate variability.

Conversely, in-migration to towns and peri-urban areas increases water demand, placing pressure on already constrained urban water supply systems, particularly during dry seasons.

Urban Growth and Environmental Service Pressure

Internal migration and return migration have contributed to rapid population growth in municipalities, especially Pokhara Valley and other emerging urban centres. This growth has increased demand for:

- housing and land,

- water supply and sanitation,
- waste management and energy,
- transport and public infrastructure.

Urban expansion has often occurred faster than infrastructure development, leading to:

- informal or unplanned settlements,
- increased solid waste and wastewater generation,
- encroachment on river corridors, agricultural land, and hazard-prone areas.

Migration-driven urbanisation thus shifts environmental pressure from rural ecosystems to urban systems, rather than eliminating it.

Waste Generation and Pollution

Growing urban populations linked to migration contribute to rising solid waste and wastewater loads. In municipalities where waste management capacity is limited, increased generation leads to:

- open dumping and burning,
- pollution of rivers and streams,
- degradation of urban environmental quality.

Climate change further amplifies these impacts by increasing flood-related waste dispersion and overwhelming drainage systems during extreme rainfall events.

Housing, Construction, and Material Use

Remittance income and return migration have influenced housing patterns, including:

- construction of larger and more permanent houses,
- increased use of concrete and energy-intensive materials,
- expansion of built-up areas in peri-urban zones.

While improved housing quality enhances safety and living standards, it also increases demand for land, water, energy, and construction materials, contributing to environmental pressure and urban sprawl when not guided by land-use planning.

Differential Impacts and Inequality

The environmental impacts of migration are not uniform. Households without migrants may continue to depend heavily on natural resources for survival, while migrant households may reduce direct resource dependence but increase consumption-based environmental footprints. Women, elderly persons, and marginalized groups often bear the burden of managing resources and services under changing demographic conditions. From the Environment perspective, migration in Gandaki Province:

- alters land use and natural resource management in rural areas,
- shifts environmental pressure toward urban and peri-urban systems,
- interacts with climate change to amplify risk and service stress.

Recognising these impacts is essential for integrated planning across land management, forestry, water resources, urban development, and climate adaptation. Migration should therefore be treated as a cross-cutting factor shaping both environmental pressure and adaptive capacity, rather than as a purely socio-economic issue.

6.10.6 Migration Policy and Institutional Framework

Migration governance in Gandaki Province operates within Nepal's federal system, involving multiple institutions at federal, provincial, and local levels. While Nepal has a relatively well-developed policy framework addressing labour migration, employment, and remittances, explicit integration of migration with environmental management, urban planning, and climate adaptation remains limited.

National Policy and Legal Framework

At the national level, migration is primarily governed through policies and legislation focused on foreign employment, labour rights, and remittance management. These instruments aim to:

- regulate international labour migration,
- protect migrant workers' rights and welfare,
- promote safe and legal migration channels,
- encourage productive use of remittances.

In parallel, national policies on climate change, disaster risk reduction, urban development, forestry, land use, and environmental protection indirectly shape migration–environment interactions. However, these frameworks generally treat migration as a socio-economic issue, rather than as a cross-cutting factor influencing environmental pressure, land use change, or climate vulnerability. As a result, environmental and climate policies rarely incorporate migration dynamics explicitly, despite their relevance for adaptation, resource management, and urban resilience.

Provincial Policy and Planning Context

Gandaki Province has identified migration as a key development concern in its periodic plans and sector strategies, particularly in relation to:

- employment generation,
- youth out-migration,
- remittance utilization,
- skills development and returnee reintegration.

Provincial plans recognize both the opportunities and challenges associated with migration, including labour shortages in agriculture, increasing feminisation of responsibility, and urban growth pressures. However, migration is largely addressed from an economic and labour perspective, with limited articulation of its environmental and spatial implications.

Environmental planning instruments at the provincial level covering forests, water resources, climate adaptation, and urban development do not yet systematically integrate migration trends into scenario analysis, risk assessment, or resource planning.

Role of Local Governments

Local governments play a central role in managing the environmental consequences of migration, even though they have limited authority over migration itself. Their responsibilities include:

- land use planning and settlement management,
- water supply, sanitation, and waste management,
- local infrastructure development,
- disaster risk reduction and emergency response,
- community forest and natural resource management.

In practice, local governments in high in-migration areas face increasing pressure on environmental services and infrastructure, while out-migration areas struggle with labour shortages and declining institutional capacity. Capacity constraints technical, financial, and human often limit the ability of local governments to respond proactively to migration-related environmental challenges.

Institutional Coordination and Gaps

Migration governance involves multiple institutions across sectors, including labour, urban development, environment, forestry, water, and disaster management. However, coordination across these sectors remains weak, leading to fragmented responses. Key gaps include:

- lack of routine migration data integration into environmental and urban planning;
- absence of migration-sensitive land use and infrastructure standards;
- limited consideration of migration in climate adaptation planning;
- weak mechanisms to channel remittances toward environmentally sustainable investments.

As a result, migration's environmental impacts are often addressed reactively after service systems are stressed or hazards occur rather than through anticipatory planning.

Inclusion, Protection, and Vulnerability Considerations

Existing migration policies focus primarily on migrant workers themselves, with less attention to households and communities left behind, including women, elderly persons, and children. Environmental and climate risks faced by these groups such as increased workload, disaster exposure, and reduced access to services are not systematically addressed within migration frameworks.

Similarly, internal migrants and returnees are not consistently integrated into urban environmental planning, increasing the risk of informal settlement, service exclusion, and exposure to hazards.

6.10.7 Migration Indicators: Baseline, State, Change, and Synthesis

This section presents key migration-related indicators relevant to environmental change, urban pressure, and adaptive capacity in Gandaki Province. 2011 is used as the baseline and 2021 as the current state, based on national census data. The indicators focus on scale, structure, and spatial implications of migration, rather than migration alone.

Table 6-97. Migration Indicators for Gandaki Province (Baseline–State–Change–Synthesis)

Indicator	Baseline (2011)	State (2021)	Change / Trend	Environmental & SoE Synthesis
Households with at least one absent member (%)	Lower than 2021	**31.4% of households**	Increasing	Confirms migration as a structural driver; reshapes who manages land, forests, and water in rural areas
Absent population (number)	Lower	**286,593 persons**	Increasing	Sustained out-migration reduces rural labour availability while shifting pressure to urban systems
Share of male migrants (%)	High	**83.7% male**	Persistently high	Drives feminisation of responsibility in agriculture and resource management

Indicator	Baseline (2011)	State (2021)	Change / Trend	Environmental & SoE Synthesis
Female-headed households (%)	~40%	**~41%**	Slight increase	Indicates growing workload and decision-making responsibility for women in migrant-sending areas
Dominant age group of migrants	20–39 years	20–39 years	Stable	Loss of working-age labour affects agricultural practices and local environmental stewardship
Main reason for migration	Wage employment	Wage employment	Stable	Migration primarily labour-driven, not education- or disaster-led
International vs internal migration	International dominant	International dominant, internal rising	Internal migration increasing	Internal migration contributes to urban growth and environmental service demand
Urban population share	Lower	Higher than 2011	Increasing	Migration-driven urbanisation intensifies pressure on water, sanitation, waste, and energy systems
Remittance dependence (household level)	Significant	Widespread	Increasing	Improves income security but increases consumption and construction-related environmental pressure
Agricultural labour availability	Higher	Reduced	Declining	Contributes to land abandonment, forest regeneration, and fire/invasive species risk
Population ageing in rural areas	Emerging	More pronounced	Increasing	Affects capacity to manage land, forests, and irrigation systems

Migration indicators clearly show that Gandaki Province has transitioned into a high-migration system over the last decade. More than three out of ten households are directly affected by labour migration, with a strongly gendered and age-selective pattern. This has resulted in significant socio-environmental consequences, including labour shortages in agriculture, changing land-use patterns, and increased responsibility for women and elderly persons in rural areas. At the same time, rising internal migration toward urban and peri-urban centres has intensified demand for housing, water supply, sanitation, waste management, and energy services. These pressures are further amplified by climate variability and extreme events.

The indicator set suggests that migration in Gandaki Province functions as a cross-cutting driver of environmental change, redistributing pressure across space rather than reducing it. Without migration-sensitive environmental and urban planning, these trends risk increasing both rural landscape degradation and urban environmental stress.

Note: Migration–environment indicators at provincial level remain limited. This SoE relies primarily on Census 2011 and 2021 data, complemented by provincial planning documents. Strengthening routine migration-disaggregated environmental and urban service data is essential for future assessments.

6.10.8 Future Outlook for Migration and Environment

The future trajectory of migration in Gandaki Province will be shaped by the interaction of labour demand, demographic change, climate variability, environmental stress, and development choices. Current trends indicate that migration will remain a structural feature of provincial development, with important implications for land use, urban systems, and environmental sustainability.

Persistence of Labour Migration

International labour migration is expected to continue in the medium term, driven by limited local employment opportunities and sustained demand for migrant labour abroad. Given the existing migration networks and remittance dependence, a rapid decline in out-migration is unlikely. Continued out-migration will sustain labour shortages in agriculture and natural resource management in rural areas, reinforcing trends of land abandonment, changing cropping patterns, and altered forest dynamics.

Growth of Internal and Return Migration

Internal migration toward urban and peri-urban centres is likely to increase further, particularly as:

- towns expand their service and employment functions,
- return migrants settle in municipalities with better facilities,
- youth seek education and non-agricultural opportunities.

This trend will accelerate urban expansion and densification, especially in high-attraction areas such as Pokhara Valley. Urban systems will face rising pressure on land, water supply, sanitation, waste management, energy, and transport, with climate change increasing exposure to flooding, heat stress, and service disruption.

Climate Change and Migration Dynamics

Climate change is expected to intensify existing migration drivers rather than create entirely new patterns. Increasing frequency of extreme rainfall, landslides, floods, droughts, and heat stress will:

- reduce the reliability of climate-sensitive livelihoods,
- increase disaster-related displacement risk,
- encourage migration as an adaptive strategy for some households.

However, migration as adaptation will remain **uneven**, benefiting households with resources and networks while increasing vulnerability for those unable to migrate safely.

Changing Land Use and Ecosystem Implications

Future migration trends are likely to produce mixed environmental outcomes:

- continued forest regeneration in some depopulating rural areas,
- increased risk of forest fires, invasive species, and unmanaged landscapes where institutional presence declines,
- expansion of built-up areas and infrastructure in urban and peri-urban zones.

The balance between positive and negative outcomes will depend on land management, planning, and governance responses.

Social and Environmental Inequality

Without targeted policy intervention, migration-related environmental impacts are likely to exacerbate inequality. Rural areas with high out-migration may struggle to maintain environmental infrastructure and services, while urban migrants particularly the poor may settle in environmentally vulnerable or hazard-prone locations. Women, elderly persons, and marginalized groups are expected to continue bearing a disproportionate share of environmental and climate-related burdens.

6.10.9 DPSIR Analysis (Migration–Environment)

The DPSIR framework helps explain how migration in Gandaki Province interacts with environmental systems by linking demographic and economic drivers to environmental pressures, changing states, impacts, and responses. Migration operates both as a driver of environmental change and as a coping or adaptation strategy to environmental and climate stress.

Drivers

Key drivers shaping migration–environment interactions in Gandaki Province include:

- limited local employment opportunities and declining labour absorption in agriculture;
- strong international labour demand and established migration networks;
- uneven access to services and opportunities across rural and urban areas;
- environmental stress and climate variability affecting livelihoods;
- aspirations for education, income security, and improved living conditions.

Climate change acts as a **cross-cutting driver**, intensifying livelihood uncertainty and influencing both migration decisions and environmental outcomes.

Pressures

Migration-related drivers generate several environmental pressures through changes in population distribution and resource use:

- reduced agricultural labour leading to land abandonment or under-management in rural areas;
- weakening of traditional land, irrigation, and forest management systems in high out-migration areas;
- increased demand for land, housing, water, sanitation, waste management, and energy in urban and peri-urban destinations;
- expansion of built-up areas, often in hazard-prone or environmentally sensitive locations.

These pressures are unevenly distributed, shifting environmental stress from rural landscapes to urban systems rather than eliminating it.

State

The combined effect of migration and climate stress alters the environmental state in multiple ways:

- changes in land use, including forest regeneration in some rural areas and unmanaged landscapes in others;
- increased stress on urban environmental services, particularly water supply, sanitation, drainage, and waste management;
- rising exposure of settlements and infrastructure to floods, landslides, and heat stress;
- reduced capacity for maintenance of local environmental infrastructure in depopulating areas.

Environmental state changes are highly location-specific, reflecting differences in governance capacity and planning.

Impacts

Changes in environmental state lead to several socio-environmental impacts:

- increased disaster risk and environmental degradation in urban growth areas;
- mixed ecosystem outcomes in rural areas, including both recovery and degradation;
- heightened workload and vulnerability for women, elderly persons, and marginalized groups managing resources in migrant-sending communities;
- livelihood insecurity for households dependent on climate-sensitive systems or informal urban settlements.

Over time, these impacts can reinforce migration drivers, creating feedback loops between environmental stress and population mobility.

Responses

Current responses to migration–environment interactions include:

- community forestry and local land management institutions in rural areas;
- municipal service provision and urban planning in destination areas;
- climate adaptation and disaster risk reduction initiatives;
- labour and migration policies focused on employment and remittances.

However, responses remain fragmented. Migration considerations are rarely integrated explicitly into environmental management, land use planning, or climate adaptation strategies, limiting their effectiveness.

Table 6-98. DPSIR Synthesis for Migration and Environment in Gandaki Province

DPSIR Element	Migration–Environment Linkages
Drivers	Labour migration demand, livelihood constraints, service access gaps, climate variability
Pressures	Land abandonment, reduced rural management capacity, urban service demand, land conversion
State	Changing land use patterns, forest regeneration and fire risk, stressed urban water and waste systems
Impacts	Ecosystem change, disaster risk, livelihood vulnerability, increased inequality
Responses	Community forestry, urban planning, DRR and climate policies, labour migration governance (largely unintegrated)

Migration in Gandaki Province functions as a systemic cross-cutting driver that redistributes environmental pressure across space and interacts strongly with climate change. While migration can support household adaptation and income security, unmanaged migration dynamics risk increasing environmental stress in urban systems and weakening resource stewardship in rural areas. Integrating migration trends into environmental planning, urban development, and climate adaptation is therefore essential to break negative feedback loops and support sustainable outcomes.

6.10.10 Recommendations

The analysis shows that migration in Gandaki Province is reshaping environmental pressure, land use, and vulnerability patterns. Migration itself is neither inherently positive nor negative for the environment; outcomes depend on how population mobility is integrated into land management, urban planning, and climate adaptation. The recommendations, therefore, focus on anticipating pressure shifts, strengthening governance, and reducing vulnerability.

Table 6-99. Migration–Environment Recommendations (Observed Trends, Risks, and Targeted Actions)

Observed Trend	Key Environmental and Climate Risks	Targeted Actions
High and sustained international labour migration	Labour shortages and under-management of rural land, forests, and irrigation	Promote land consolidation, climate-resilient agriculture, and community land stewardship in high out-migration areas
Increasing feminisation of responsibility in migrant-sending households	Overburdening of women in resource management and disaster response	Integrate GESI-responsive support into land, water, and forest management programmes
Rising internal migration toward urban and peri-urban centres	Overloading of water, sanitation, waste, and energy systems	Integrate migration projections into municipal environmental service and infrastructure planning
Expansion of built-up areas driven by migration and remittances	Encroachment into hazard-prone and environmentally sensitive areas	Strengthen land-use zoning, risk-sensitive settlement planning, and enforcement
Land abandonment in rural and mountain areas	Invasive species spread, forest fires, and erosion	Support active land management, fire control, and invasive species management in depopulating areas
Remittance-driven consumption and housing construction	Increased material use, energy demand, and waste generation	Promote green building standards and incentives for sustainable remittance investment
Migration as an informal adaptation strategy to climate stress	Unequal resilience outcomes and distress migration	Integrate migration into climate adaptation and disaster risk reduction planning
Weak integration of migration into environmental governance	Reactive management of environmental impacts	Mainstream migration considerations into environmental, climate, and urban policies
Limited data on migration–environment linkages	Inadequate evidence for planning and monitoring	Strengthen migration-disaggregated environmental data systems and indicators
Uneven local government capacity	Ineffective response to migration-driven pressure	Build local institutional and technical capacity for migration-sensitive environmental management

To operationalize these recommendations:

- Prioritize high-pressure zones: urban municipalities with rapid in-migration and rural areas with extreme out-migration.

- Strengthen coordination between labour, environment, urban development, and climate institutions.
- Support local governments with technical guidance, financing, and data tools.
- Align migration management with climate resilience and inclusion objectives.

Migration will continue to shape environmental outcomes in Gandaki Province by redistributing population, labour, and resource demand. The recommended actions emphasize a shift from reactive responses to anticipatory, migration-sensitive environmental planning. Integrating migration into land use management, urban services, and climate adaptation will be critical for reducing risk, enhancing resilience, and ensuring sustainable environmental outcomes.

6.10.11 Migration and the Sustainable Development Goals (SDGs)

Migration in Gandaki Province is closely linked with progress across multiple Sustainable Development Goals (SDGs). While migration contributes to poverty reduction, income diversification, and resilience at household level, it also reshapes environmental pressure, urbanization patterns, and vulnerability to climate risks. Aligning migration dynamics with the SDG framework helps ensure that mobility supports inclusive, resilient, and environmentally sustainable development.

Table 6-100. Migration–Environment Indicators, DPSIR Category, and SDG Linkages

Indicator	DPSIR Category	Relevant SDG Targets	Policy Significance for Gandaki Province
Households with absent members (%)	Driver	SDG 1.2, SDG 8.8	Reflects reliance on labour migration for income security and risk management
International labour migration (male-dominated)	Driver	SDG 5.4, SDG 10.7	Highlights gendered migration patterns and feminisation of responsibility
Internal migration toward urban areas	Driver	SDG 11.1, SDG 11.3	Drives urban expansion and pressure on environmental services
Remittance-dependent household income	Impact	SDG 1.1, SDG 10.c	Supports poverty reduction but increases consumption-related environmental pressure
Declining agricultural labour availability	Pressure	SDG 2.4, SDG 15.3	Contributes to land abandonment and changes in rural land management
Land abandonment in rural areas	State	SDG 15.1, SDG 15.3	Linked with forest regeneration, invasive species, and fire risk
Expansion of built-up areas	Pressure	SDG 11.3, SDG 11.5	Increases exposure to hazards and demand for land and resources
Urban water, sanitation, and waste demand	Pressure	SDG 6.1, SDG 6.2, SDG 11.6	Highlights migration-driven stress on urban environmental systems
Migration as an adaptation strategy	Impact	SDG 13.1, SDG 1.5	Reduces vulnerability for some households but creates unequal resilience outcomes

Indicator	DPSIR Category	Relevant SDG Targets	Policy Significance for Gandaki Province
Climate-induced displacement risk	Impact	SDG 13.1, SDG 11.5	Emphasizes need for climate-resilient settlements and services
Migration-sensitive land-use planning	Response	SDG 11.b, SDG 13.2	Supports risk-informed urban and rural development
Integration of migration in climate adaptation	Response	SDG 13.2, SDG 16.7	Strengthens anticipatory planning and inclusive governance

The migration–environment linkages in Gandaki Province demonstrate that population mobility is both a development enabler and an environmental stress factor. Migration supports progress toward SDGs related to poverty reduction, decent work, and resilience (SDGs 1, 8, and 13), while simultaneously influencing outcomes under SDGs 2, 6, 11, and 15 through land-use change, urban expansion, and resource demand.

Ensuring positive SDG outcomes requires treating migration as a cross-cutting structural process within environmental and climate policy, rather than a standalone labour issue. Integrating migration considerations into land management, urban planning, and climate adaptation will be essential for achieving inclusive and sustainable development pathways in Gandaki Province.

Chapter 7. Conclusion and Recommendation

7.1 Conclusion

Gandaki Province is one of Nepal's most distinctive and valuable regions, defined by its mountains and rivers, forests and lakes, and by the close relationship between people and nature. From the high Himalayas of Manang and Mustang to the fertile river valleys and the growing urban center of Pokhara, the province's environment shapes livelihoods, culture, and economic opportunity. Tourism, hydropower, agriculture, and urban services all depend directly on the health of natural systems. For Gandaki, the state of the environment is not a separate issue, it is central to development and well-being.

This State of Environment assessment shows that Gandaki is undergoing rapid environmental change. Urban areas are expanding, infrastructure is spreading into fragile landscapes, and demand for water, energy, and land is increasing. Tourism continues to grow, bringing income and employment, but also placing pressure on lakes, forests, trails, and municipal services. Hydropower development has strengthened energy security, yet it has also altered river systems and raised new concerns about sediment, aquatic ecosystems, and long-term sustainability. In rural areas, migration and changing livelihoods are transforming land use, leading to fallow farmland in some places and increased pressure on forests and resources in others.

Climate change is intensifying these challenges. Rising temperatures, especially at higher elevations, are affecting glaciers, snow cover, and water availability. Rainfall patterns are becoming more variable, with intense downpours increasing the risk of landslides, floods, and sedimentation, while dry-season water stress is growing in many hill settlements. These changes are already visible across the province and are expected to become more pronounced in the coming decades. Their impacts are felt most strongly by communities that depend directly on natural resources and by those with limited capacity to adapt.

The assessment also makes clear that environmental pressures and risks are not evenly distributed. Urban municipalities face growing problems related to waste management, air pollution, and water quality. Hill districts struggle with slope instability, road-related erosion, and declining agricultural productivity. High mountain regions face glacier retreat and increasing climate uncertainty. Poor and marginalized groups, including women, elderly populations, and resource-dependent households, are often the most exposed to environmental degradation and climate-related hazards.

At the same time, Gandaki Province has strong foundations for a more sustainable future. Community forestry has strengthened forest cover and local stewardship. Electrification rates are high, creating opportunities for cleaner household energy use. Tourism offers pathways for green growth if managed responsibly. Provincial institutions and legal frameworks for environmental protection are in place and continue to evolve. These strengths provide a solid basis for addressing current challenges and reducing future risks.

The central message of this State of Environment report is that Gandaki's long-term prosperity depends on the careful management of its environmental systems. Economic growth, infrastructure development, and service expansion cannot be sustained if rivers are degraded, slopes become unstable, lakes are polluted, and ecosystems lose their resilience. Environmental protection should not be viewed as an obstacle to development, but as a necessary investment in economic stability, disaster resilience, and quality of life.

Moving forward, Gandaki's development pathway must place greater emphasis on integration between sectors, between provincial and local governments, and between development planning and environmental risk management. Land use decisions, infrastructure investments, tourism expansion, and energy development all need to be guided by environmental evidence and climate risk considerations. Preventive action, early planning, and nature-based solutions will be far more effective and less costly than reactive responses after damage has occurred.

This State of Environment report provides a shared understanding of where Gandaki stands today, the pressures it faces, and the opportunities it can build upon. It is intended not only as a record of environmental conditions, but as a foundation for informed decision-making. By using this evidence to guide policies, budgets, and investments, Gandaki Province can protect its natural heritage while advancing inclusive, resilient, and sustainable development.

The choices made today will shape the landscapes, livelihoods, and well-being of future generations. With thoughtful planning and committed action, Gandaki can remain a province where nature and development support one another, rather than compete.

7.2 Strategic Recommendations

The following recommendations are structured around practical action areas for provincial planning and budgeting.

Strengthen Environmental Governance and Coordination

1. Establish a Provincial Environmental Monitoring System
   - Standardize key indicators across sectors.
   - Create an annual environmental dashboard.
   - Improve data sharing between ministries and municipalities.
2. Strengthen inter-ministerial coordination
   - Integrate environment, infrastructure, tourism, agriculture, and DRR planning.
   - Institutionalize regular cross-sector review of high-risk projects.
3. Improve Environmental Impact Assessment (EIA) enforcement
   - Ensure compliance monitoring of hydropower, road, and tourism infrastructure.
   - Strengthen post-approval environmental auditing.

Promote Climate-Resilient Infrastructure and Land Use Planning

1. Introduce slope-sensitive and watershed-based road design
   - Prioritize drainage, bioengineering, and stabilization in hill districts.
   - Reduce sediment discharge into rivers and lakes.
2. Develop and enforce municipal land-use zoning
   - Protect agricultural valleys and wetlands.
   - Prevent settlement expansion into floodplains and landslide-prone areas.
3. Integrate climate risk screening into MTEF and ADP processes
   - All major infrastructure investments should undergo climate risk review.

Protect Water Systems and River Basins

1. Implement environmental flow standards for hydropower projects
   - Protect aquatic ecosystems and downstream users.
2. Strengthen lake and wetland management
   - Control sediment inflow.
   - Improve sewage treatment around Phewa, Begnas, and Rupa lakes.
3. Promote integrated river basin management
   - Align irrigation, hydropower, tourism, and watershed protection policies.

Accelerate the Clean Energy Transition

1. Reduce household fuelwood dependence
   - Promote electric cooking and improved stoves in hill districts.
   - Target vulnerable and marginalized households.
2. Encourage solar and decentralized renewable solutions
   - Support remote mountain settlements.
3. Promote energy-efficient buildings and tourism facilities.

Strengthen Urban Environmental Management

1. Improve solid waste systems
   - Increase collection coverage and segregation.
   - Develop environmentally safe landfill management.
   - Encourage recycling and circular economy initiatives.
2. Address construction and road dust
   - Enforce dust control measures.
   - Improve monitoring of air quality in Pokhara Valley.
3. Develop urban drainage and flood management systems
   - Reduce monsoon flooding risk.

Safeguard Forests and Biodiversity

1. Strengthen community forestry institutions
   - Expand forest-based enterprises sustainably.
   - Support carbon and ecosystem service payment mechanisms.
2. Address habitat fragmentation
   - Review rural road alignments in forest corridors.
   - Promote wildlife corridors.
3. Improve human–wildlife conflict management mechanisms.

Promote Sustainable and Responsible Tourism

1. Develop a Provincial Green Tourism Standard
   - Waste management compliance for hotels and trekking operators.
   - Water efficiency and energy efficiency measures.
2. Support eco-friendly homestay models
   - Provide incentives for sustainable waste and sanitation systems.
3. Manage carrying capacity in high-pressure destinations.

Strengthen Disaster Risk Reduction and Climate Adaptation

1. Expand early warning systems and hazard mapping.
2. Invest in nature-based solutions (reforestation, slope stabilization, riverbank protection).
3. Prioritize climate-resilient agriculture and water source protection in hill districts.

Promote Equity and Inclusion in Environmental Action

1. Ensure that marginalized communities are prioritized in clean energy and climate adaptation programs.
2. Integrate Gender, Disability, and Social Inclusion (GESI) into environmental budgeting.
3. Support livelihood diversification linked to green sectors (eco-tourism, agroforestry, renewable energy services).

Looking Ahead: A Sustainable Gandaki by 2035

If Gandaki strengthens environmental governance, integrates climate risk into planning, manages urban growth responsibly, and protects its natural capital, it can:

- Maintain tourism competitiveness
- Secure hydropower reliability
- Improve agricultural resilience
- Reduce disaster losses
- Enhance quality of life in growing urban centers
- Attract green investment and climate finance

However, if environmental degradation continues unchecked, economic gains may become increasingly fragile and recovery costs will rise.

7.3 Specific Recommendations

Strengthening Environmental Database and Capacity Development

- Strengthening environmental database information system at Provincial Policy and Planning Commission as central data hub, linking all local municipalities to support the provincial periodic planning process to address the environmental issues;
- Strengthening capacity on evidence-based integrated environmental assessment and reporting system of the Local and provincial government for the Sustainable Decision making for sustainable resources use;
- Strengthening the capacity of the planning unit of municipalities on handling and analysis of the spatial data with GIS and remote sensing technology;
- Establishment of the Natural System Monitoring (metrological station, water quality, land quality etc.) in each municipality and strengthening capacity of Municipality on monitoring environmental variables;
- Strengthen and build the capacity of the Information Technology (IT) staff of the Municipalities in understanding of environment and handling of environmental variable and information to support the sustainable decision making and resource mobilization;

Strengthening Environment Management System

- Conduct an integrated environmental assessment of Pokhara Metropolitan and other emerging bigger Municipalities to identify the key priority environmental issues and detail analysis to find out the pressing issues and gap based on which prepare an action plan with projects;

Environmental Data and Monitoring System Development

- Establish a drinking water quality monitoring system and maintain a routine water quality database at local level;

- Assessment of air pollution spatial trends and routs for the establishment of the air pollution monitoring instrument;
- Build the capacities of the Municipalities through training and awareness programme and for those municipality prone to air pollution air quality monitoring system is to set up;
- Air Quality Monitoring instrumentation across low-land (Kawasoti) to high-Mountain (Lo-Manthang) and maintain the air-quality database;

Urban Environment and Solid Waste

- Support to prepare risk sensitive landuse plan of municipality and growing urban centres;
- Assessment of current urban solid waste management practices at local level and explore alternative measures for the sustainable waste management;

Agriculture and Soil Health (Food Security)

- Assessment of the agriculture production and soil health of the selected districts/municipalities on depletion of soil production a capacity and prepare the action plan to reverse the soil productivity degradation trend;
- Establish a soil test programme in regular intervals in all the districts and maintain the database and based on the test report needful action can be taken to restore the soil health.
- Support to prepare landuse zone map in each municipality (rural and urban) and develop landuse policy;

Forest and Biodiversity:

- Assessment of the fruit producing plants species under the community forest in the municipalities affected by the Human animal conflicts and prepare the action plan on promote the fruit-bearing plants (Agro-forestry) in the community forest to keep the animals in the forest;
- Assess the grassland biodiversity and prepare grass land protection and restoration strategy;
- Prepare protocol for forest protection from fire and develop forest fire monitoring and fire risk mitigation guideline;
- Assess the types of invasive species in local level, their impacts and develop strategy to control invasive species;
- Assess and support wildlife friendly infrastructure development through policy and design guidelines;

Mainstream climate and disaster risk into infrastructure planning

- Assessment of the debris deposited river system's (e.g. Kaligandaki in Mustang, Darmkhola in Baglung, Myagdi Khola in Myagdi, Daraudi in Gorkha, Andhi Khola in Syangja, Modi Khola in Parbat, seasonal stream in Kawasoti area, and other major rivers) watershed for its annual sand, gravel and stone yield prediction and develop strategy for sustainable harvesting by the local municipalities;
- Support the local government for spatial assessment of the Municipalities to identify the hazard and disaster prone area for developing the sustainable landuse plan and infrastructure development;
- Develop the Glacier and Glacier Lake monitoring system and learning center (e.g. Gangapurna in Manang and Birendra Tal in Gorkha) to assess the climate change and its impact in high altitude region for the national and international researcher and visitors;
- Prepare municipality level road network map and assess the state of interconnection facility, and develop roadside slope protection guideline;
- Assess landslide and flood prone areas at local level, develop early warning system;

Clean Energy Promotion

- Assessment of the Municipalities household electric wiring capacities on use of the electric cooking stoves and recommendation for the action plan to enable the municipalities transform from fuel wood and fossil (and LPG) fuel to clean electricity cook stove;

River Basin and Water Resources

- Establish the lake and wetland monitoring and development system in the institution for addressing the degradation of the water quality and aquatic lives;
- Assess River Basin (watershed and sub-watershed) health, and rank the river basin in terms of its health/state and develop climate responsive integrated watershed management plan;
- Establish water quality monitoring protocol of province river basins, perform regular water quality assessment to achieve Water Quality Index (WQI);
- Establish monitoring system for the e-flow of hydropower projects;

Crosscuttings:

- Build the program on raising awareness among hospitality sector on sustainable consumption of the resources use at the hotel and production of the waste;
- Promote the green labeling of the hotel on use of resources and production of waste by the hotels/homestays;
- Build the program on community awareness on inclusive developmental plan;
- Review local level GESI policy to assess any gaps and support local government to improve and develop inclusive developmental plan and policies;

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Annexes:

Annex 7: Table A1: International Environmental Conventions and Frameworks Relevant to Gandaki Province

Thematic Area	International Instrument	Focus / Relevance
Air Quality & Climate	Paris Agreement (2015)	Climate mitigation and adaptation; co-benefits for air quality
	Montreal Protocol (1987)	Protection of ozone layer; reduction of harmful substances
Water Resources	UN Watercourses Convention (1997)	Equitable and sustainable management of international watercourses
	SDG 6	Safe water, sanitation, and water ecosystem protection
Land & Agriculture	UNCCD (1994)	Sustainable land management and drought mitigation
	FAO VGGT (2012)	Responsible land tenure and agricultural governance
Forest & Biodiversity	Convention on Biological Diversity (1992)	Conservation and sustainable use of biodiversity
	Forest Principles (1992)	Sustainable forest management framework
Energy & Industry	UNFCCC (1992)	Climate action and low-carbon energy transition
	SDG 7	Affordable and sustainable energy
Urban & Waste	Agenda 21 (1992)	Sustainable urban development and waste management
	Basel Convention (1989)	Hazardous waste control
Climate & DRR	Sendai Framework (2015)	Disaster risk reduction and resilience
	Kyoto Protocol (1997)	GHG reduction commitments

Annex 8: Table A2: National Policies, Acts, and Regulations Relevant to Environmental Governance

Thematic Area	Key National Instruments
Air Quality	Environment Protection Act (2019); National Ambient Air Quality Standards (2012); Emission Standards for Vehicles (2016); National Climate Change Policy (2019)
Water Resources	Water Resources Act (1992); National Drinking Water Quality Standards (2005); IWRM Policy (2015); Groundwater Policy (2016)
Land & Agriculture	Land Use Policy (2015); Soil Conservation Act (1982); Agriculture Development Strategy (2015); National Agriculture Policy (2004)
Forest & Biodiversity	Forest Act (2019); National Parks and Wildlife Conservation Act (1973); NBSAP
Energy & Industry	Energy Policy (2008); Hydropower Development Policy (2001); Renewable Energy Policy (2013); Industrial Enterprises Act (1992)
Urban & Waste	Solid Waste Management Act (2011); Urban Development Act (2015); National Urban Policy (2024)
Climate & DRR	Disaster Risk Reduction and Management Act (2017); NAPA; Climate Change Action Plan (2020–2030); NDC 3.0
Cross-cutting	Sixteenth National Plan (2024/25–2028/29)

Annex 9: Table A3: Provincial Policies, Acts, and Regulations (Gandaki Province)

Thematic Area	Provincial Instruments
Air Quality	Gandaki Environment Protection Act (2076); Environment Protection Rules (2079); Environmental Study & Forest Land Use Procedure (2080)
Water Resources	Irrigation Act (2078); Drinking Water & Sanitation Act; LCDA Act (2075)
Land & Agriculture	Cooperative Act (2075); Small & Modern Irrigation Programme Procedure; Second Five-Year Plan
Forest & Biodiversity	Forest Act (2080); Forest Rules (2081); Sustainable Forest Management Guideline (2082); Wildlife-Friendly Infrastructure Guideline
Energy & Industry	Industrial Business Act (2075); Electricity Development Act (Bill); Compliance Provisions under EP Rules
Urban & Waste	LCDA Rules (2076); Integrated Lake Basin Management Plan (Pokhara)
Climate & DRR	Provincial Disaster Management Rules (2080); Climate Change & GESI Strategy; PCCFF (2082)

Annex 10: Table A4: Local-Level Policies and Regulations (Representative Municipalities)

Thematic Area	Examples of Local Instruments
DRR & Climate	Disaster Risk Reduction Acts; Disaster Fund Procedures; Preparedness & Response Plans
Water & Sanitation	Drinking Water Acts; Water Source Registration Procedures; Riverbed Extraction Regulations
Land & Agriculture	Land Use Acts; Agriculture Promotion Acts; Organic Farming Programs
Forest & Biodiversity	Local Forest Acts; Biodiversity Management Plans; Wetland Protection Guidelines
Energy & Industry	Renewable Energy Development Policies; Micro-hydro Guidelines; Small Industry Procedures
Urban & Waste	Urban Waste Management Acts; Waste Segregation Guidelines; Public Toilet Regulations
Cross-cutting	GESI Policies; Child Rights Acts; SDG Localization Procedures

Annex 11: Table A5: Unique Municipal Policies in Gandaki Province (Selected Examples)

Thematic Area	Unique Instrument	Municipality
Air Quality	Air Quality Management Guidelines	Pokhara Metropolitan City
DRR	Disaster Risk Insurance Procedure	Bhimsen Thapa RM
Water	Hot Spring Conservation Procedure	Chame RM
Land & Agriculture	Organic Model Agriculture Program	Devghat Municipality
Forest	Aquatic Biodiversity Protection Act	Khathekhola RM
Energy	Micro-Hydro Development Guidelines	Machhapuchhre RM
Urban Waste	Comprehensive Waste Management Act	Besisahar Municipality
Cross-cutting	SDG Localization Procedures	Devghat & Ghiring RMs

Annex 12: Governance Reform Priority Matrix (2025–2030): Gandaki Province

Purpose:

This matrix translates identified governance gaps and reform opportunities into **prioritized, actionable governance reforms**, clarifying *what needs to change, who should lead, and what environmental outcomes are expected* over the medium term.

Table A6: Priority Environmental Governance Reforms for Gandaki Province

Priority Area	Core Governance Reform	Lead Institutions*	Timeframe	Expected Environmental Outcome
Policy Coherence & Coordination	Establish formal inter-sectoral coordination mechanisms for land use, water, urban development, and climate governance	PPPC; sectoral ministries	2025–2027	Reduced policy conflicts; integrated planning at landscape and river-basin scales
Regulation & Enforcement	Strengthen enforcement capacity through standardized compliance procedures, inspections, and penalties at provincial and municipal levels	MoFE (Prov.); MoIAL; Municipalities	2025–2030	Improved compliance with environmental standards; reduced pollution and resource degradation
Urban Environmental Governance	Create a provincial technical support unit for urban waste management, land-use planning, and environmental safeguards	MoFE (Prov.); MoPID; Municipalities	2025–2028	Improved waste management performance; reduced urban pollution and health risks
Environmental Data & Monitoring	Develop an integrated provincial environmental data and monitoring system linked to federal datasets	PPPC; DHM; NSO	2025–2027	Evidence-based planning; improved early warning and adaptive management
Climate & Disaster Governance	Mainstream climate adaptation and DRR into provincial and municipal planning and budgeting processes	MoIAL; PPPC; Municipalities	2025–2030	Increased climate resilience; reduced disaster losses
Land Use & Agriculture Governance	Clarify land-use authority and strengthen sustainable agriculture extension services	MoALMC; Municipalities	2026–2030	Reduced land degradation; improved soil and water conservation
Forest & Biodiversity Governance	Update community forest management plans and strengthen biodiversity monitoring and conflict management	MoFE (Prov.); Local Forest Institutions	2025–2029	Enhanced ecosystem resilience and biodiversity protection
Energy & Industry Oversight	Harmonize licensing and environmental oversight for energy, mining, and industrial activities	MoEA; MoIT; MoFE (Prov.)	2026–2030	Reduced cumulative environmental impacts; improved industrial compliance
Capacity Development	Targeted capacity-building programs for provincial and local environmental officials	PPPC; Sector Ministries	2025–2030	Improved governance effectiveness and service delivery
Participation & Inclusion	Institutionalize GESI-responsive participation mechanisms in environmental decision-making	MoSDYS; Municipalities	2025–2030	More equitable governance; improved legitimacy and community ownership

* *Lead institutions shown indicate coordinating responsibility; effective implementation requires inter-agency collaboration.*

Annex 13: **Phased Recommendations for Climate Change Adaptation and Disaster Risk Reduction**

Timeframe	Focus Area	Key Recommendations
Short-term (1–3 years)	**Risk-informed planning & governance**	• Make climate and multi-hazard risk screening mandatory for provincial and municipal plans and projects. • Apply MHRA and climate indicators (extreme rainfall, CDD, flood and landslide exposure) in development approvals, especially for roads, hydropower, and urban expansion. • Clarify institutional roles and coordination mechanisms for multi-hazard events across provincial and local governments.
	Early warning & preparedness	• Upgrade multi-hazard early warning systems (flood, landslide, forest fire, heat) with district-specific thresholds. • Strengthen last-mile communication, evacuation planning, and emergency shelters in high-risk municipalities. • Establish clear operational protocols linking early warnings with road closures, school safety measures, and hydropower safety actions.
	Priority hotspot interventions	• Initiate targeted risk-reduction actions in high-risk districts (e.g. Gorkha, Lamjung, Kaski, Tanahun, Nawalpur, Manang, Mustang). • Address immediate slope instability, drainage failures, and floodplain encroachment in identified hotspots.
Medium-term (3–7 years)	**Prevention and resilience-building**	• Shift DRR investments toward prevention and risk reduction, reducing over-reliance on response and relief. • Institutionalize "build back better" standards in post-disaster reconstruction of infrastructure and public facilities. • Strengthen enforcement of environmental safeguards and construction standards in hazard-prone areas.
	Ecosystem-based adaptation	• Scale watershed management, slope bioengineering, riverbank stabilization, and forest fire management as core DRR and adaptation measures. • Integrate ecosystem-based adaptation into community forestry, protected landscapes, and watershed programmes.
	Sectoral integration	• Mainstream CC & DRR into infrastructure, energy, urban development, agriculture, and forestry sector plans. • Require cumulative risk assessments for major infrastructure corridors (roads, hydropower, transmission lines).
Long-term (7–15 years)	**Climate-resilient development pathways**	• Establish risk-sensitive land-use zoning and development control in floodplains, steep slopes, and wildfire-prone landscapes. • Gradually reduce exposure through relocation, redesign, or land-use change in areas with intolerable risk.
	Institutional capacity & systems	• Build sustained technical capacity at provincial and municipal levels in climate science, risk assessment, GIS-based planning, and enforcement. • Strengthen inter-sectoral coordination mechanisms for climate adaptation and disaster risk governance.
	Monitoring, finance & accountability	• Institutionalize a provincial CC & DRR monitoring system aligned with SoE indicators and regularly updated hazard data. • Introduce climate and DRR budget tagging within provincial plans and programmes. • Align provincial priorities with federal climate finance and international support mechanisms to sustain long-term resilience investments.

Annex 14: Policy Matrix: Industry and Energy Sector – Gandaki Province (SoE)

Time Frame	Policy Objective	Key Actions	Responsible Institutions	Expected Environmental & Development Outcomes
Short Term (1–3 years)	Improve data and governance for industry and energy	Establish an integrated provincial database linking industry registration, electricity consumption, petroleum sales, and renewable energy installations	MoIT, MoEWRWS, NEA, NOC, AEPC, Provincial Planning Commission	Evidence-based planning, stronger SoE monitoring, better coordination
	Reduce household dependence on LPG and biomass	Promote electric cooking (induction stoves, wiring upgrades, awareness campaigns) in Pokhara, Nawalpur, Tanahun	MoEWRWS, NEA, Local Governments	Lower LPG imports, reduced forest pressure, improved indoor air quality
	Improve environmental compliance of industries	Introduce a Green Compliance Checklist (wastewater, solid waste, energy efficiency) for all registered industries	MoIT, MoFE Provincial Office, Local Governments	Reduced water and soil pollution, better industrial environmental standards
	Improve energy efficiency in tourism sector	Promote energy-efficient appliances, solar water heaters, and waste segregation in hotels and restaurants	MoIT, Tourism Board, Local Governments	Lower energy demand, cleaner tourism image, reduced waste
	Begin transition to electric mobility	Pilot electric buses/taxis in Pokhara; install initial EV charging stations	MoEWRWS, Ministry of Physical Infrastructure, Local Governments, Private Sector	Reduced urban air pollution, demonstration effect for EV adoption
	Control quarrying and riverbed extraction	Strengthen licensing, GIS-based monitoring, seasonal extraction limits	MoIT, MoFE, Local Governments	Reduced river degradation, lower landslide and erosion risk
Medium Term (3–7 years)	Promote environmentally managed industrial growth	Develop industrial zones with Common Effluent Treatment Plants (CETP) and waste management systems	MoIT, MoFE, Provincial Planning Commission, Local Governments	Reduced industrial water pollution, organized industrial expansion

Time Frame	Policy Objective	Key Actions	Responsible Institutions	Expected Environmental & Development Outcomes
	Make Gandaki a "Clean Tourism Energy Province"	Mandate green building codes, wastewater treatment, and electric transport in tourist hubs	MoIT, Tourism Board, Local Governments	Sustainable tourism, improved water and air quality
	Scale up electric transport system	Replace diesel buses and government fleets with EVs; expand charging corridors	MoEWRWS, Transport Offices, Local Governments	Major reduction in fossil fuel use and emissions
	Support cleaner production in SMEs	Provide incentives for electric boilers, efficient machinery, and waste minimization technologies	MoIT, Financial Institutions, Private Sector	Energy efficiency gains, reduced industrial emissions
	Implement basin-scale hydropower planning	Require cumulative impact assessment and environmental flow monitoring	MoEWRWS, WECS, MoFE	Protection of river ecosystems, sustainable hydropower expansion
	Strengthen renewable energy in remote districts	Expand solar mini-grids, battery management systems, and micro-hydro rehabilitation	AEPC, MoEWRWS, Local Governments	Improved energy access, reduced diesel dependence

Time Frame	Policy Objective	Key Actions	Responsible Institutions	Expected Environmental & Development Outcomes
Long Term (7–15 years)	Transform Gandaki into an "Electric Province"	Electrify cooking, transport, and industrial processes	MoEWRWS, NEA, MoIT, Provincial Government	Large reduction in fossil fuel use and emissions, energy self-reliance
	Promote green industrial development	Only support low-emission, low-water, circular economy industries	MoIT, MoFE, Investment Boards	Sustainable industrial growth, lower pollution footprint
	Develop energy storage and grid resilience	Implement pumped storage, battery storage, and smart grids	MoEWRWS, NEA, WECS	Stable power supply, climate-resilient energy system
	Develop Gandaki as a clean energy innovation hub	Explore green hydrogen, energy export, and energy-intensive clean industries	MoEWRWS, WECS, Private Sector	High-value green economy, national leadership

Time Frame	Policy Objective	Key Actions	Responsible Institutions	Expected Environmental & Development Outcomes
	Establish circular economy systems	Recycling of construction waste, e-waste, organic waste-to-energy systems	MoIT, MoFE, Local Governments	Reduced landfill pressure, resource efficiency
	Create an integrated Energy–Industry–Environment Authority	Coordinate licensing, compliance, and planning under one provincial mechanism	Provincial Government, OCMCM	Strong governance, faster implementation, integrated sustainability management

Government of Gandaki Province

Gandaki Province Policy and Planning Commission

Pokhara, Nepal