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COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Abbreviations

AWD	Alternate Wetting and Drying
BAU	Business-as-Usual
BBIN	Bangladesh, Bhutan, Nepal, and India
BFI	Bank and Financial Institution
CCBC	Climate Change Budget Code
CCDR	Country Climate and Development Report
CCFF	Climate Change Financing Framework
CEPIR	Climate Public Expenditure and Institutional Review
CSA	Climate-Smart Agriculture
CSO	Civil Society Organization
DHM	Department of Hydrology and Meteorology
DNF	Digital Nepal Framework
DRF	Disaster Risk Financing
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EPA	Environment Protection Act
EPF	Environment Protection Fund
EPCCMC	Environment Protection and Climate Change Management Council
EWS	Early Warning System
FDI	Foreign Direct Investment
FITTA	Foreign Investment and Technology Transfer Act
FSP	Fertilizer Subsidy Program
GDP	Gross Domestic Product
GESI	Gender, Equity, and Social Inclusion
GHG	Greenhouse Gas
GLOF	Glacial Lake Outburst Flood
GRID	Green, Resilient, and Inclusive Development
IMCCCC	Inter-Ministerial Climate Change Coordination Committee
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
LAPA	Local Adaptation Plans of Action
LPG	Liquefied Petroleum Gas
LTS	Long-Term Strategy
MFMoD-CC	Climate Change Macro-Fiscal Model
MoEWRI	Ministry of Energy, Water Resources, and Irrigation
MOF	Ministry of Finance
MoFAGA	Ministry of Federal Affairs and General Administration
MoFE	Ministry of Forests and Environment
MOHA	Ministry of Home Affairs
MoHP	Ministry of Health and Population
MoITFE	Ministry of Industry, Tourism, Forests, and Environment
MtCO2	Million tons of Carbon Dioxide
MTEF	Medium-Term Expenditure Framework
NAP	National Adaptation Plan
NAPA	National Adaptation Program of Action
NBC	National Building Code
NCCP	National Climate Change Policy
NCD	Noncommunicable Disease
NDC	Nationally Determined Contribution
NDRRMA	National Disaster Risk Reduction and Management Authority
NEA	Nepal Electricity Authority
NPDRR	National Policy for Disaster Risk Reduction
NPC	National Planning Commission
OPMCM	Office of the Prime Minister and Council of Ministers
PC4	Provincial Climate Change Coordination Committee
PM	Particulate Matter
PPA	Power Purchase Agreement
PV	Photovoltaic
RCP	Representative Concentration Pathway
SAARC	South Asian Association for Regional Cooperation
SASEC	South Asia Subregional Economic Cooperation
SFM	Sustainable Forest Management
SMEs	Small and Medium Enterprises
SOE	State-Owned Enterprise
SRI	System of Rice Intensification
SRN	Strategic Road Network
SRSP	Shock-Responsive Social Protection
SWM	Solid Waste Management
VBD	Vector-Borne Disease
WBD	Waterborne Disease
WHO	World Health Organization
WSS	Water Supply and Sanitation

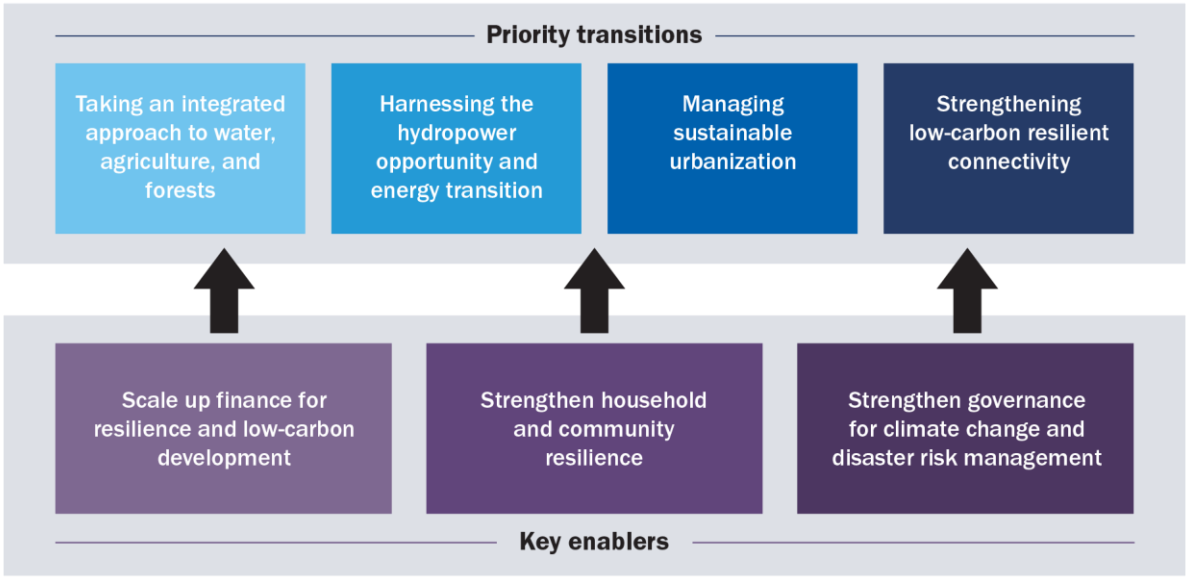
Objective and scope

This Country Climate and Development Report (CCDR) identifies ways that Nepal can achieve its overall development objectives while fostering its strategic ambition to transition to a greener, more resilient, and inclusive development pathway. It identifies the major risks and opportunities that climate change presents for Nepal's economic growth and poverty reduction and shows how investments in climate actions are good for sustainable development and vice versa. This CCDR is a contribution to an evolving analytical agenda on climate and development in Nepal. While it does not address all dimensions of climate and development, it proposes an overall framework, recommends selected priority actions to enhance synergies and manage trade-offs between development and climate objectives, and identifies areas for further research.

This report is organized as follows: Chapter 1 captures the current situation in the country with respect to climate impacts and risks, emission sources, and opportunities for integrated climate change adaptation and mitigation. **Chapter 2** describes the government's response, through sectoral and economywide commitments, laws, and regulations. **Chapter 3** assesses the impacts of climate change on the macroeconomy and road transport systems, given their critical role to connectivity. It also analyzes the links between climate change and air pollution, poverty, health, social inclusion, and community resilience. **Chapter 4** presents pathways to transition to resilience, looking at integrated management of landscape systems comprising water, agriculture, and forests as well as strengthening climate and disaster risk management governance. **Chapter 5** analyzes pathways to transition to decarbonization, primarily the potential for hydropower expansion domestically and in the region. It also looks at transport and urban opportunities to reduce emissions while enhancing resilience and adaptation co-benefits. **Chapter 6** discusses how to scale up financing for resilience, hydropower, and other opportunities, given the limitations of the country's fiscal space. **Chapter 7** presents a prioritization framework for the most transformational climate action with seven 'policy packages'—one for each priority transition and each key enabler—that contain specific recommendations for how to move from analysis to action.

Based on the analysis in Chapters 1–6, this CCDR identifies four priority transitions that Nepal should continue to pursue to manage climate risk and achieve an integrated path toward green, resilient, and inclusive development: (a) an integrated, network approach to water, forests, and agriculture (see Section 4.1); (b) the sustainable harnessing of Nepal's hydropower assets and the energy transition (Section 5.1); (c) sustainable urbanization (Section 5.3); and (d) low-carbon resilient connectivity (Section 5.2). To support these transitions, Nepal needs scaled-up finance for resilience and low-carbon development (Chapter 6), strengthened household and community resilience (Subsection 3.1.6), and stronger climate change and disaster risk management governance (Section 2.2) (see the figure on the next page).

Priority action framework for a climate-adaptive development pathway



Source: World Bank

1. Nepal's development pathway in a warming world

KEY MESSAGES

Nepal has achieved significant development progress in recent decades. Due in large part to steady inflows from remittances, the country has expanded access to electricity and drinking water, improved youth literacy, raised primary and secondary school enrollment, and reduced infant mortality.

Development gains may be at risk due to climate change. Nepal is highly vulnerable to climate and disaster risks. Rising temperatures, melting glaciers, and more intense rainfall are expected to increase climate-related hazards, particularly river flooding and landslides. Women, indigenous people, and other marginalized groups are often excluded from mainstream development and suffer from cumulative and cascading impacts of climate change and disasters.

Nepal is a negligible contributor to global greenhouse gas (GHG) emissions, but emissions are rising. Virtually all of Nepal's population is reported to be exposed to unsafe levels of air pollution, with significant negative impacts on health, productivity, and economic output.

There are many low-carbon and climate-resilient opportunities in Nepal, including development of hydropower to fuel its own growth and for export to neighbors, clean cooking solutions, electric vehicles, and solar energy. Bringing in the private sector by improving the business environment and financing avenues will be critical to helping Nepal achieve its ambitious climate goals.

1.1. Development context and priorities

Over the past decade, Nepal achieved gross domestic product (GDP) growth averaging 4.9 percent in FY09–FY19, enabling the country to attain lower-middle-income status in 2020. Growth was broad-based, with multidimensional poverty estimated to have declined from 30.1 percent in 2014 to 17.4 percent in 2019.[1] However, the country faces significant vulnerabilities to continue a path of inclusive and sustainable growth. A series of economic shocks starting with the 2015 earthquake have led to a surge in debt levels that need to be addressed, although the risk of debt distress remains low.[2]

The latest official data on poverty in Nepal is from 2010 when 25 percent of the population was living below the national poverty line. Notable progress has been made in expanding access to electricity and drinking water, youth literacy, primary and secondary school enrollment, and reducing infant and child mortality for most of the population despite Nepal's continued recovery from the devastating effects of the 2015 earthquake. The primary driver of these equitable improvements in welfare was remittances, which accounted for 27 percent of all poverty reduction from 1996 to 2011.[3]

The COVID-19 pandemic contributed to the country's first economic contraction since 1983, with GDP shrinking by 2.4 percent in FY20. Tourism and the informal sector have been particularly affected. Of those employed in January 2020, 52 percent experienced a job or earning loss during the first COVID-19 wave in 2020, the highest in the South Asia region.[4] While men and women experienced a similar overall shock, more women reported a permanent loss of job (30 percent

[1] National Planning Commission, GoN (Government of Nepal). *Nepal Multidimensional Poverty Index 2021*. Kathmandu, GoN.
[2] IMF (International Monetary Fund). 2021. *Nepal: Request for an Arrangement under the Extended Credit Facility – Debt Sustainability Analysis.* IMF Country Report No. 22/24, Washington, D.C.: IMF. December 22, 2021.
[3] World Bank. 2021. *Risks to Poverty, Vulnerability, and Inequality from COVID-19: Nepal Light Poverty Assessment*. Washington, DC: World Bank.
[4] World Bank. 2022a. *Nepal Development Update: Global Challenges and Domestic Revival*. World Bank.

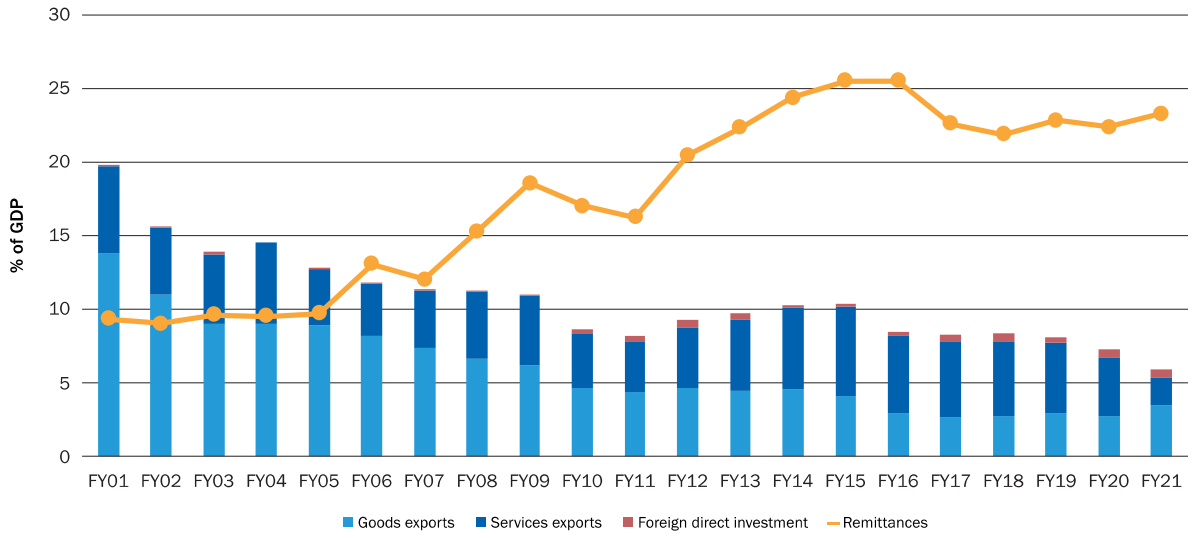
compared to 23 percent for male workers) as did the younger age cohorts.[5] A gradual recovery is currently under way, supported by vaccine rollouts and border openings.

Past growth has come at a high cost to the environment and health,[6] and the current economic model needs to change to achieve green, resilient, and inclusive development (GRID). Nepal faces structural challenges, including high rates of outmigration, slow domestic job creation, and large infrastructure gaps.[7] While remittances have had many positive benefits, they have also contributed to a steady loss of competitiveness through appreciation of the real exchange rate resulting in the proliferation of low-productivity services.[8] In the absence of significant foreign direct investment (FDI), the country's twin fiscal and external deficits since FY18 have been financed through borrowing and, in some years, a drawdown in reserves.

Connectivity is a challenge as much of the country consists of remote and disaster-prone mountainous areas. Inter-provincial differences in connectivity also significantly impact vulnerability levels. New and more resilient physical infrastructure is required, particularly for water supply, transportation, and agricultural market access. Nepal has poor access to affordable, resilient, and inclusive digital networks and services.[9] As a small, landlocked economy, Nepal's connectivity to its two large neighbors—China and India—could be a major source of growth. However, leveraging this possibility is complicated by infrastructure limitations, geopolitics, and mountainous terrain.

Since 2005, Nepal has earned significantly more foreign exchange from international migration than from goods exports, services exports (including tourism), and FDI combined (Figure 1).[10] Remittances are, in many ways, the backbone of Nepal's economy.

Figure 1: Nepal's sources of foreign exchange as percent of GDP (excluding debt flows)



Source: Nepal Rastra Bank and World Bank staff calculations.

[5] World Bank 2022a.
[6] In 2013, air pollution-induced loss of welfare was recorded at US$2.8 billion, equivalent to nearly 5 percent of Nepal's GDP. Source: Clean Energy Nepal. 2013. *Air Quality Status and Management in Kathmandu Valley: Make the City Air Breathable (MaYA Factsheet 5).*
[7] Ministry of Labor, Employment, and Social Security, GoN. 2020a. *Nepal Labour Migration Report 2020.* Kathmandu, GoN.
[8] Cosic, D., S. Dahal, and M. Kitzmuller. 2017. *Climbing Higher: Toward a Middle-Income Nepal*. Country Economic Memorandum. Washington, D.C.: World Bank.
[9] GoN and Millennium Challenge Corporation. 2014. *Nepal Growth Diagnostic*. May 2014.
[10] The remittance figures presented in Figure 1 are only those sent to Nepal through formal channels, as registered by the central bank. The use of informal channels remains prevalent, and remittances sent through those channels are not included.

Temporary labor outmigration from Nepal is likely to continue for generations, but its characteristics may change. In Nepal, as in other developing countries, migration supports household resilience to shocks, including climate shocks, by scaling up remittances. However, rising temperatures resulting from climate change in the host countries will be a formidable challenge. The top four destinations of Nepali workers are India (for which migration data are unavailable), Saudi Arabia, Qatar, and the United Arab Emirates. By 2039, Qatar is estimated to experience over 45 days of temperatures above 35°C each year.[11] Similar temperature increases are expected in the other Gulf countries that have traditionally been Nepali migrant destinations. India will also experience higher temperatures, with over 12 days of temperatures above 35° C each year by 2039 and, in the extreme case, over 81 days in the southern region of Puducherry.[12] Nepal should assess the potential impacts of rising temperatures in the Gulf and the rebalancing of energy away from fossil fuels on remittances as its migrant workforce may shift away from the Gulf countries in response to these global trends.

Nepal's ambitions to digitalize its economy can support low-carbon and climate-resilient development, but strategic investments, policies, and institutional reforms are needed to realize this ambition. Integrating digital services into infrastructure can help deliver transport, energy, and water services more efficiently while also helping farmers improve monitoring and adaptative responses to climate change and its effects. The 2019 Digital Nepal Framework (DNF) articulates the potential of digitizing Nepal and includes programs to boost farm productivity and sustainability, create a sustainable energy infrastructure, and improve the quality of life in Nepal's cities by improving traffic and water management, among others.[13] Nepal will need over US$1 billion in investments to make broadband access universal. Implementation of all DNF initiatives is estimated to require an additional US$1 billion. [14]

Tourism has potential to generate employment and promote sustainable and resilient growth. Most tourism operators in Nepal are small and medium enterprises (SMEs) and women-run businesses such as homestays and teahouses, which have limited access to financing and government incentives. There are other challenges such as high interest rates, regulatory hurdles faced by FDI, and an unclear policy environment. There is an opportunity to boost high-value sustainable tourism in Nepal, especially in areas such as Kathmandu, Pokhara, and Chitwan.

Strengthening growth, supporting a smooth rural-urban transition, and diversifying sources of foreign exchange will become more important as the climate warms. Hydropower development supports economic growth as electricity is a fundamental ingredient of most productive processes. As the period up to 2015 has demonstrated, power shortages lead to a marked decline in GDP growth. Reliable electricity supply is expected to shift demand to cleaner energy services such as electric cooking and e-vehicles. Large-scale infrastructure investments in transport and energy should factor in climate-induced variability.

Nepal's economic growth trajectory was challenging before climate change became a growing limitation. Future policy choices and their trade-offs are expected to become even more problematic. Like many other landlocked countries, Nepal has struggled to gain a foothold in merchandise export markets. On the services side, while tourism generates jobs domestically, it earns only 10 percent of total foreign exchange revenues.[15] Migrant work and remittance inflows are likely to remain the key driver of growth in the future. However, it has been seven years since remittances peaked as a percentage of GDP (25 percent in 2016), and they may not return to this level. Nepal has enormous

[11] World Bank Climate Change Knowledge Portal, accessed July 2022. https://climateknowledgeportal.worldbank.org/country/qatar/climate-data-projections

[12] World Bank Climate Change Knowledge Portal, accessed May 2022, https://climateknowledgeportal.worldbank.org/country/india.

[13] Ministry of Communication and Information Technology, GoN. 2019. *Digital Nepal Framework: Unlocking Nepal's Growth Potential.* Kathmandu: GoN.

[14] World Bank staff analysis, June 2021.

[15] National Planning Commission, Central Bureau of Statistics, GoN. 2021. *National Economic Census 2018: Analytical Report Tourism.* Kathmandu, GoN

hydropower potential but must balance development of the sector with existing fiscal space and securing export markets. Ensuring macroeconomic stability and a sustainable debt burden is critical when planning multiple and larger-scale infrastructure investments. Export of electricity to India and Bangladesh may also generate a new stream of income.

The transition toward a greener economy will have significant economywide employment effects. New green jobs will demand a different set of skills from those currently available in the economy whereas some jobs and skills will likely become less relevant or obsolete over time. This includes providing human resources with the new skills as well as reskilling and upskilling existing workers. A green skills strategy and mainstreaming green skills into education and training programs will help support the country's transition to a green and climate-resilient economy.

After a decade-long political transition, Nepal adopted a new constitution and transitioned to a federal democratic republic in 2015. The new governance structure has seven provincial governments and 753 local governments. The federal system provides both challenges and opportunities for translating shared national goals of economic prosperity, social justice, and climate and disaster resilience into a comprehensive development approach. Among other impacts, the transition has elevated public spending, leading to higher public debt and reduced fiscal space to address shocks, and raised expected challenges with respect to institutional capacity and coordination across levels, jurisdictions, and sectors. In terms of opportunities, the federal structure provides an enabling environment to ensure effective governance at the local level with enhanced development and citizen participation fostering social inclusion, pluralism, accountability, and appropriate policy responses to local development challenges. Furthermore, it encourages decentralized development with actions relating to climate change and disaster risk reduction (DRR) embedded into the exclusive jurisdiction of the local bodies. Additionally, federalism has empowered local bodies with extensive fiscal autonomy and resource mobilization and management responsibilities.

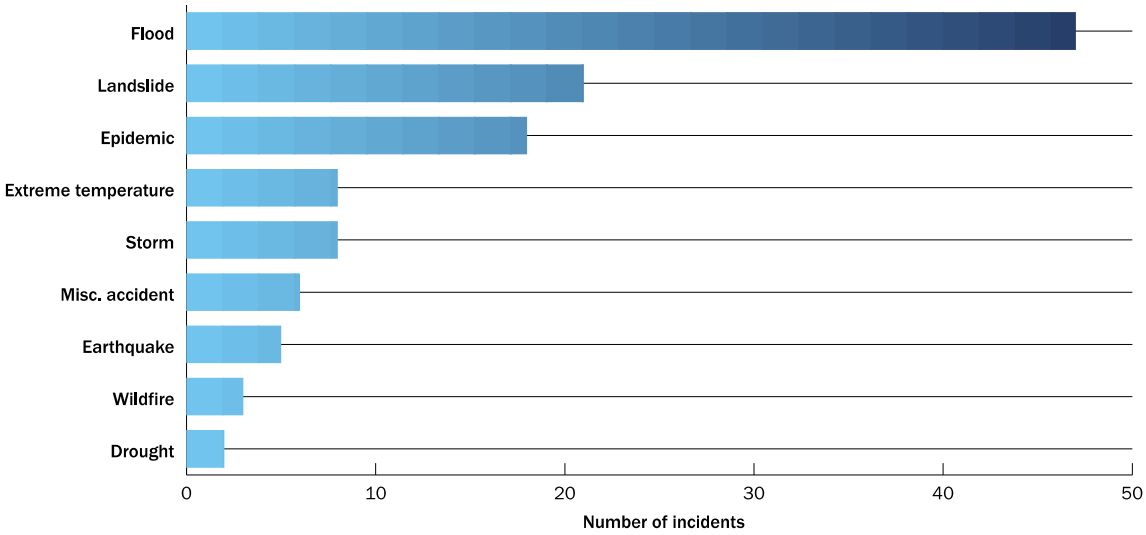
1.2. Risks from climate change

Nepal is highly vulnerable to climate change and natural disasters and faces both extreme and slow-onset climate-related hazards. Nepal's climate vulnerabilities emerge from a combination of fragile mountainous topography and ecosystems, highly variable monsoon-driven hydrology, unplanned settlements, and a lack of resilient infrastructure. Recent shocks include the Gorkha earthquake and fuel crisis in 2015, floods in 2017, landslides, and the COVID-19 pandemic in 2020.[16] Nepal ranks as the 10th most affected country in the world according to the Climate Risk Index.[17] Approximately 80 percent of its population is at risk from natural and climate-induced hazards, including extreme heat stress, flooding, and air pollution.[18] Vulnerable communities, particularly those living in poverty, in remote areas, and working in subsistence agriculture, are at highest risk, with exposure being spatially heterogenous (see Section 3.1.2). Earthquake and flood risk are the most damaging natural hazards to date, while floods and landslides were the most frequent hazards over the past 40 years (Figure 2).[19] The number of flood events has doubled in recent years; storms, erosion, and landslides are also on the rise, resulting in loss of life and livelihoods.[20] Heavy monsoon floods and landslides in

[16] World Bank Group. 2021. *World Bank Group Climate Change Action Plan 2021–2015: South Asia Roadmap*, p. 102.
[17] Eckstein, David, Vera Künzel, and Laura Schäfer. 2021. *Global Climate Risk Index 2021: Who Suffers Most From Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000–2019*. Berlin: Germanwatch.
[18] Ministry of Home Affairs, GoN. 2018. *Nepal Disaster Report 2017: The Road to Sendai*. Kathmandu, GoN.
[19] While earthquakes are not a climate-related hazard, most policies and measures to manage risks—from construction norms to disaster risk finance instruments—have to consider the full range of threats. Ignoring geophysical risks would also obscure important synergies and risks. Additionally, as the Climate Risk Country Profile: Nepal (World Bank Group and Asian Development Bank 2021) notes, "earthquake exposure remains relevant in the context of a changing climate. More precipitation and higher temperatures affect the stability of terrain and hence susceptibility to hazards from mudflows, avalanches, glacial lake outburst floods, and landslides that could be triggered by an earthquake. Additionally, the risk of simultaneous, multi-hazard, exposure is significant, for instance hydro-climatic hazards following an earthquake have been shown to compound damages."
[20] World Bank Group and Asian Development Bank. 2021. *Climate Risk Country Profile: Nepal.* Washington, D.C.: World Bank and Manila: Asian Development Bank (ADB).

2020 caused hundreds of deaths, displaced thousands of people, and damaged many roads. Mountains are warming faster than the plains, triggering melting of ice and permafrost and an increase in the risk of landslides. Incidences of dry spells, droughts, forest fires, heatwaves, flash floods, and disease outbreaks are increasing along with slow-onset risk.

Figure 2: Average annual natural hazards occurrence in Nepal for 1980–2020



Source: World Bank Climate Change Knowledge Portal: Nepal, Vulnerability (World Bank Group), https://climateknowledgeportal.worldbank.org/country/nepal/vulnerability.

Climate and disaster risks are expected to further increase, affecting people and the environment, putting development gains at risk. Temperature is projected to increase by 0.92–1.07^{0}C in the medium term (2016–45) and 1.3–1.8^{0}C in the long term (2036–65) from the reference period of 1981–2010.[21] Likewise, annual precipitation is expected to increase in both the medium and long term by 2–6 percent to 8–12 percent with more precipitation expected in the higher regions.[22] Winters are projected to be drier and monsoon summers wetter, with up to a threefold increase in rainfall. The number of people in Nepal annually affected by river flooding caused by climate change could more than double to around 350,000 in 2030 (from 157,000 in 2010).[23] The economic impact from this flooding could triple.[24] This will contribute to further increasing Nepal's relative exposure to climate-related hazards.

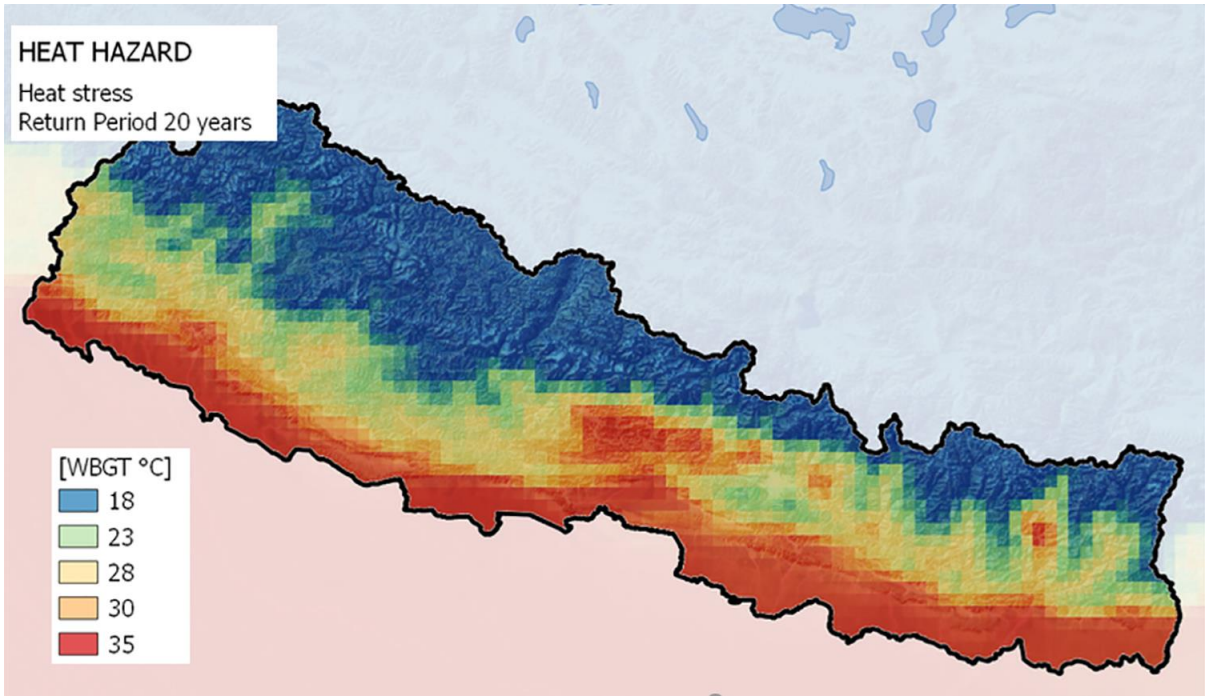
Climate variability is already a major driver of poverty, food insecurity, and energy insecurity in Nepal. The costs of climate variability to the Nepali economy are incurred through lower agricultural output, high energy imports, and high health and coping costs due to prolonged water and electricity shortages. The lack of reliable water and electricity is a major constraint to development (see Section 4.1).

Rapidly urbanizing areas and rural agriculture communities are experiencing increased climate change risks. Overall, built-up area accounts for less than 1 percent of total land cover; more than 25 percent of palikas or municipalities have negligible built-up area.[25] However, the Kathmandu and Pokhara Valleys and southern municipalities in the Terai have seen 62 percent growth relative to 2000. These changes lead to growing hazard exposure and vulnerability. Agricultural land is at risk of

[21] MoFE (Ministry of Forests and Environment), GoN. 2019. *Climate Change Scenarios for Nepal for National Adaptation Plan (NAP).* Kathmandu: MoFE.
[22] Ibid.
[23] World Bank Group and Asian Development Bank 2021.
[24] Ibid.
[25] These municipalities are heavily concentrated in province 6 (mean elevation 3,387 m above sea level) and the northern parts of province 7 and province 1 (mean elevation approximately 1,900 m above sea level). Slope is a more binding determinant of the ability to build than elevation. While the average elevation of a province in Nepal is 1,857 m above sea level, the mean elevation of built-up areas is 454 m.

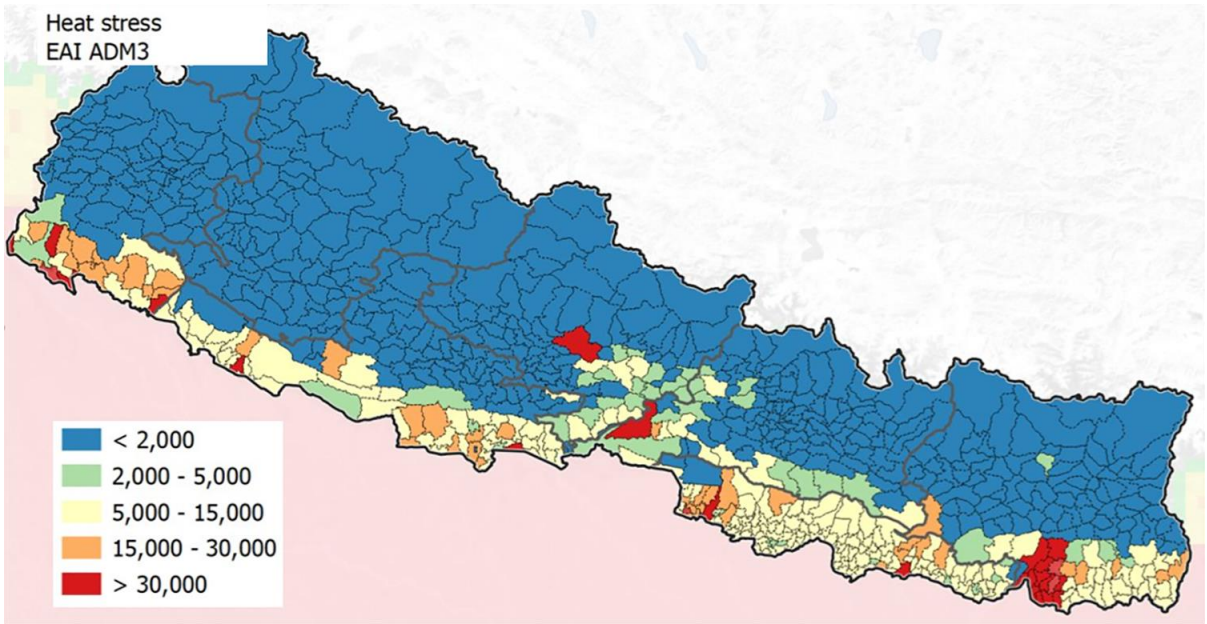
severe drought, which is associated with reduced crop harvests, increasing food costs, and negative impacts on livelihoods of primarily rural communities. Heat stress affects large swathes of the country (Figure 3), with over 4 million Nepalese facing the health impacts of extreme heat (Figure 4).

Figure 3: Current rates of heat stress (return period of 20 years, in wet-bulb globe temperature °C)



Source: Extreme Heat Hazard layer, Wet Bulb Globe Temperature (WBGT) - VITO/GFDRR (2017) (EH-GLOBAL-VITO-5).
Note: This map shows probabilistic extreme heat intensity on a 20-year return period, built from a 30-year record spanning 1981–2010.

Figure 4: Current rates of heat-stress exposed population at the municipal level (return period of 20 years)



Source: Extreme Heat Hazard layer, Wet Bulb Globe Temperature (WBGT) - VITO/GFDRR (2017) (EH-GLOBAL-VITO-5); WorldPop Constrained Population 2020.
Note: This map shows the number of people estimated to be affected to extreme heat intensity on the 20-year return period.

Climate impacts are being felt across all sectors, particularly those related to water. Water is among Nepal's most abundant yet unharnessed natural resources. Water security is one of the lowest in all

of Asia.[26] Warming threatens the future of Nepal's high mountain glaciers, which are a critical supply of freshwater to the region. In Kathmandu, water stress is so severe that piped supply is reported to meet less than 32 percent of household demand in the monsoon and 19 percent in the dry season.[27] Water availability also affects small-scale hydropower and agriculture, which remains a vital part of livelihoods of 64 percent of the population. Declining availability of water comes at critical cropping times, decreasing soil moisture, with prolonged droughts resulting in crop failures and productivity losses (see Section 4.1). In the energy sector, hydropower makes up 90 percent of Nepal's domestic electricity generation. Currently, all but one hydroelectric plant is run-of-river; its productivity is impacted by river runoff volume and sedimentation caused by poor land and forest management as well as extreme weather events. This represents a potential vulnerability in the context of uncertain future precipitation regimes, glacial melting, and potential increases in the risks of landslides and glacial lake outburst floods (GLOFs).

Lack of climate considerations in the built environment and urban planning exposes cities and major trade corridors—where much of the economy is concentrated—to greater risks. Nepal's infrastructure is vulnerable to heavy rainfall, flooding, and landslides, the frequencies and intensities of which are increasing. Ninety percent of Nepal's movement of passengers and goods takes places on road transport networks.[28] In FY2019/20, road infrastructure incurred damages worth over NPR 2 billion (US$16.4 million).[29] Nepal has been urbanizing rapidly, with almost half of the urban population living in informal settlements. Projections for 2050 show that the number of municipalities under 'very high' and 'high' risk from climate change impacts will more than double.[30] However, urban areas in Nepal suffer from significant deficits in municipal infrastructure and services that undermine their economic growth potential and increase vulnerability to climate-related hazards.[31]

Nepal's diverse ecosystems and natural capital—which provide vital ecosystem services for the poor in remote locations—are at risk because of increasing frequency and severity of drought, erosion, biodiversity loss, forest fires, and diseases. Forests are an important source of livelihoods for over 30,000 communities and cover more than 40 percent of Nepal's land area.[32] They are also important buffers to climate impacts and provide critical ecosystem services, including groundwater recharge, water quality and quantity control, and reduction of landslides, erosion, drought, and flood risks. While Nepal is home to a wealth of biodiversity, its many unique ecosystems and natural resources are also being affected by climate change, with a negative impact on the tourism economy and the life and livelihoods of mountain peoples. This, in combination with poor access to services, drives migration to lowland cities, causing additional pressure on resources.

Women, indigenous people, and other marginalized groups are often excluded from mainstream development and suffer from cumulative and cascading impacts of climate change and disasters. They are further susceptible due to preexisting vulnerabilities driven both by discrimination based on socially ascribed identities such as caste, ethnicity, and indigeneity as well as factors such as geographic remoteness, socioeconomic marginalization, interaction with the climate shocks, fragility, and weak governance.[33] These groups are not well integrated into mainstream development due to

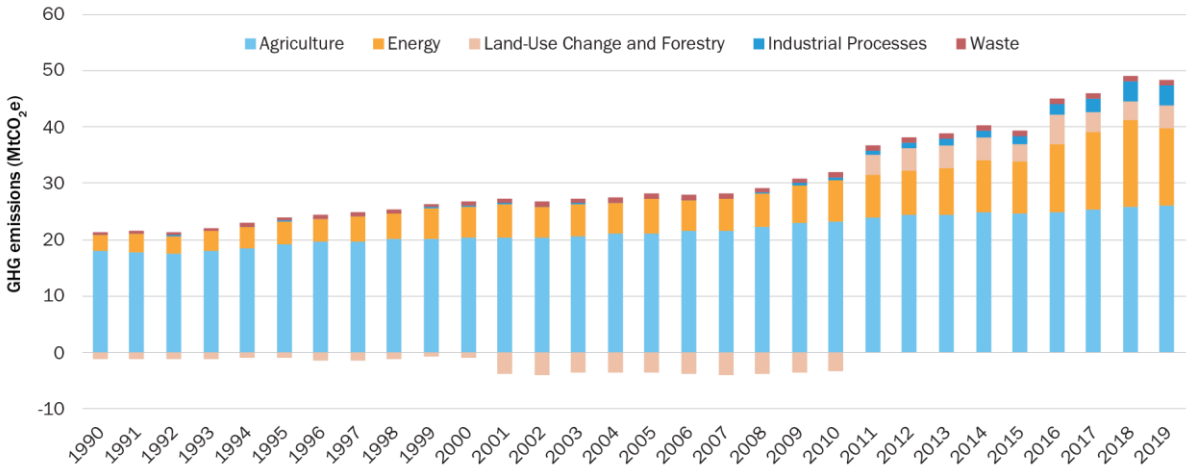
[26] ADB. 2020. *Asian Water Development Outlook 2020: Advancing Water Security Across Asia and The Pacific*. Manila: ADB.
[27] Udmale, P., H. Ishidaira, B. Thapa, and N. Shakya. 2016. "The Status of Domestic Water Demand: Supply Deficit in the Kathmandu Valley, Nepal." *Water* 8 (5): 196.
[28] ADB. 2016. *Risk Assessment and Risk Management Plan: Transport Sector.* Manila: Asian Development Bank.
[29] Shrestha, Prithvi Man. 2021. "Rain Damage to Roads, Bridges Estimated at Rs 3 Billion." *The Kathmandu Post*, October 5, 2021. https://kathmandupost.com/national/2021/10/05/rain-damage-to-roads-bridges-estimated-at-rs3-billion; https://docs.google.com/spreadsheets/d/1ygwurvveDG52t0vx8Jc5QTvxrYaYl0ByRqTOzVHHtgE/edit#gid=0
[30] MoFE, GoN. 2021. *Vulnerability and Risk Assessment and Identifying Adaptation Options in Rural and Urban Settlements.* Kathmandu: MoFE.
[31] Nepal's cities have the lowest number of people in the region with access to improved sanitation facilities (only about 52 percent). Road density is very low in many municipalities irrespective of size and is far from reaching the national goals of 7.5 km per km^2 of road density for 58 preexisting municipalities and 5 km per km^2 for new municipalities. Less than one-third of municipal roads are blacktopped. Storm water drainage systems vary in coverage between 15 and 35 percent but, in almost all cases, are far below the national goal of 60 percent coverage.
[32] World Bank. 2019a. *Nepal Environment Sector Diagnostic: Path to Sustainable Growth Under Federalism.* A Country Environmental Analysis.
[33] Study commissioned by UNDP Nepal under the regional initiative called 'Accelerating Disaster Risk Reduction and Enhancing Crisis Response through Digital Solutions' across four countries—Indonesia, Nepal, the Philippines, and Sri Lanka (Draft).

social and institutional constraints on their inability to exercise their juridical rights to access and control information, resources, and decision making, including governance processes that do not yet prioritize in practice the full and fair participation of vulnerable communities in policy, planning, and implementation processes of development activities.

1.3. Emissions and reduction opportunities

Nepal is a negligible contributor to global GHG emissions. With 48 million tons of carbon dioxide equivalent ($MtCO_2e$) in 2019,[34] Nepal contributes around 0.1 percent of total global GHG emissions.[35] These come primarily from agriculture (54 percent) and energy (28 percent).[36] Biofuels and waste (including fuelwood, dung, biogas, and agricultural waste) provide 72 percent of energy supply, followed by oil, coal, and hydropower.[37] [38]

Figure 5: Nepal historical GHG emissions ($MtCO_2e$)



Source: Climate Watch Historical Country Greenhouse Gas Emissions Data (1990–2019).

However, the country's GHG emissions are rising. Emissions increased by 26,86 percent between 2012 and 2019.[39] This is linked to rising energy consumption, which doubled in the residential sector between 1990 and 2018 and, from a smaller base, increased almost tenfold in the transport and industry sectors over this period.[40] The carbon intensity of Nepal's energy supply has also risen steadily since 1990; the largest driver of emission growth was the transport sector. [41]

Reducing GHG emissions and improving air quality and environmental health go hand in hand. Nepal was ranked 178 out of 180 countries for air quality in the 2020 Environmental Performance Index, and virtually all of the population is exposed to unhealthy levels of air pollution. Each year, over 30,000 people die prematurely from air pollution.[42] People are exposed to air pollution in their own homes (due to the burning of biomass) and outdoors (due to the collective burning of biomass, transport, and manufacturing). The economic cost of air pollution is sizeable: the yearly welfare cost of household (indoor) air pollution alone is estimated to be about 3.5 percent of GDP. In addition, the welfare cost of ambient air pollution is estimated to be about 3 percent of GDP.[43] Implementing the

[34] Climate Watch, Country Profile Nepal, https://www.climatewatchdata.org/countries/NPL.
[35] World Bank Group 2021, 5.
[36] Climate Watch, Country Profile Nepal, https://www.climatewatchdata.org/countries/NPL.
[37] International Energy Agency (IEA), Energy Country Profile Nepal, accessed June, 2022, https://www.iea.org/regions/asia-pacific.
[38] International Hydropower Association, Country Profile Nepal, accessed June, 2022, https://www.hydropower.org/country-profiles/nepal.
[39] Climate Watch, Country Profile Nepal, https://www.climatewatchdata.org/countries/NPL.
[40] World Bank. 2021. *Nepal Public Expenditure Review - Fiscal Policy for Sustainable Development.* Washington, D.C.: World Bank. Based on IEA 2020 data.
[41] Climate Transparency. 2020. *Climate Transparency Report Nepal*. https://www.climate-transparency.org/wp-content/uploads/2021/11/Nepal-CP2020.pdf
[42] World Bank. 2019b. *Nepal – Country Environmental Analysis: Strengthening Institutions and Management Systems for Enhanced Environmental Governance*. https://openknowledge.worldbank.org/handle/10986/7996
[43] World Bank. 2019a.

air quality measures in line with the South Asia Vision 2030 could result in a 67 percent reduction in annual premature deaths, compared to a 2018 baseline.[44]

There are growing opportunities to invest in low-carbon and climate-resilient solutions. Across sectors, there is increased demand for cleaner solutions, particularly where costs have declined over the last decade. In addition to hydropower, this includes solar energy, improved waste management, climate-smart agriculture (CSA), and green buildings.

[44] World Bank. 2021. *Solutions for Improved Air Quality and a Green Recovery in South Asia*. 2021 Spring Meetings. Washington, D.C.: World Bank.

2. Nepal's climate commitments, policies, and institutions

KEY MESSAGES

Nepal is committed to addressing climate change. The country's 2020 nationally determined contribution (NDC) includes ambitious mitigation targets. The National Adaptation Plan (NAP) includes a comprehensive set of programs until 2050 that aim to boost adaptive capacity and resilience. The 2021 Long-term Strategy (LTS) further raised ambition by setting a 2045 net-zero mitigation target.

Nepal has built an enabling legal and regulatory framework to spur climate action and its climate change commitments are embedded in a GRID approach.

The integration of climate strategies and actions into the development plans, policies, programs, and budgets at all levels of government is still a work in progress. There are gaps in sectoral and intergovernmental coordination, local technical capacity is low, and credible climate data is not readily available. In addition, state-owned enterprises (SOEs) lack mandates and do not actively support the government's climate targets. Key stakeholders such as the private sector, civil society, think tanks, and the media are not actively engaged in climate action.

2.1. Nepal's climate ambition

Nepal submitted its second NDC in December 2020, including more quantifiable targets for 2030, broader sectoral coverage, and a net-zero emission target (Error! Reference source not found.).[45] T he new NDC includes a commitment to increase clean energy generation capacity to 15,000 megawatts (MW) by 2030.[46] It also commits to increase the use of electric vehicles to 25 percent of all passenger vehicles (including two-wheelers) by 2025. The NDC includes a goal to install 500,000 clean cookstoves and an additional 200,000 household biogas plants by 2025. By 2030, Nepal aims to maintain 45 percent of the country under forest cover. For the agriculture sector, the NDC promotes CSA practices in crop and livestock systems. An NDC Implementation Plan is currently being finalized and will spell out sectoral activities as well as clarify roles, means of implementation, reporting procedures, and transparency of actions.[47]

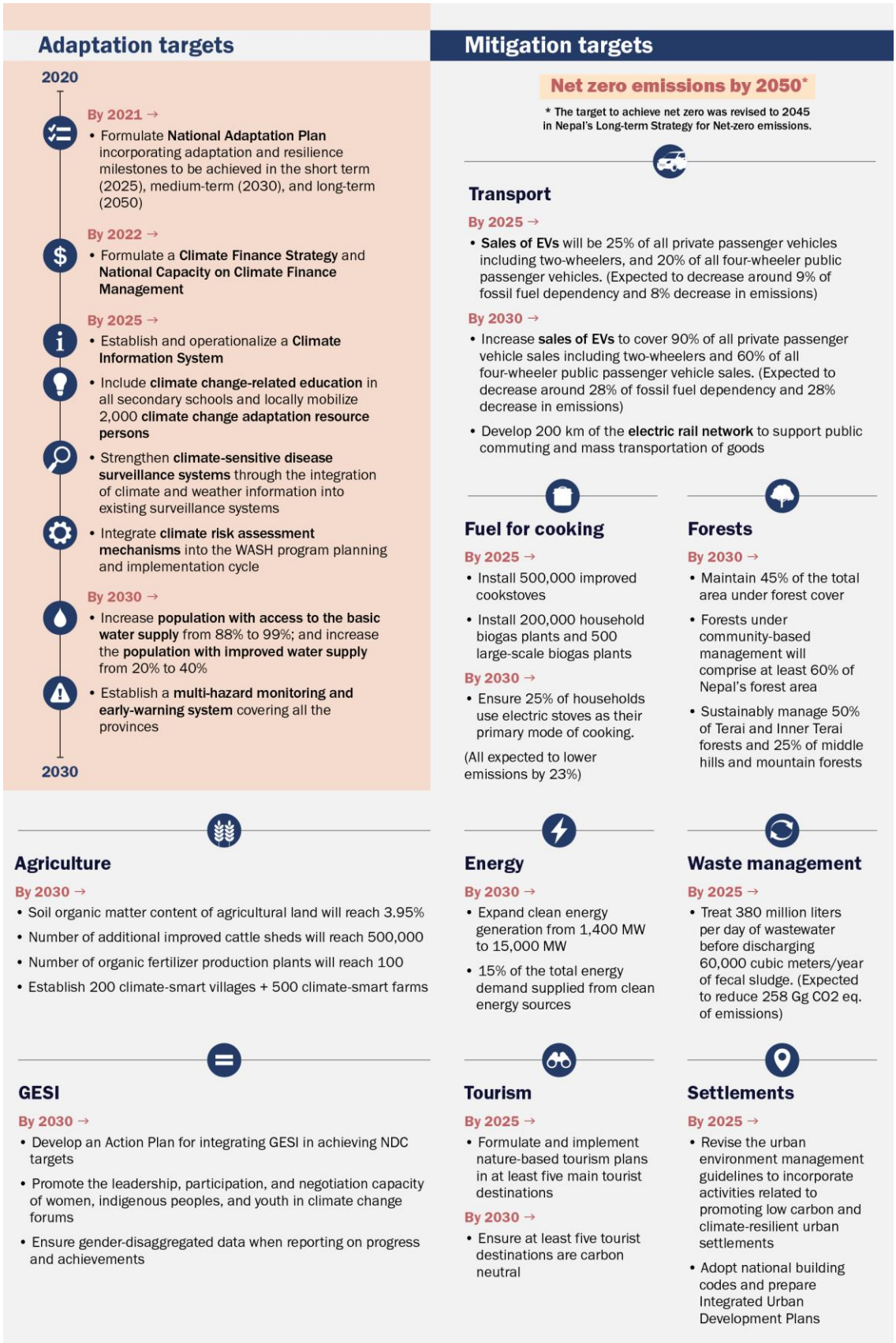
Adaptation and resilience are the clear priorities. Through the National Adaptation Program of Action (NAPA) in 2010,[48] the Local Adaptation Plans for Action (LAPA) framework in 2019,[49] and the NAP Summary for Policy Makers in 2021,[50] Nepal has laid the policy foundation for ambitious adaptation action. The NAP consists of 64 priority programs for the short (2025), medium (2030), and long term (2050).

Nepal's LTS steps up mitigation ambition by aiming to achieve net-zero GHG emissions by 2045, five years earlier than the original NDC timeline.[51] This is meant to be achieved through expanding hydropower for domestic and regional use, e-mobility, shifting out of fossil fuels for industrial

[45] GoN. 2020b. *Second Nationally Determined Contribution*. Kathmandu, GoN. https://unfccc.int/sites/default/files/NDC/2022-06/Second%20Nationally%20Determined%20Contribution%20%28NDC%29%20-%202020.pdf
[46] This commitment is conditioned upon receiving international support; the unconditional target is 5 MW.
[47] GoN, 2022. NDC Implementation Plan. (Draft for public opinion, March 2022).
[48] GoN. 2010. *National Adaptation Programme of Action (NAPA) to Climate Change.* Kathmandu, GoN. https://unfccc.int/resource/docs/napa/npl01.pdf
[49] GoN. 2019. *Local Adaptation Plans for Action (LAPA).* Kathmandu, GoN. https://mofe.gov.np/downloadsdetail/2/2018/43993951/
[50] Currently, only the summary for policy makers of the NAP has been made publicly available at https://mofe.gov.np/noticefile/NAP percent20Rep percent202021-2050_Suggestion_1634621834.pdf
[51] GoN. 2021a. *Nepal's Long-term Strategy for Net-Zero Emissions.* Kathmandu, GoN. https://unfccc.int/sites/default/files/resource/NepalLTLEDS.pdf

processes, and reducing methane emissions from waste. It also envisions switching to practices that deliver CSA and increasing and maintaining its forest cover.

Figure 6: Overview of Nepal's key NDC commitments



Nepal's climate change commitments are embedded in a GRID approach. The government issued the Kathmandu Declaration for the GRID Partnership in 2021 (see Annex 2). In support of these efforts, the World Bank Group and 15 development partners endorsed the GRID Declaration and earmarked the bulk of their planned support— more than US$4 billion—to GRID outcomes. The government is currently preparing a GRID Strategic Action Plan to coordinate financing efforts, including from the private sector, and build back better amidst COVID-19.

2.2. Legal, regulatory, and institutional framework for climate action in Nepal

Nepal has built an enabling legal and regulatory framework to spur climate action. The 25-year long-term vision of prosperity and happiness (2019) recognizes climate change adaptation and sustainable utilization of national resources as a target, under the 'Healthy and Balanced Ecology' goal of the Happiness pillar.[52] The 'Sustainable Development Goals Status and Roadmap 2016–30' proposed key actions to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters.[53] Furthermore, Nepal prioritizes a low-carbon and climate-resilient approach to development in its 15th Periodic Plan, the 2019 Environment Protection Act (EPA), the National Climate Change Policy (NCCP), and the 2018 National Policy for Disaster Risk Reduction (NPDRR).[54] The EPA has provisioned 'climate change management' as a separate chapter outlining legal mandates on climate change risk and resilience, mitigation, and carbon trading. The NCCP aims to promote a green economy by developing policies and guidelines for all critical sectors. It also includes cross-cutting priority areas such as gender equality and social inclusion, awareness raising, research, and climate finance. To support NCCP and NPDRR implementation, Provincial Climate Change Action Plans and a comprehensive set of planning guidelines have been prepared (see Annex 3). The Gender, Equity, and Social Inclusion (GESI) Strategy and Action Plan on Climate Change (2020–30) outlines sectoral strategies to increase access of women and vulnerable and marginalized groups to resources and decision-making processes on climate action and build adaptive capacity to climate impacts.

The government has taken steps to integrate climate change into public financial management. Building on the recommendations of the 2011 Climate Public Expenditure and Institutional Review (CPEIR),[55] the Climate Change Budget Code (CCBC) was introduced in 2013 to track climate change-related expenditure at the national level.[56] In 2017, the government prepared a Climate Change Financing Framework (CCFF) to mainstream climate change in planning and budgeting at all levels of government, including for reporting and verification of climate change financing for improved accountability. As part of the reform, the CCBC was also included in the Medium-Term Expenditure Framework (MTEF).

Federal funding for climate-related activities has increased in recent years, but available resources fall short of what is needed. Climate-related budget allocation has increased more than threefold since FY14: in FY23, 33.98 percent of the total budget was tagged as climate related, up from 10.34 percent (Figure 7). This was driven by increased fiscal transfers to provincial and local governments and post-earthquake reconstruction. However, of the total climate-relevant budget in FY23, only 17.4 percent was estimated to be highly relevant, markedly down from 5.9 percent in FY14 (Figure 8). The

[52] The long-term vision aims to make Nepal a developing country within the first three years; attain the Sustainable Development Goals by ending absolute and multidimensional poverty by 2030, and graduate to middle-income country status and reach the level of developed countries by 2043. https://npc.gov.np/images/category/15th_plan_English_Version.pdf.

[53] GoN.2017. *Sustainable Development Goals Status and Roadmap 2016–2030.* Kathmandu, GoN https://www.npc.gov.np/images/category/SDG_Status_and_Roadmap_(2016-2030).pdf.

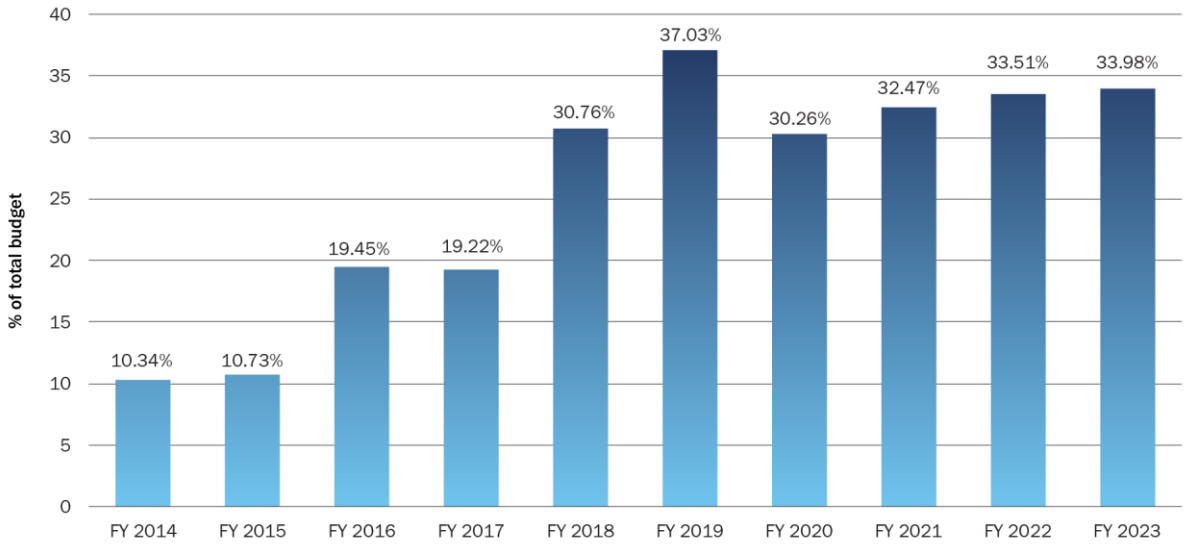
[54] GoN. 2019. *National Climate Change Policy*. Kathmandu, GoN https://mofe.gov.np/downloadfile/climatechange_policy_english_1580984322.pdf.

[55] CPEIR. 2011. *Nepal Climate Public Expenditure and Institutional Review (CPEIR).* Published by GoN, National Planning Commission with support from UNDP/UNEP/CDDE in Kathmandu, Nepal. https://www.npc.gov.np/images/category/climate_public_expenditure.pdf.

[56] Eleven specific criteria were identified for climate-responsive budgeting, based on which the budget was categorized as Highly relevant (if more than 60 percent is allocated to climate change activities), Relevant (if 20–60 percent of the program budget is allocated to climate change activities), and Neutral (if less than 20 percent is allocated to climate-change related activities).

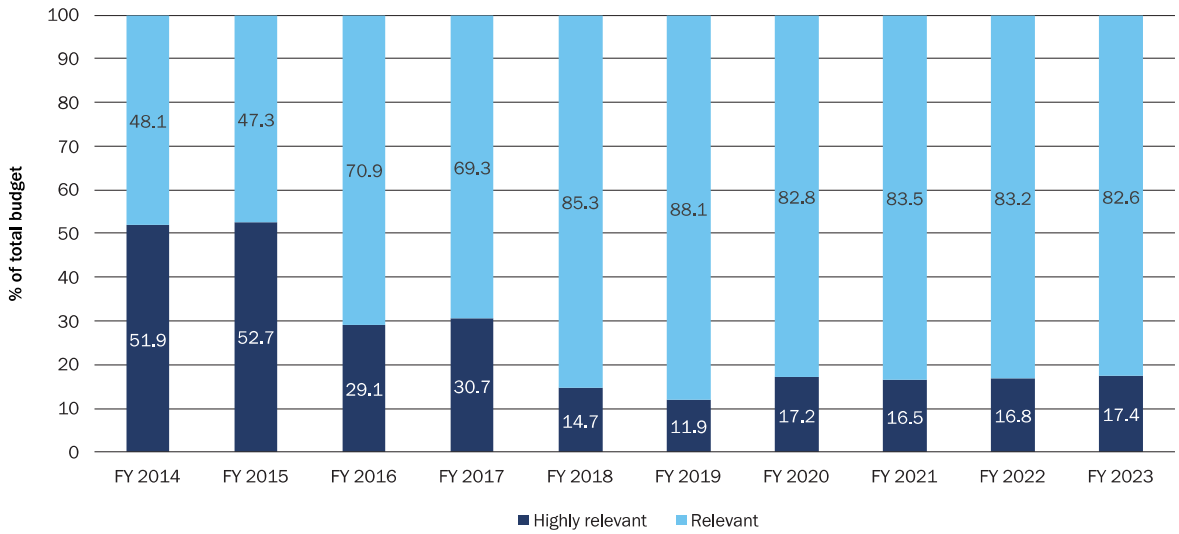
trend shows that the national climate-relevant budget has increased over the last five years, rising from US$3.2 billion in 2017/18 to US$5.2 billion in 2022/23.[57]

Figure 7: Climate-related budget (as share of total budget)



Source: Ministry of Finance (MOF) (https://www.mof.gov.np/site/publication-category/17).

Figure 8: Relevance of climate budget (as share of total climate budget in percent)



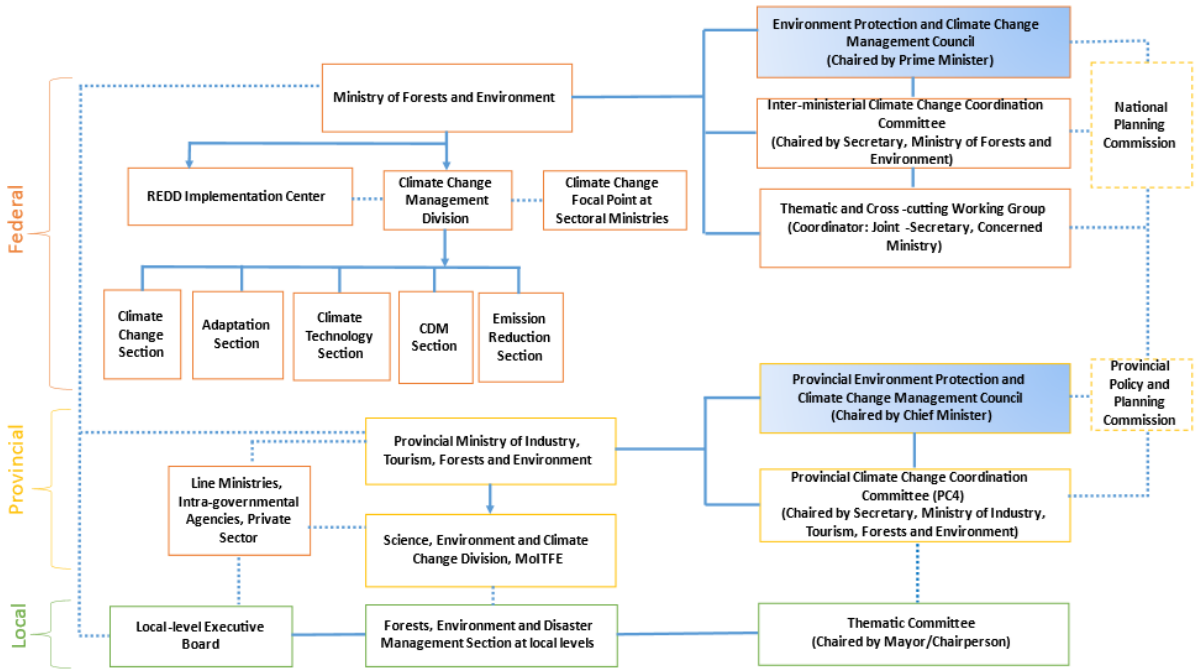
Source: MOF (https://www.mof.gov.np/site/publication-category/17).

The government has established dedicated funds to undertake climate and disaster risk management (DRM) actions. The 2019 EPA has mandated the establishment of an Environment Protection Fund (EPF) for the management of climate change, among others. The National Disaster Risk Reduction and Management Act also envisioned establishing DRM funds at the federal, provincial, and local levels to facilitate DRM-related works. The Disaster Risk Reduction National Strategic Plan of Action (2018-2030) has articulated the provision of at least 5 percent of the annual budget of every public institution for DRM. However, these mechanisms are relatively new and require enhanced understanding of key stakeholders to be properly operationalized.

[57] Based on the exchange rate of US$1 = NPR 120.

The government has also developed institutional arrangements to address climate change at all levels (Figure 9). The Environmental Protection and Climate Change Management Council under the leadership of the Prime Minister is envisioned as an apex institution to provide overall guidance and leadership on climate change action. The Ministry of Forests and Environment (MoFE) is the lead entity for climate change at the federal level whereas the Ministry of Industry, Tourism, Forests, and Environment (MoITFE) is a lead entity at the provincial level. The government established the Inter-ministerial Climate Change Coordination Committee (IMCCCC) at the federal level and the Provincial Climate Change Coordination Committee (PC4) at the provincial level to facilitate cross-sectoral coordination at all levels of government. Additionally, the NDC implementation plan proposes a High-Level Climate Change Steering Committee, chaired by the Minister for Forests and Environment with secretaries of all relevant sectoral ministries providing political leadership and commitment for NDC implementation.[58]

Figure 9: Institutional arrangements for climate change in Nepal



Source: Based on GoN. 2021b. National Adaptation Plan 2021–50: Summary for Policy Makers, p. 41. https://www.preventionweb.net/publication/national-adaption-plan-nap-2021-2050-nepal.

2.3. Implementation gaps and challenges

While there is a comprehensive policy framework, effective implementation faces significant challenges. These challenges are rooted in existing gaps in coordination, technical capacity, and financial resources. Coordination across sectors and all levels of government is insufficient due to a lack of clarity on responsibilities between the three levels of government. The coordination mechanisms—Environment Protection and Climate Change Management Council (EPCCMC), IMCCCC, and PC4—are in a formative stage and have limited support structure. Few ministries have integrated climate change into their sectoral plans, policies, legal framework, budget, and institutional architecture. Coordination mechanisms are also absent at the local level. Capacity gaps are more pronounced in subnational governments, particularly at the local level. There is no basis for planning due to the lack of robust climate information system. Data on natural resources, the environment, climate adaptation, and mitigation are scattered across different agencies and different government levels. The climate budget tagging exercise is undertaken late in the budgeting cycle and only

[58] GoN, 2022.

provides a descriptive categorization of expenditure patterns, rather than prioritizing programs based on evaluation through a climate lens. Also, the tagging system does not indicate if an activity is counter to climate objectives. While the MTEF guidelines require planning based on national climate targets, information systems do not document the contribution of activities to climate targets. Ex post reviews of projects on climate outcomes are not conducted.

Climate action at the subnational level is severely constrained. Provincial governments have started to design climate strategies and action plans in line with the national policy framework, but there is a lack of defined screening and prioritization criteria for financing climate action through annual budgetary allocations. Only one provincial government has assigned climate response in its allocation of business rules. At the local level, the process of developing policies, strategies, and action plans has not gained momentum because of capacity constraints and other pressing local priorities. In addition, the requirements of separate assessments and action plans for environmental, disaster risk, and climate change management are challenging given low capacity. In the short term, an integrated approach should focus on the local level where capacity is weakest and, in the longer term, on integration of various climate-related laws and regulations at all levels.

While climate targets have direct impact on SOEs, there is limited evidence of climate action by these entities. Integration of climate and disaster risk in SOE business and service delivery is yet to occur at the functional level. For instance, Nepal Electricity Authority (NEA) is listed as a primary entity responsible for the NDC's decarbonization and grid modernization/efficiency targets, but there is little evidence of the agency playing a leading role in implementing the targets. Similarly, the National Telecommunications Corporation and Nepal Water Supply Corporation should have distinct roles in achieving adaptation and resilience, but they do not appear in the NAP. Further, there is no evidence of plans or strategy to implement the NDC or NAP at any of the SOEs. The lack of clear mandates and assignments of SOE roles in line with the NDC and NAP is a critical impediment.

Existing procurement laws and regulations do not guide and provide options and procedures for adapting to and promoting climate-friendly services. Procurement policies prioritize the lowest market price, creating a disincentive for the government, SOEs, or contractors to focus on quality-enhancing measures such as sustainability or resilience. Green product catalogs and green marketplaces and eco-labels and other standards (for example, International Standards Organization) are not recognized.

There is no institutionalized process of engaging important stakeholders such as the private sector, civil society organizations (CSOs), think tanks, and the media in climate planning. The challenge is exacerbated by a general lack of awareness and information sharing on climate issues, resulting in a lack of pressure for climate-specific oversight.

Several barriers exist to mobilizing private finance for resilience and adaptation. These include an absence of localized climate risk and vulnerability data for specific investments, a lack of policies and institutional structures at the sectoral level to enable private sector participation, and weak financial incentives to address risks/higher costs.[59] Further analysis will help the private sector price climate risks, thus transferring risks to the market. The financial sector lacks an understanding of the impact of climate risks—both physical and transition—on its investments. Nepal also lacks a methodology that identifies investments as 'green' or 'climate' finance for each sector, leading to limited financial sector capacity to evaluate climate-related projects and find viable project pipelines.

[59] World Bank Group. 2021. *Enabling Private Investment in Climate Adaptation and Resilience*. Washington, D.C.: World Bank Group.

Recommendations to strengthen climate governance

- Specify and clarify functional climate change mandates, roles, and responsibilities of sectoral ministries, subnational governments, SOEs, the private sector, CSOs, and other stakeholders.
- Specify functional mandates, roles, and responsibilities of local governments for integrated climate action, which includes environmental and disaster risk management.
- Operationalize existing coordination mechanisms and establish missing legal mandates to further strengthen horizontal and vertical coordination across sectors and levels of government.
- Mainstream climate action aligned with existing plans and targets into the national development plan, sectoral plans, MTEF, project banks, and annual budget by developing the required mechanisms and information systems.
- In the short term, develop a climate-specific capacity-building plan for all levels of government; in the longer term, consider revising the Civil Service Act to include climate-specific functions.
- Review the CCBC process and develop a typology of the climate change-related sectoral activities to support robust tagging of the climate change budget at the sectoral budget formulation level and roll out the CCBC and CCFF at the provincial and local levels.
- Establish an integrated national climate and disaster management information system.
- Incorporate climate considerations into the procurement framework.
- Establish an integrated system to track NDC and of NAP targets supported by an enhanced data generation and validation framework for the three levels of government.
- Improve public disclosure and dissemination of climate-related information in a user-friendly and integrated manner.
- Institutionalize climate-specific oversight (for example, citizen climate budget, parliamentary oversight, and public audit system).
- Develop a green taxonomy for private sector financial and real sectors.

3. The impact of climate change on Nepal's people and systems

KEY MESSAGES

Climate change is exacerbating inequities in Nepal. It is negatively affecting the development potential for the poor, particularly those migrating to urban areas due to floods and heat stress, drought, glacial melt, and other extreme conditions. Women, indigenous people, and other marginalized communities are disproportionately affected.

Climate is having a negative impact on health and productivity. Vector- and water-borne disease incidence is on the rise, and health care coverage does not address climate-related vulnerabilities.

Current social protection programs have limited coverage and are not shock responsive. Social protection is needed to build the resilience of households to prepare for, cope with, and adapt to shocks.

Poor air quality has significant health costs in Nepal, and emissions are rising. Implementing air quality measures for biomass use and in urban transport and industry would have significant climate and health co-benefits**.**

Resilient road transport infrastructure and systems are key to Nepal's economic and social development. Ninety percent of passengers and goods rely on road transport, and it is increasingly disrupted by disasters and climate change. Building resilience along major transport corridors will enhance network redundancy and deliver improved accessibility to jobs, health, education, and service provision.

3.1. The impacts of climate change on people, livelihoods, and systems

3.1.1. Modeling climate change impacts on the macroeconomy

The World Bank periodically updates its analysis of macroeconomic developments through a macro-structural model which incorporates global developments as well as Nepal-specific policy changes and developments. An expanded version of this model, a Climate Change Macro-Fiscal Model (MFMod-CC), has been used to model the links between damages caused by climate change and macroeconomic aggregates (see Annex 4 for more details on the model). The MFMod-CC for Nepal has been used to estimate (a) a baseline growth scenario which assumes no additional climate change impacts beyond what has already been experienced up to 2021; (b) three separate growth scenarios under increasingly severe climate change outcomes: Representative Concentration Pathway (RCP) 2.6, RCP 4.5, and RCP 8.5;[60] and (c) damages that would occur to the economy through increased variability of rainfall patterns and the impact of higher temperatures on agricultural output, labor productivity, and built infrastructure.[61]

In the baseline forecast, GDP growth is expected to continue recovering from the COVID-19 pandemic and gain momentum through the decade of 2030 before experiencing a gradual decline through 2050 as population growth slows. Average growth in the 2030s is projected to peak at almost 6 percent per year before waning during the 2040s (to 4.8 percent) and the 2050s (to 3.9 percent). Although the growth rate is projected to decline, each decade begins with a higher GDP

[60] RCP = Representative Concentration Pathway, which is a GHG concentration trajectory adopted by the Intergovernmental Panel on Climate Change (IPCC). RCP 2.6 is a scenario where carbon dioxide emissions start declining in 2020 and are reduced to zero by 2100, and average global temperatures rise 1.5°C. The RCP 4.5 scenario is an intermediate scenario, where emissions peak around 2040 and then decline, and average global temperatures rise 2.5°C. RCP 8.5 is the most pessimistic scenario used in this analysis, as emissions continue to rise through the end of the century and average global temperatures rise 4°C.

[61] Annex 1 presents the long-term forecast for the Nepali economy under each of these scenarios.

level, resulting in a projected continuous improvement in GDP per capita. Real GDP per capita is forecast to more than triple in real terms from US$1,113 in 2020 to US$3,841 by 2050.[62]

The baseline projection does not impose policies to promote an export-oriented economy and, as a result, the trade deficit is projected to continue widening through 2050. The gap between exports and imports, and therefore the current account deficit, would continue to widen through 2050 under these business-as-usual (BAU) assumptions.

Private investment represented 26 percent of real GDP in 2020, which is a significant share in a developing country context. In the baseline scenario, it is projected to rise a further 6 percentage points of GDP by 2050. Public investment is projected to rise at a much slower pace through 2050, from 8.8 percent of GDP in 2020 to 9.6 percent of GDP in 2050.

Looking at GDP growth from the production side, the services sector, including tourism, digital services, and retail trade, is expected to drive growth in the future as it has in the past. The sector's contribution is forecast to grow steadily from 54 percent of GDP in 2020 to 71 percent by 2050.

In the baseline projection, under unchanged policies, the ratio of public debt to GDP rises as expenditure growth outstrips revenue growth in the 2030s before stabilizing in the 2040s and 2050s. Expenditure begins to stabilize in the projection period, tapering slightly in the 2040s which allows the debt burden to decline slowly over time.

3.1.2. The impact of climate change on Nepal's economy

Global warming and an increasing frequency of extreme weather events will impact economic activity.. In addition, there could be extreme weather events that cause large-scale disruptions of supply chains with lasting repercussions through production and transport networks or a persistent drought which could cause food shortages and rising food prices, with lasting impacts on farm incomes, nutrition, and poverty, that would cascade into many other sectors of the economy. Recent major disasters include the GLOFs in Bhote Koshi in 2016 and Barun Khola in 2017 as well as the June 2021 Melamchi flood and landslide which severely damaged the water supply to Kathmandu. These events are expected to increase in frequency and severity due to climate change. In addition, multiple climate hazards will occur simultaneously, and multiple climatic and non-climatic risks will interact, compounding the overall risk and cascading some risks across sectors or regions.

Infrastructure

Flooding damages to infrastructure are severe in Nepal. The probability of damages and associated costs of flooding are shown in Table 1. The frequency and severity of extreme events are expected to increase as temperatures rise (Figure 10). Economic losses from flooding are anticipated to be severe. In Table 1, the column 'no additional warming' shows the probability of a flood destroying 2.55 percent of built infrastructure and capital stock (return period of 50 years) at 2.0 percent today. As temperatures rise, that probability triples to 5.7 percent with 1.5°C of additional warming and more than triples again to 18.4 percent under 3.2°C of additional warming. The anticipated damages from flooding in any given year also multiply at these rates.[63]

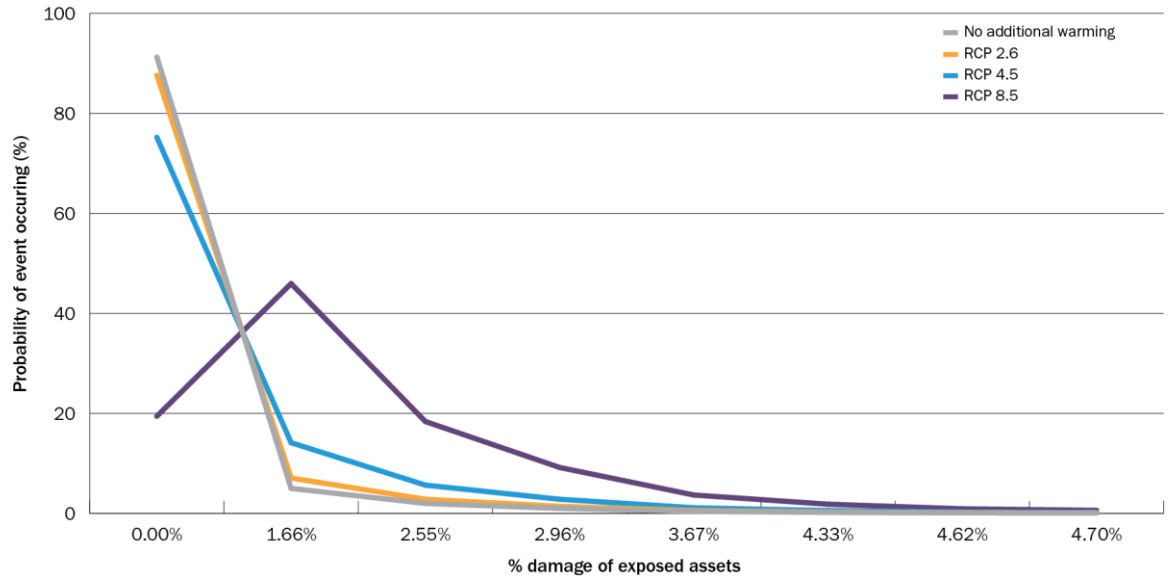
[62] In constant 2020 US$.
[63] These estimations are based on Nepali data on damages and frequency and the assumption that the frequency of floods of any given size doubles with every degree increase in temperature. Myhre, G., K. Alterskjær, C. W. Stjern, Ø. Hodnebrog, L. Marelle, B. H. Samset, J. Sillmann, N. Schaller, E., Fischer, M. Schulz, and A Stohl. 2019. "Frequency of Extreme Precipitation Increases Extensively with Event Rareness under Global Warming." *Scientific Reports* 9 (1).

Table 1: Current and estimated probabilities for flood damages of a given size

Return period (years)	Damage (% of capital stock)	Probability under additional warming scenarios from 2020 through 2100 (%)			
		No additional warming (*)	0.5°C of additional warming (RCP 2.6)	1.5°C of additional warming (RCP 4.5)	3.2°C of additional warming (RCP 8.5)
20	1.66	5.00	7.07	14.14	45.95
50	2.55	2.00	2.83	5.66	18.38
100	2.96	1.00	1.41	2.83	9.19
250	3.67	0.40	0.57	1.13	3.68
500	4.33	0.20	0.28	0.57	1.84
1,000	4.62	0.10	0.14	0.28	0.92
1,500	4.70	<0.10	0.09	0.19	0.61

** Source: Background data for UNISDR (United Nations Office for Disaster Risk Reduction). 2015. Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction. Geneva. https://www.preventionweb.net/english/hyogo/gar/2015/en/home.*
Note: RCP 2.6, RCP 4.5, and RCP 8.5 represent climate trajectories envisioned by the IPCC, based on projected GHG emission. Data on estimated flooding damages for Nepal come from UNISDR (2015).

Figure 10: Flood damages and probabilities under different climate scenarios



Source: Background data for UNISDR (2015)
Note: RCP 2.6, RCP 4.5, and RCP 8.5 represent climate trajectories envisioned by the IPCC, based on projected GHG emission. Data on estimated flooding damages for Nepal come from UNISDR (2015).

More severe temperatures are projected to amplify flood damage to infrastructure with related macroeconomic impact, underscoring the need for resilient infrastructure. In all scenarios, flooding is projected to reduce the capital stock (built infrastructure such as roads and buildings) and potential output and production. Simulations show direct negative impacts on GDP, consumption, and private investment. In the RCP 8.5 scenario (Annex 1), flooding is projected to shave off about 3.5 percent from GDP and 1.6 percent from private consumption by the end of 2050. As growth and consumption slow, government revenues would decrease but with a lag. In the model, reductions in physical capital result in a decline in potential GDP relative to market price GDP in the immediate short run. It is estimated that flooding's negative impact on built infrastructure is the largest of the three climate shocks projected in the model, accounting for around half of the almost 7 percent reduction in GDP projected by 2050.

Disaster risk management for infrastructure

Preemptively making key infrastructure more resilient will provide better macroeconomic outcomes than rebuilding infrastructure after a damage event occurs. Figure 11 examines how much

infrastructure should be improved before a climate-induced damage event such as a flood or landslide occurs.[64]

Public budget envelopes are tight and there are trade-offs between investing in infrastructure versus any other public good or service. In this simulation, under the most severe warming scenario, periodic 10-year recurring damage events are imposed (downward spikes in Figure 11). The severity and frequency of the damage events are likely to increase over time as the climate warms. Two separate investments are embedded in the model—the ex ante hardening of existing infrastructure and the ex post reconstruction of damaged infrastructure. Following a damage event, reconstruction occurs to replace damaged infrastructure. This is shown as the upward slope of the projections following each damage event and occurs in all hardening estimations (Figure 11). The multiple lines in each graph depict how much infrastructure is hardened before the event occurs, ranging from 0 percent (no preemptive hardening) to 100 percent (all infrastructure is hardened before a damage event). Built into the model is an assumption of rank ordering the economic importance of different elements of the infrastructure grid. For instance, keeping important transport routes (such as bridges connecting trunk roads) operational would be a higher priority as they provide greater economic returns by connecting a greater number of people and communities than, for example, rural roads of unconnected communities.

The results of the simulation are shown in Figure 11 as differences from the baseline forecast when damage events do not occur. It is estimated that when no hardening takes place beforehand (0 percent), potential GDP falls by over 1 percent of GDP following the first shock. When a subsequent damage event occurs in 2031, the magnitude of the loss is amplified by higher temperatures, and potential GDP is projected to remain 2 percent of GDP lower than the baseline projection. Impacts compound over time, leading the economy to lower and lower potential GDP.

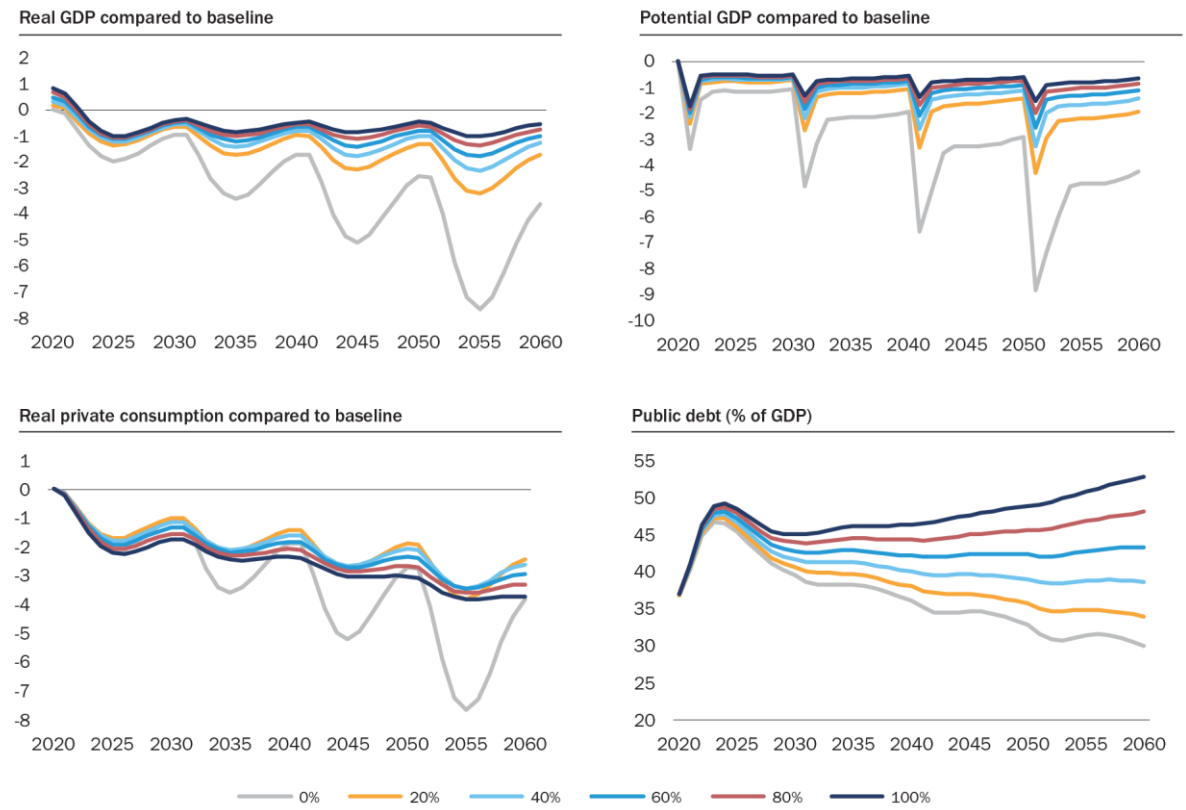
When 20 percent of the infrastructure is hardened before the event occurs, losses are reduced dramatically, and the investment needed for reconstruction is lower. It is assumed that a deliberate selection of critical key infrastructure elements guides the choice of investments to be hardened. Real private consumption continues to fall over time but by much less, and the increase in public debt is only slightly higher than under the no-hardening (0 percent) simulation.

An important caveat to interpreting these results is that specific economic returns from individual infrastructure installations (such as bridges, roads, and buildings) have not been calibrated in the model for Nepal. This is a stylized simulation that assumes a linear decrease in the economic returns of infrastructure ranked from very important to marginal.

Under this model construction, hardening a greater percentage of infrastructure would lead to diminishing returns, as the most critical infrastructure is hardened first. While hardening all infrastructure (100 percent) results in the smallest erosion of potential GDP by 2050, the costs of such a large investment weigh heavily on public debt. A key conclusion from this model simulation is that preemptively hardening key—and not all—infrastructure provides the strongest economic support to recovery at the lowest total cost to the economy. Depending on the nature of built infrastructure in Nepal, the percentage of infrastructure to harden before a damage event occurs may optimally be 10 percent, 20 percent, or even 30 percent.

[64] Hardening of infrastructure, in this context, means making the infrastructure more resilient to a future shock and can include making electrical grids more wind resistant, improving drainage and sewer systems to prevent flooding, and upgrading roads and bridges to prevent them from washing away.

Figure 11: Flood protection: Comparison across varying degrees of disaster management investment (RCP 8.5 climate scenario)



Source: World Bank projections based on the MFMod-CC model.

Agriculture

Climate change-induced losses in agricultural productivity are expected to have severe macroeconomic impacts. The impact modeled is the negative impact of rising temperatures on crop yields. The negative impacts on GDP are projected to be relatively similar across warming scenarios through 2030 and could cause an annual GDP reduction of around 0.8 percent. By 2050, larger differences are projected to emerge. Under RCP 8.5, lower agricultural yields due to heat are projected to reduce overall GDP by a cumulative 2.2 percent of GDP while losses under RCP 2.6 remain three times lower at around 0.8 percent.[65]

Labor productivity

Labor productivity is very sensitive to temperature changes.[66] Productivity losses due to heat are projected to reduce GDP under all temperature scenarios, with real GDP 1.4 percent smaller by 2050 under the RCP 8.5 scenario as shown at the bottom of the table in Annex 1.[67] Consumption would also be reduced under the pessimistic climate warming scenario, as lower labor productivity translates into lower household income and lower domestic demand. Investments to prepare the workforce with green skills, increase the shock responsiveness of social protection programs, and expand health care coverage would lower the impacts of higher temperatures on labor productivity and, in return, enhance resilience of economic growth to higher temperature conditions.

[65] These findings assume the absence of adaptation and mitigation measures and are based on regional inputs for South Asia and not Nepal-specific data. Adaptation and mitigation options in agriculture include cropland management, livestock management, management of organic soils (peatlands and wetlands), land use change, and improving energy efficiency and the use of renewable energy. Source: https://climatepolicyinfohub.eu/technical-options-climate-change-mitigation-eu-agriculture.html

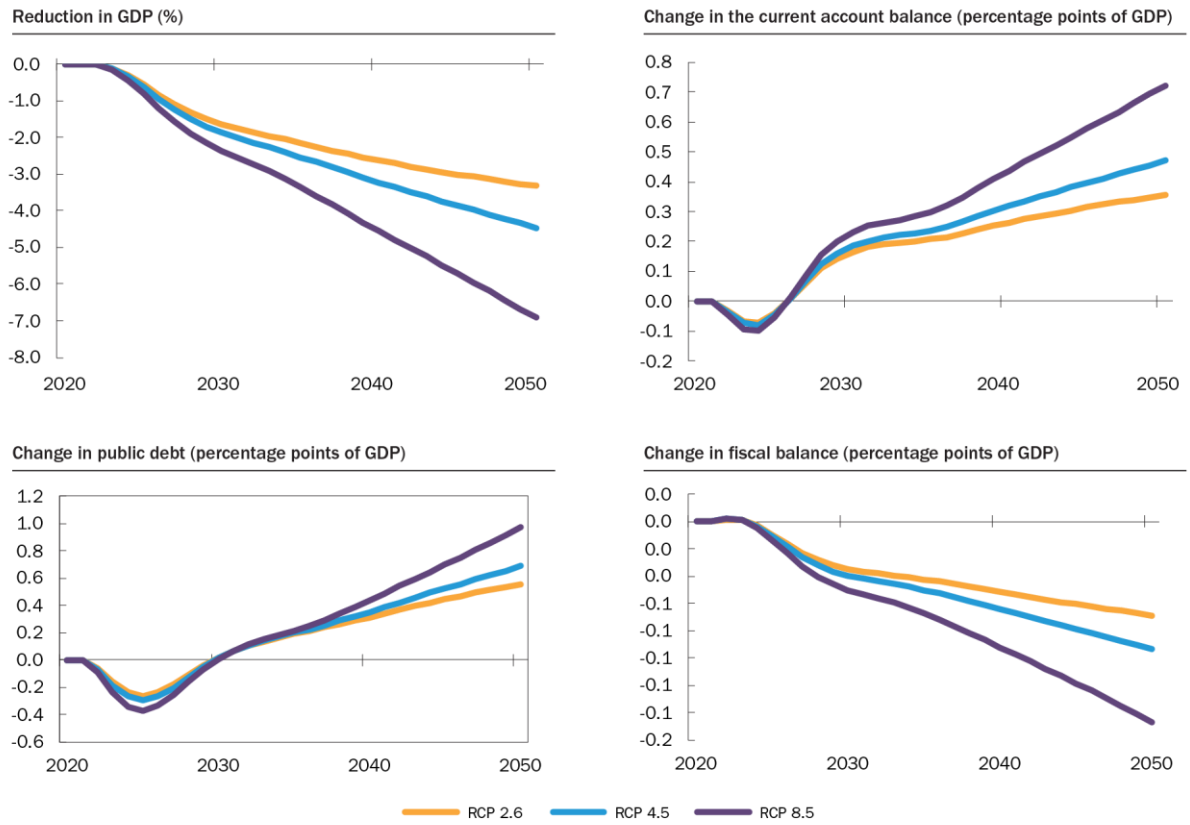
[66] UNDP. 2016. *Climate Change and Labour: Impacts of Heat in the Workplace*. Geneva: CVF Secretariat at UNDP.

[67] The baseline forecast is described in detail in Section 4.1. The assumptions of labor productivity losses are based on country-specific inputs from UNDP (2016) and do not include other factors such as how heat will interact with air pollution and how population distribution may change in the future.

Combined heat, flooding, and agricultural productivity shocks

Combining the shocks on infrastructure, agriculture, and labor productivity amplifies the dangers of the severe climate scenario RCP 8.5 (Figure 12 and Figure 13). Damages are projected to accelerate over time, as the macroeconomic impacts across warming scenarios become far-reaching after 2040. Private consumption would fall below the baseline projection, leading to lower imports and improvements in the current account balance. As Nepal raises a significant portion of fiscal revenues from trade taxes and duties, the fiscal balance is projected to deteriorate by 0.2 percentage points of GDP by 2050 relative to the baseline. There would be a corresponding increase in the public debt-to-GDP ratio of around 1 percentage points of GDP per year.

Figure 12: Combined shock on agriculture, infrastructure, and labor productivity

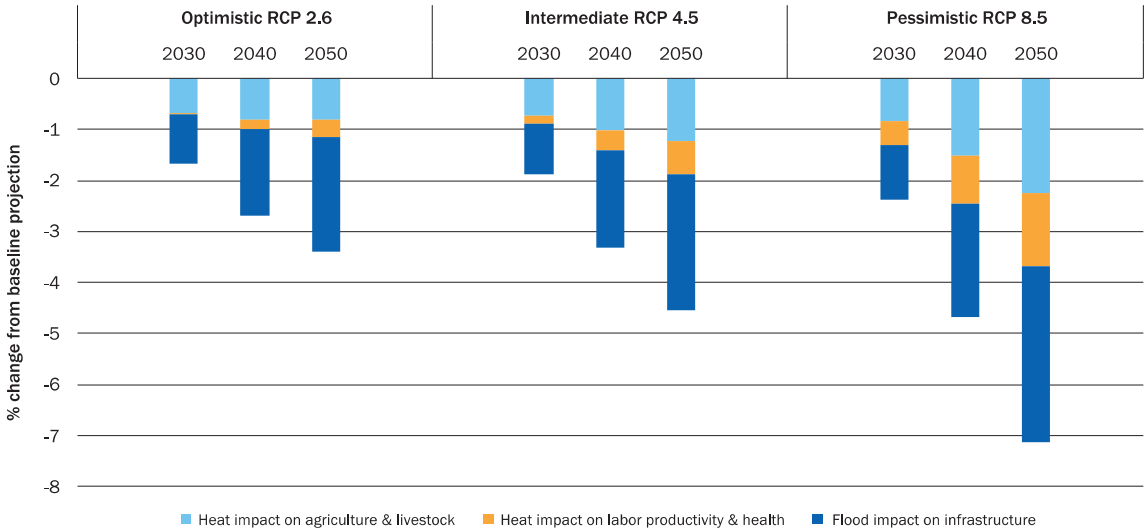


Source: World Bank projections based on the MFMod-CC model.

Figure 13 is based on the same simulations, taking a closer look at the impact on projected GDP losses for the optimistic, intermediate, and pessimistic scenarios by each of the three selected transmission channels. As explained in earlier sections, these three climate threats are projected to create considerable loss in GDP relative to a no-damage baseline: 7 percent by 2050. The expected GDP loss is reported relative to the baseline scenario. In the optimistic RCP 2.6 case, GDP by 2050 is over 3 percent lower than the baseline while, in the pessimistic scenario, the cumulative GDP losses are as high as 7 percent. These are sizeable impacts given that the models only consider selected threats and transmission channels and thus underestimate the cost of climate damages as they abstract from important additional concerns: interactions across various damage types, damages from knock-on effects, uncertainties regarding the realization of climate shocks, models and parameters, the risks of catastrophic outcomes, and so on. Hence, these losses should be taken as a lower bound of measurable climate damages for selected shocks and channels. Moreover, the most severe climate damages relative to baseline are expected to materialize after 2050. Since global

warming is already progressing, there is almost no difference between the GDP forecasts of the optimistic and pessimistic scenarios up until 2030 and differences by 2050 are moderate. Temperatures will rise at a higher rate after 2050, particularly in the pessimistic scenario, and GDP losses in the second half of the century are expected to be significantly higher.

Figure 13: Real projected GDP losses by climate damage and climate scenario



Source: World Bank projections based on the MFMod-CC model.

3.1.3. Resilience to climate shocks across Nepal

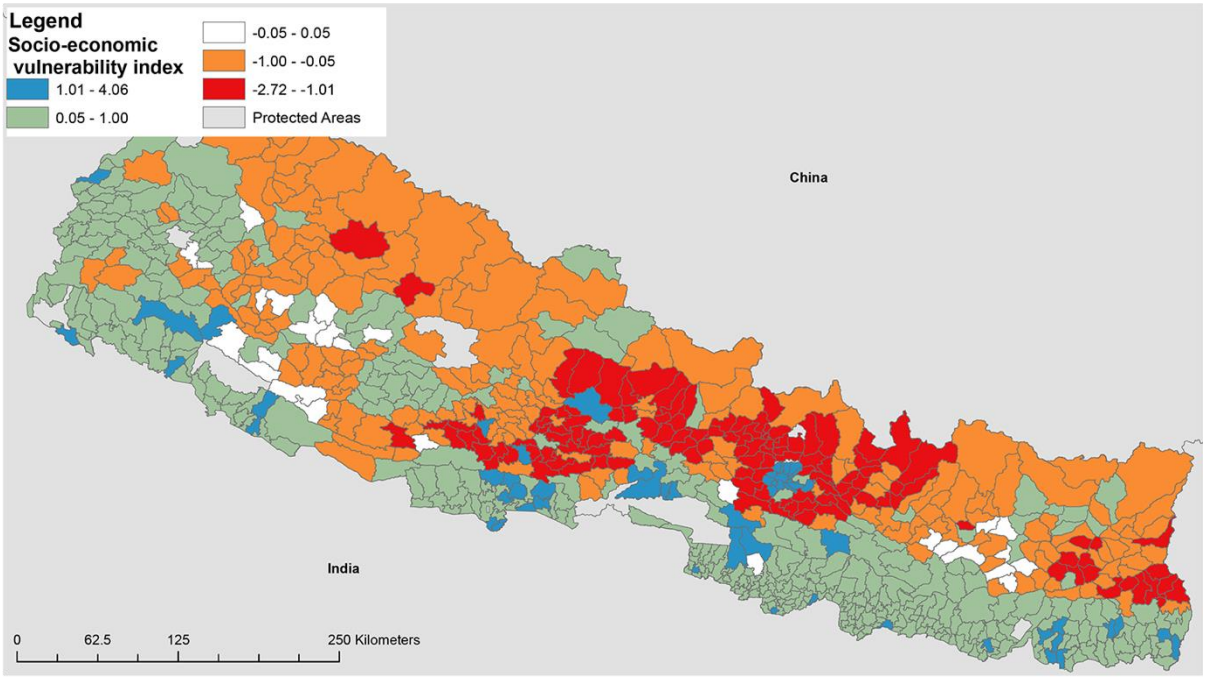
Women, indigenous people, and other marginalized communities in Nepal are disproportionately affected by climate change. This is due to deep-rooted inequality, marginalization, livelihoods that are highly dependent on natural resources, and locational factors from often living in remote and vulnerable geographies. Women in Nepal make up about 73 percent of the agricultural workforce and the sector is feminized due to male outmigration. Women farmers are more vulnerable because of their limited access to agricultural inputs, extension services, training, and financing.[68] Further, women and indigenous people often do not have tenure security and control over land and other natural resources on which they depend. Female-headed households are vulnerable to climate shocks because they grow fewer crop types and lack resources to undertake perceived risky crop diversification.[69] Agricultural practices that draw on indigenous and local knowledge can contribute to addressing climate challenges in a sustainable way while contributing to food security, biodiversity conservation, and resilience.[70]

The effects of climate change are diverse in Nepal. While southern and urban municipalities are more likely to experience climate hazards of heat stress and flooding, the North is affected primarily by landslides, water stress, and flooding, including glacial lake overflow. Southern municipalities are able to better cope because of their higher access to credit, savings, private support networks, and other forms of assistance (Figure 14). Resilience is measured as the ratio of asset losses to predicted well-being losses from a climate shock, with more negative resilience ratios indicating higher vulnerability, as a unit of asset loss implies more than proportionate losses in well-being.[71] Based on this metric, the

[68] MoFE, GoN. 2021. *National Adaptation Plan (NAP) 2021 to 2050. Summary for Policymakers.* Kathmandu: MoFE.
[69] Ibid.
[70] IPCC. 2019. *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* Geneva: IPCC.
[71] We cannot directly measure well-being losses to disasters in Nepal given current data limitations, but these are proxied using household consumption from the Nepal Household Risk and Vulnerability Survey. Resilience ratios are calculated based on survey data from Nepal and the methodology pioneered in Hallegatte, S., A. Vogt-Schilb, M. Bangalore, and J. Rozenberg. 2017. *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters.* Climate Change and Development. Washington, D.C.: World Bank. We report here only an index showing the relative position of an administrative unit in the distribution of the resilience ratio. This provides a relative sense of which locations are more or less vulnerable based on their resilience ratio. More negative index values indicate higher vulnerability.

areas around Kathmandu are some of the most vulnerable. Southern parts of Nepal, where agriculture plays a dominant role, have the highest resilience ratio—that is, in southern parts of the country, asset losses translate to the lowest level of consumption losses. The southern portion of the country is generally less vulnerable than the northern portion. The most vulnerable places have a resilience ratio that is nearly three standard deviations below the average in Nepal. The North has more limited access to coping mechanisms and will need concerted support to deal with weather shocks, reduced access to water for drinking and irrigation, and glacial melt. With 64 percent of the country's employment in agriculture, investments in agricultural livelihoods will be particularly important to protect livelihoods and adapt to climate change (see Section 4.1.2).

Figure 14: Current resilience ratio by municipality in Nepal



Source: World Bank analysis using proxy household consumption data from the Nepal Household Risk and Vulnerability Survey. Resilience ratios are calculated based on survey data from Nepal and the methodology pioneered in Hallegatte et al. (2017).
Note: We report here only an index showing the relative position of an administrative unit in the distribution of the resilience ratio. This provides a relative sense of which locations are more or less vulnerable based on their resilience ratio. More negative index values indicate higher vulnerability.

Looking at resilience in the future, using projections of temperature and precipitation for 2041–60 under high-, intermediate-, and low-emission climate change scenarios, reveals a worrisome picture for Nepal. Current heat stress patterns are set to increase in severity and, while the overall precipitation patterns are unlikely to considerably alter, extreme rainfall events are also likely to increase in magnitude. The stark projected increase in extreme events in the historically less-affected western provinces calls for particular attention to adaptative measures and preparedness efforts. Simultaneously, the forecast deepening of historical spatial patterns of agricultural drought and wetness demonstrates that structural measures are required to overcome current disparities to protect the lives and livelihoods of all Nepalis (see Section 4.1.2).

Only limited information about climate-induced migration in Nepal is available. Male migration from the hills and mountains to the Terai predominantly occurs for work and represents an associated shift out of agriculture and into services, at a time when Nepal is concerned over national food security.[72] Simultaneously, almost half of the urban population of Nepal lives in informal settlements,[73] and half

[72] Sharma, S, S. Pandey, D. Pathak, and B. Sijapati-Basnett. 2014. *State of Migration in Nepal, Research Paper VI, Centre for the Study of Labour and Mobility.*
[73] UNSD. n.d. *Millennium Development Goals Indicators Database.* https://mdgs.un.org/unsd/mdg/.

the informal settlers in Kathmandu at last count were indigenous peoples.[74] Better understanding how individuals and households use migration as a coping strategy to deal with the negative shocks of climate change and how public policy and social protection can facilitate effective adaption is an important policy question that needs further study.[75]

Adaptation requires learning from experience and changing behaviors, in fact direct engagement with communities. The most vulnerable people often live in the most extreme environments and must constantly manage and adapt to resource scarcity and shocks. Engaging with communities can help the government fine-tune its adaptation plans and design a mechanism for tracking the effectiveness of adaptation interventions over time.[76] It will also facilitate community ownership and ensure that the most marginalized are not left behind.[77]

Nepal's 2019 NCCP aims to mainstream GESI into its climate change response. Nepal's NDC aims to develop an action plan to integrate GESI by developing targeted programs to ensure full, equal, and meaningful participation of women, indigenous people, and other vulnerable communities in climate change policy formulation as well as in planning, implementation, and monitoring processes. The National Disaster Risk Reduction Strategic Plan of Action 2018–30 prioritizes empowerment, inclusivity, accessibility, and nondiscriminatory participation, paying special attention to people disproportionately affected by the disasters; however, this is not adequately resourced.

Recommendations for increased community resilience in Nepal

- Invest in livelihoods for the most vulnerable farmers, particularly in the most severely affected mountain areas, and for women.
- Actively recruit and use indigenous knowledge in climate policy and planning.
- Assess and plan for impact of internal and cross-border migration on livelihoods and integration of informal settlements in urban areas, including in service delivery, job creation, and social cohesion.
- Ensure mitigation interventions include users in, for example, the design of cookstoves, and ensure action on mitigation includes a focus on co-benefits such as energy access and skills training, including for 'green' jobs.
- Strengthen the government's ability to conduct environmental and social impact assessments and develop gender equality and social inclusion plans to ensure policies and programs are inclusive and do not undermine resilience of vulnerable and marginalized groups. Directly engage with local communities in design, implementation, and monitoring of a locally led climate action approach, featuring devolved finance and decision making, and links to such policies as the NAP to ensure strong ownership.
- Conduct further study on the dimensions of adaptation to shocks to refine and scale up an adaptive social protection approach to enhancing local resilience.

[74] United Nations. 2013. *A Country Analysis with a Human Face*. Kathmandu: United Nations Country Team in Nepal. https://reliefweb.int/report/nepal/country-analysis-2011-human-face.
[75] Dasgupta, S., D. Wheeler, S Bandyopadhyay, S. Ghosh, and U. Roy. 2022. "Coastal Dilemma: Climate Change, Public Assistance and Population Displacement." *World Development* 150.
[76] Pokhrel, P., A. Shrestha, S. Fisher, and D. Devkota. 2015. *Tracking Adaptation and Monitoring Development in Nepal.* International Institute for Environment and Development.
[77] Kato, T., M. Rambali, and V. Blanco-Gonzalez. 2021. "Strengthening Resilience in Mountainous Areas." OECD Development Co-operation Working Paper 104.

3.1.4. Climate change and air pollution

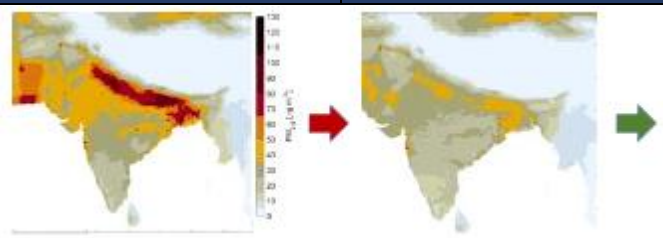
Poor air quality has significant health costs in Nepal. Virtually all of Nepal's population is reported to be exposed to unsafe levels of fine particulate matter (PM).[78] The mean annual exposure of $PM_{2.5}$ (the most consequential air pollutant for adverse health effects) is nearly 80 microgram per cubic meter ($\mu g/m^3$).[79] Nepal's $PM_{2.5}$ levels exceed the World Health Organization (WHO) guidelines for what can be considered healthy air quality by more than 15 times. These high levels of exposure have significant effects on morbidity and mortality. Approximately 12 percent of the population in Kathmandu suffers from chronic respiratory diseases, including pneumonia, which is found to be a high cause of mortality in children under the age of five.[80] The latest Global Burden of Disease Study finds that around 7 percent of deaths can be attributed to ambient PM pollution and 6 percent to household air pollution every year.

The sources of air pollution vary across the country, with transportation, household biomass use, and industry being the biggest sources in the Kathmandu Valley. Vehicle emissions and manufacturing emissions (especially from brick kilns and cement factories) are two of the three main sources of air pollution in the Kathmandu Valley. In rural areas, household biofuel use and the burning of agricultural residues contribute significantly to indoor and outdoor air pollution.[81]

The implementation of air quality management measures would lead to significant climate co-benefits through reduced CO2 and short-lived climate pollutants. In the South Asia region, implementing these measures to reach 35 $\mu g/m^3$ (the WHO interim target 1) would result in a yearly reduction of about 750,000 premature deaths from air pollution throughout the region, including a reduction of about 67 percent in Nepal. Another benefit from reduced air pollution is improved food security, as black carbon and methane not only have negative effects on leaf health, growth, and productivity of rice, wheat, maize, and soybean[82] but also contribute to snow and glacial melt.

Figure 15: Climate co-benefits from implementing a clean air scenario in South Asia

Current $PM_{2.5}$ concentrations (2018)	South Asian region vision for 2030



Reduction in premature deaths from air pollution	
Location	**in % (2030)**
Bangladesh	-50%
India (IGP)	-49%
India (non-IGP)	-14%
Nepal	-67%
Pakistan	-53%
Sri Lanka	-1%
Total deaths avoided annually:	**752,000**

Source: World Bank. 2022b. SAR AQM Flagship Study [forthcoming].
Note: 2030 result of possible AQM policies in Southwestern parts of Pakistan and Afghanistan to be further clarified due to high share of natural dust; IGP = Indo-Gangetic Plain).

[78] Hsu A., D.C. Esty, M.A. Levy, and A. de Sherbinin. 2016. *Environmental Performance Index.* New Haven, CT: Yale University; www.epi.yale.edu.
[79] World Bank 2019b.
[80] Pathak, K. P., and T. Gaire.2020. "Nepal: Country Report on Children's Environmental Health." *Reviews on Environmental Health* 35 (1): 53–56. https://doi.org/10.1515/REVEH-2019-0086.
[81] Kim, B.M., J-S. Park, S.-W. Kim, H. Kim, H. Jeon, C. Cho, J.-H. Kim, S. Hong, M. Rupakheti, A. K. Panday, R. J. Park, J. Hong, S.-C. Yoon. 2015. "Source apportionment of PM10 mass and particulate carbon in the Kathmandu Valley, Nepal". *Atmospheric Environment* 123 (Part A), 190-199; Filippini, M., N. Kumar, and S. Srinivasan, 2021. "Behavioral Anomalies and Fuel Efficiency: Evidence from Motorcycles in Nepal," *CER-ETH Economics working paper series* 21/353, CER-ETH - Center of Economic Research at ETH Zurich.
[82] Current estimates reveal that relative yield losses from high ozone concentrations is 7–12 percent for wheat, 6–16 percent for soybean, 3-4 percent of rice, and 3–5 percent for maize.

Recommendations for air pollution and climate change

- Increase the density and management of air monitoring networks to enhance data and information; prepare timely updates of emission inventories; and develop abatement policies for short-lived climate pollutants.
- Promote cleaner cooking practices and technology to reduce indoor air pollution, including improved drafting of traditional cookstoves and the transition to biogas and electric alternatives.
- Adopt low emission technologies in brick and cement factories, which improve fuel efficiency and switch from coal to cleaner fuels and enact and enforce emission standards.
- Improve and enforce vehicle and fuel emission standards; promote the use of nonmotorized transport; enforce measures to reduce road-based sources of dust pollutants; improve urban planning to ease traffic congestion.
- Improve solid waste management (SWM) to prevent the burning of garbage and ill-managed dumping of building materials on roadsides.
- Promote conservation agriculture and the creation of markets for agricultural residue to reduce agricultural waste burning; improve governance and enforcement around

3.1.5. Human capital

Climate-related health risks

Climate change is among the top threats to public health, livelihoods, and productivity, affecting nutrition outcomes and learning and educational attainment. Climate change is best characterized as a risk multiplier for health affecting vulnerable groups, leading to vicious cycles of risk and impact. Climate affects health through interdependent pathways, including direct risks such as extreme heat or flooding leading to traumatic injury, exacerbating noncommunicable disease (NCD) and worsening mental health; ecosystem-mediated risks including vector-borne diseases (VBDs) such as dengue and malaria; and indirect risks such as poverty, conflict, and migration.

While Nepal has made notable progress in key health indicators, including reduced child mortality and improved health care coverage, climate and environmental threats still loom large.[83] Four key emerging climate-related health threats should be considered:[84]

- **Heat-related morbidity and mortality.** Higher annual mean temperature coupled with an increase in the intensity and frequency of heatwaves will place a greater number of people at risk of heat-related NCDs. Nepal has made progress in reducing its burden of disease in the last three decades; however, it now faces an increasing burden from NCDs exacerbated by climate-induced extreme heat. Projections indicate that, under a high-emission scenario, heat-related mortality would increase to around 53 deaths per 100,000 annually by the 2080s, compared with four deaths per 100,000 between 1961 and 1990.[85]

- **Nutrition risks.** Climate change is likely to substantially aggravate food insecurity and poor nutrition outcomes in Nepal, which already ranks among the highest in the South Asia Region and

[83] Haines, A., and K. Ebi. 2019. "The Imperative for Climate Action to Protect Health." *The New England Journal of Medicine* 380 (3). https://researchonline.lshtm.ac.uk/id/eprint/4651182/1/Haines-Ebi-2019-The-imperative-for-climate-action-to-protect-health.pdf.
[84] World Bank Group. Forthcoming. Nepal Climate and Health Vulnerability Assessment.
[85] Honda, Y., Y. Honda, M. Kondo, G. McGregor, H. Kim, Y.L. Guo, Y. Hijioka, M. Yoshikawa, K. Oka, S. Takano, S. Hales, R.S. Kovats. 2014. "Heat-Related Mortality Risk Model for Climate Change Impact Projection." *Environ Health Prev Med.* 19 (1): 56–63. https://pubmed.ncbi.nlm.nih.gov/23928946/.

where stunting already affects nearly one-third of the population. Global estimations project that populations at risk of climate-related nutritional threat will increase by up to 30 percent between 2010 and 2050. Adverse climate impacts agriculture and crop yields, particularly rice, the main staple food in Nepal. Food insecurity is projected to increase, further straining nutritional outcomes. The long-term negative implications of nutrition risks, including stunting that affects cognitive development, lead to low educational attainment, affecting lifetime earning potential resulting in long-term impacts on labor productivity and economic growth.[86]

- **VBDs.** Vector suitability ranges, particularly for mosquitoes, are highly sensitive to climate. Analyses indicate that climate will place an additional 600,000 people at risk of malaria and an additional 400,000 at risk of dengue. This is on top of an already very high burden of VBD across the country and will additionally strain already stretched surveillance, control, and treatment services.

- **Waterborne diseases.** Nepal's extreme topography and limited access to safely managed drinking services result in a large proportion of the population being already vulnerable to waterborne diseases (WBDs). Climate-related changes to precipitation patterns, floods, and landslide events will increase the vulnerability to WBDs.[87]

Climate change risks exacerbate existing disparities in health service delivery, particularly in remote regions. Despite significant improvements in health coverage, gaps remain between policy and practice, especially at the subnational level. The Ministry of Health and Population (MoHP) has not completed the full assessments of climate readiness of the health care infrastructure and workforce. There is also a need to put in place adequate contingency planning for anticipated climate-related hazards such as heat, floods, and landslides. Minimum standards for climate-sensitive health care infrastructure have also not been developed further impeding refurbishment efforts of existing health care facilities.

Nepal has a Health-NAP which is incorporated within the National Health Sector Strategy. The strategy acknowledges the climate-related burden of disease and impacts on health system capacities; however, a lack of resource allocation and integration with health budgets to respond to climate-related health risks is a challenge.

Despite significant improvements of the early warning system (EWS), there is insufficient integration with health information systems across a sufficient breadth of climate-related health risks. Since its establishment in 1997, the flow of information to the EWS on VBDs and certain other outbreak-prone diseases has been strengthened. However, there is limited inclusion of climate-related information focused on aspects of health risks. EWS mechanisms do exist for several climate- related disasters such as community-based EWS for floods; however, no comprehensive approach to a fully climate-informed health EWS exists. Health information systems are currently not integrated with hydromet services, and there is limited collaboration between entities across the health and environmental sectors. Strengthening a shock-responsive social protection (SRSP) system is another key area of risk management and preparedness, which is discussed in more detail in Section 4.2.

Education and skills

While Nepal has made significant progress in improving key education indicators—including improved access to school education and gender parity in access—learning levels remain low and are further depressed because of COVID-19 and climate-induced disasters. The World Bank Human Capital Index suggests that a child born today in Nepal will be 50 percent as productive when she

[86] See, for example, USAID. 2021. *Nepal: Nutrition Profile* and Devkota, M. D., R. K. Adhikari, and S. R. Upreti. 2016. "Stunting in Nepal: Looking Back, Looking Ahead." *Matern Child Nutr.* 12 (Suppl 1).

[87] Suwal, Sahisna. n.d. "Water in Crisis - Spotlight Nepal." The Water Project, https://thewaterproject.org.
"Nepal: Monsoon Floods and Landslides Operation Update Report Dref Operation N° MDRNP010." *ReliefWeb*, https://reliefweb.int.

grows up as she could be if she enjoyed full education and health.[88] In Nepal, frequent closure of schools due to damage to school infrastructure and/or roads to schools due to climate-induced disasters is common. In addition to directly impacting learning through school closures, extreme heat stress and air pollution impede learning.[89] These impacts are higher for the poorest and most vulnerable children. Building system resilience, including resilient school infrastructure, digitized learning programs, and ensuring equity in access are therefore of critical importance.

The education sector can play an important role in strengthening climate adaptation and mitigation efforts. Educational attainment is a strong predictor of climate change awareness and studies have shown a positive correlation between education, environmental awareness, and skills and behaviors that support policies that positively impact the environment.[90] The Ministry of Education, Science, and Technology's efforts to integrate climate change issues into the construction of green and resilient school infrastructure and curriculum, raise environmental awareness among school communities, and combine climate change education in preservice and in-service teacher training, including emergency preparedness and response measures, should be supported and strengthened. These efforts to increase climate awareness through education can accelerate widescale behavioral change to transition to a more resilient and greener economy.

Good-quality education and human resources with relevant skills can also be key factors in engaging communities in climate solutions. Steps can be taken to promote rural women's green skill development, including maintaining solar panels, engaging in CSA, and designing and marketing cook stoves. They can also be given small grants to utilize power provided through solar mini-grids and micro-hydro with positive multiplier effects, creating access to a pool of useful skills at the local level and improving women's economic empowerment and social status.

Recommendations to reduce climate-related health risks and enhance education and skills for resilience

- Improve overall health service delivery and engage communities in climate and health assessments and health emergency planning: this would include reviewing the climate readiness of the current health care system, conducting health technology assessments targeted at understanding the value and benefits of adaptation measures in the health sector, establishing a national register for climate-related health risks with seasonal climate outlooks to inform health sector programming, enhancing contingency planning for acute climate shocks at all administrative levels, and investing in climate proofing of health infrastructure and technologies.
- Increase financing to cover climate-related health risks: this could be achieved by allocating a proportion of national health funding for adaptation and mitigation policies, pooling health funds to cover climate-related health risks, and engaging in strategic purchasing that includes climate considerations.
- Strengthen health information and surveillance systems: this could be achieved through developing an intersectoral platform to monitor climate-related health risks, establishing a climate-integrated disease EWS and response mechanism, introducing a systematic approach to the monitoring of climate and health vulnerabilities, and filling climate and health research gaps.
- Support efforts to promote climate awareness and incorporate climate change into school infrastructure, curricula, and teacher training.

[88] World Bank. 2020a. *The Human Capital Index 2020 Update: Human Capital in the Time of COVID-19*. Washington, D.C.: World Bank.
[89] Dell, M., B. F. Jones, and B. A. Olken. 2012. "Temperature Shocks and Economic Growth: Evidence from the Last Half Century." *Am. Econ. J. Macroecon.* 4: 66–95; Park, R. J., J. Goodman, M. Goodman, and J. Smith. 2020. "Heat and Learning." *Am. Econ. J. Econ. Policy* 12: 306–339.
[90] Chankrajang, T., and R. Muttarak. 2017. "Green Returns to Education: Does Schooling Contribute to Pro-environmental Behaviours? Evidence from Thailand." *Ecological Economics* 131: 434–448.

3.2. Addressing climate change impacts on transport infrastructure and systems to boost the economy and people's adaptative capacity

The road network is vulnerable to climate-related hazards linked to extreme weather events such as heavy rainfall, flooding, and landslides, which are increasing in frequency and intensity. Moving goods and people within the borders of Nepal is a complex endeavor, mainly because of the unique and challenging topography, along with landlocked borders and high vulnerability to climate risks. Road transport infrastructure is key to Nepal's economic and social development, as road transport is the primary form of transportation in the country with 90 percent of passengers and goods relying on road transport for connectivity.[91] Nepal's recent vulnerability and risk assessment documents that the country has seen an increasing number of climate hazards, including floods in the Terai region, landslides, mudflows, avalanches, and wildfires.[92]

Damaged road infrastructure has a significant impact on the country's economic growth, leading to disruption of access and supply chains for agriculture and manufacturing. Disaster-related closures and damage to roads lead to reduced access to jobs, health care, education, and employment; decreased profitability of businesses due to perishable goods spoilage; and increased food insecurity. Micro, small, and medium businesses are particularly at risk—this segment contributes 22 percent to GDP and employs 2.7 million people.[93] Over time, climate-related impacts are likely to intensify, making it crucial for transport infrastructure networks to shore up resilience.

3.2.1. Economic impact of climate change-induced disasters on road transport systems

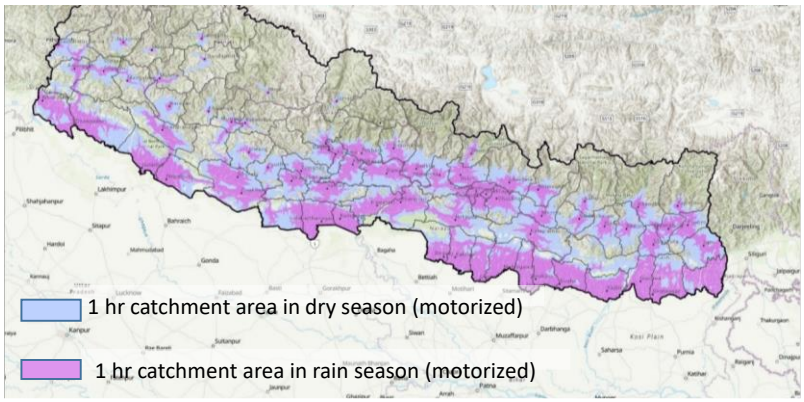
Nepal's population is dependent on a relatively limited network of roads for goods, trade, and basic access to health, education, and job opportunities. Most rural communities depend on the 63,500 km provincial and local roads network to access basic facilities. The 14,000 km federally managed strategic road network (SRN) connects major cities and serves as the conduit for all imports and exports. Route options are limited. Most traffic uses one single artery—the East-West Highway; 90 percent of the goods to Kathmandu travel on one link: the Narayanghat-Mugling Highway.

In addition to the direct economic costs of repairing damaged roads, climate events can have significant indirect costs in the form of trade disruption and lack of access to health, education, and job opportunities. Consequently, the climate scenarios discussed above were considered to estimate the impact of climatic disruptions, primarily landslides and floods, on the SRN. The analysis conducted for this report found that the direct costs of repairing damages caused by climatic incidents to the SRN would be equivalent to around 0.11 percent of GDP every year,[94] that is, NPR 3–6 billion (US$25–50 million) annually over the next 10 years.[95] Indirect costs would be around 50–75 percent of the direct costs for the same duration assuming that these climate-induced damages were addressed as a priority. In case damages were not addressed, the indirect costs could be as high as 400 percent of the direct damage.[96] Currently, the government spends approximately US$8 million annually to repair the damage caused by climatic disruption on the SRN, [97] but it is not unusual for repairs to be delayed significantly or not to take place at all. For example, the flooding of the Koshi River in 2008 caused major obstruction to the East-West Highway, which took one year to be restored, severely affecting trade along this corridor. Similarly, the newly built Jabdighat Bridge over the Babai River which collapsed in 2017 due to floods, severely disrupting access in the Bardiya District, has not been repaired since.

[91] ADB 2016.
[92] MoFE, GoN. 2021. *Vulnerability and Risk Assessment and Identifying Adaptation Options: Summary for Policy Makers*. Kathmandu: MoFE.
[93] Kharel, P., and K. Dahal. 2020. "Small and Medium-Sized Enterprises in Nepal: Examining Constraints on Exporting." ADBI Working Paper 1166, ADB Institute, Tokyo, https://www.adb.org/publications/sme-nepal-examining-constraintsexporting.
[94] GDP (constant 2015) in Nepal is US$31.6 billion (World Bank Nepal Development Report and data.worldbank.org/indicator).
[95] World Bank staff analysis. Note: The Department of Roads estimated that actual damages to strategic road and bridge infrastructure due to climatic events were worth around NPR 2.8 billion in 2021 and over NPR 2 billion in 2020.
[96] Hallegatte, S., J. Rentschler, J. Rozenberg. 2019. *Lifelines: The Resilient Infrastructure Opportunity*. Washington, D.C.: World Bank.
[97] Based on Department of Roads data and funding gap assessed in World Bank. 2019c. *The Nepal Infrastructure Sector Assessment*.

Increasing road network resilience would only cost a fraction of total construction and maintenance costs and significantly lower damage. Resilience measures are a priority for the North-South and East-West corridors and other SRN roads linking major metropolitan areas. Evidence suggests that spending an incremental cost of around 3 percent of the overall investment needs to include climate resilience measures in road works would yield at least four times the benefits.[98] Benefits would include direct gains from reduced maintenance or rehabilitation works and averted reconstruction costs as well as indirect economic benefits from increased and all-weather connectivity to jobs and services.

Figure 16: Access to and from rural communities is severely reduced during rains



Source: Based on World Bank staff analysis

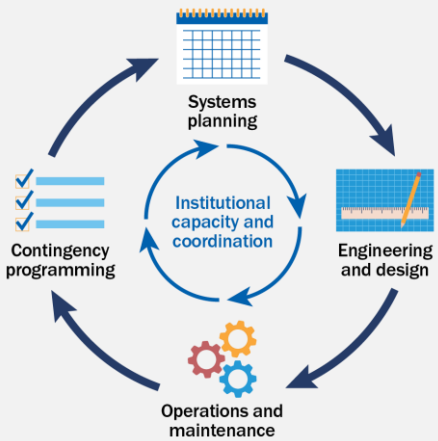
This is even more true in the case of the provincial and rural road network. Most rural communities are just one road closure away from losing access to markets and services—about 45,000 km of the provincial and local roads are earthen (only about 4,500 km are paved) and one-fifth of the population loses access to the district headquarters during the rainy season.[99]

3.2.2. Building resilience of the road network in a cost-efficient manner

The resilience challenge is to manage the trade-off between cost and risk management. Raising standards or building redundancy would enhance resilience but doing so across the network would be prohibitively expensive. Cost-efficient resilience investments should be prioritized by considering a life-cycle approach (**Error! Reference source not found.**).

Network-level risk-based planning is key to identifying the most critical transport assets. Pinpointing the most critical and exposed transport assets allows planners to target solutions such as building redundancy, raising design standards, and reducing risks, for instance, by shifting development away from vulnerable zones. In this context, there is a need to develop coordination mechanisms across levels of

Figure 17: Life-cycle approach for climate-resilient transport infrastructure



Source: Adapted from World Bank. 2017. Climate and Disaster Resilient Transport in Small Island Developing States: A Call for Action.

[98] Hallegatte et al. 2019.
[99] Measured as one hour of motorized travel.

government that allow integrated approaches to road planning in the federal context.

Revised planning and design practices for all new construction must incorporate innovative and cost-efficient resilient engineering measures. This includes incorporation of landscape approaches in road design, particularly adoption of best practice in water management along transport networks for enhanced resilience and sustainability, use of innovative cost-efficient materials and nature-based solutions, and integration of road and bridge design with updated flood maps and rainfall data.

The government should adopt a climate-smart asset management approach and increase maintenance budgets. This entails measures to increase maintenance funding and prioritize the most climate-vulnerable assets to fund required slope stabilization, drainage, spot repairs, culvert maintenance, and protection of bridges against scouring. While some of this effort will be technical (existing road asset management systems will need to integrate climate risk data), the larger endeavor will be to change priorities. At present, only one-third of the annual maintenance needs estimated at NPR 11.2 billion (US$90 million per year) are funded. There is a critical need to explore additional funding sources and mechanisms, particularly private sector financing, additional taxes, or tolling of major highways being upgraded.

There is a critical need to institutionalize and strengthen emergency response and preparedness. This includes not only the strengthening of institutional coordination mechanisms but review of protocols for emergency repairs that appropriately balance speed and governance concerns during and immediately after climatic events.

Recommendations for building resilience in the road transport sector

Manage the trade-off between cost and risk management by using a life-cycle approach to prioritize the most cost-efficient resilience investments using a four-step strategy:

- Adopt network-level risk-based planning to identify the most critical transport assets to target solutions such as building redundancy and reducing risks.
- Incorporate innovative and cost-efficient resilient engineering measures in revised planning and design practices for all new construction to incorporate.
- Adopt a climate-smart asset management approach and increase maintenance budgets, prioritizing the most climate-vulnerable assets; to the extent possible, explore additional funding sources and mechanisms, particularly private sector financing, additional taxes, or tolling of major highways currently being upgraded.
- Institutionalize and strengthen emergency response and preparedness.

4. Key pathways for adaptation and resilience

KEY MESSAGES

Nepal's water, agricultural, forest, and energy sectors must approach resilience and sustainability in an integrated way to optimize economic benefits, build resilience, and adapt to a changing climate. This will strengthen resilient rural livelihoods and reduce climate risks and uncertainties for agriculture, hydropower, and water supply systems while reducing net GHG emissions.

Water storage enhanced with integrated watershed management is essential for year-round reliability of irrigation and domestic water supply; improved water quality; and management of flood, drought, and erosion risks.

Nepal's success with community-based forestry and the new Forest Regulation provides a strong foundation for shifting to sustainable forest management (SFM) across the country. This offers the potential for multiple economic, livelihood, climate, and other environmental benefits.

Nepal needs to prioritize CSA. Policy reform and investments are needed to advance technologies that deliver mitigation, adaptation, and productivity enhancement. Policies need to be tailored for both subsistence and commercial farmers and better incentivize private sector participation. An intergovernmental funding mechanism would facilitate support for CSA by farmers as well as risk mitigation investments by subnational governments.

4.1. Integrated approaches to water, agriculture, and forest system resilience

Natural resources—arable land, forests, and water—underpin Nepal's productive sectors, rural livelihoods, and some key public services such as water and energy. These resources provide the primary source of livelihoods for over two-thirds of the population, especially the poorest. They are also the main buffer against climate-induced natural disasters such as flood, heat, landslides, and drought. Given the importance of a holistic approach to Nepal's planning, policy making, and investment in resilience, this chapter first explores pathways for boosting adaptation and resilience through water, agriculture, and forest systems as well as their interaction and concludes with the imperative of post-disaster response and resilience.

The natural resource-based sectors are vital for a greener, more resilient, and more inclusive rural economy. Agriculture, forestry, and fishing contribute almost one-fourth of GDP.[100] Forests contribute 3.5 percent of national GDP[101] and account for 20 percent of rural household incomes.[102] Nepal's rivers generate over 90 percent of total domestic electricity and support irrigation for around half of Nepal's cultivated lands. However, there are major development gaps in harnessing and managing these natural resources to expand access to essential public services, such as achieving universal access to reliable safe household water supply and boosting the economy's productive capacity through adequate water and energy provision. The lack of access to basic services, combined with low income and poverty, is a key predictor of a country's and its people's high vulnerability to climate

[100] GoN. n.d. *National Accounts Statistics of Nepal 2021/22 Annual Estimates.* Kathmandu: GoN. https://cbs.gov.np/national-accounts-statistics-of-nepal-2021-22-annual-estimates

[101] World Bank. 2018. Country Forest Note: Nepal. Washington, D.C.: World Bank.

[102] Forest income for the average Asian country, including Nepal, sampled was found to be about 20 percent (see Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C., Wunder, S. 2014. Environmental Income and Rural Livelihoods: A Global-Comparative Analysis. *World Development* 64, S12-S28).

change; closing these development gaps sustainably and reducing poverty are foundational steps toward building a climate-resilient society.[103]

It is important to acknowledge the strong and complex interlinks that exist between sustainable development and natural resource management. Investments in any one resource can have cascading impacts on the others. Similarly, climate impacts on one resource can result in knock-on effects in all sectors that depend on it. Designing policy to manage trade-offs and mutual opportunities between natural resource assets can help productive sectors and strategic infrastructure (such as hydropower, irrigation, and water supply) use resources sustainably and efficiently, despite the increasing constraints imposed by a changing climate. Integrated water resource and landscape management are recognized approaches, but water, forest, and land resources continue to be used on a project-to-project basis.

While extensive research is required to understand these links, synergies, and trade-offs, emerging evidence demonstrates the benefits of integrated approaches. For instance, a recent study showed that Nepal stands to gain higher economic returns from designing hydro storage projects that meet multiple objectives including adequate environmental flows and flood risk management, as opposed to single-outcome maximization.[104] Another study on the Koshi basin shows that integrated projects have higher resilience to climate change.[105]

Although Nepal intends to pursue integrated land and water management, it has yet to develop the essential enabling environment, institutional framework, and analytic architecture to fully implement climate-informed management and development of its abundant natural resources.[106] Apart from consistent, sustained effort, a few links are particularly important entry points. Multipurpose water storage, combined with integrated landscape and watershed management, can reduce seasonal water shortages in agriculture, power generation, and urban systems while providing flood, drought, and erosion management services. Sustainably harnessing water, renewable energy, and forest resources to improve agricultural productivity, resilience, and sustainability requires multisector cooperation which is essential to support CSA.

Recommendations to better integrate water, agriculture, and forests for climate resilience

- Invest in community-based integrated local development programs for natural resource and watershed management (water, agriculture, forest, and energy) and climate risk reduction to secure sustainable, resilient, and inclusive livelihoods, including for women and indigenous persons.
- Strengthen the enabling environment for better coordination among ministries and across the tiers of government.
- Build the analytical basis and decision support systems for climate-informed management of rivers, watersheds, and landscapes such as improved biophysical data, indicators, and analytics at the basin and municipality levels on forest, soil, water quality and quantity, crop suitability under climate change, and role of biodiversity in adapting food systems to a changing climate.

[103] Hallegatte et al. 2017; Hallegatte, S., J. Rentschler, and J. Rozenberg. 2020. *Adaptation Principles—A Guide for Designing Strategies for Climate Change Adaptation and Resilience.* Washington, D.C.: World Bank.
[104] Dhaubanjar, S., C. Davidsen, and P. Bauer-Gottwein. 2017. "Multi-objective Optimization for Analysis of Changing Trade-Offs in the Nepalese Water-Energy-Food Nexus with Hydropower Development." *Water* 9 (3): 162.
[105] Amjath-Babu, T. S., B. Sharma, R. Brouwer, G. Rasul, S. M. Wahid, N. Neupane, U. Bhattarai, and S. Sieber. 2019. "Integrated Modelling of the Impacts of Hydropower Projects on the Water-Food-Energy Nexus in a Transboundary Himalayan River Basin." *Applied Energy* 239: 494–503.
[106] For instance, the National Water Resource Plan 2005 advocated for integrated water resource management.

4.1.1. Water

Water is vital for Nepal's economy but is underutilized due to high climate variability, inadequate infrastructure, and poor resource management. Of 225 billion m^3 of annually available surface water, only 15 billion m^3 is used—96 percent in agriculture. Over 80 percent of annual precipitation occurs during the monsoon, causing problems of excess in the wet season and scarcity in the dry season. Nepal's storage volume requirement to satisfy annual average seasonal water demand is estimated to be 30 km^3, but less than 0.5 percent has been developed.[107] Despite being rich in water resources, overall water security in Nepal is one of the lowest in Asia due to inadequate infrastructure, exposure to water-induced disaster risks, and poor service delivery in irrigation and domestic and industrial water supply.[108]

Climate change is expected to increase spatial and temporal variation in precipitation. Decreasing snowfall and lengthening melt seasons are projected to cause a decline in glacier volumes by up to 90 percent by the turn of the century, reducing an important contributor to dry season flows.[109] As for rainfall, climate impacts vary by region; a study shows an increase in 12 percent of the lowland areas in the pre-monsoon season, with a significant decrease across all regions in the post-monsoon period.[110] There is also a significant decline in winter flows of spring water with 15 to 30 percent of springs in the mid-hill region drying up, impacting some of the poorest and indigenous groups and contributing to internal migration.[111] The significant heterogeneity in the impact of climate change on water availability at the sub-basin scale and across seasons suggests that management strategies need to adopt adaptive planning and investments.[112]

Climate variability in water has cascading impacts on agriculture, hydropower, and drinking water supply. In agriculture, the lack of year-round irrigation, particularly in the Terai, hinders productivity growth.[113] Less than half of net irrigable land (about 1.1 million ha) is currently irrigated; only 39 percent has access to year-round irrigation. In hydropower, dry season imports make up about half of electricity supply. In urban and rural water supply, the lack of reliable domestic water services, especially in the dry season, compels households to seek water from more distant sources. In rural areas, women routinely spend over two hours a day to collect water,[114] paying a hefty price in lost productive time and health.[115] In urban areas, households rely on alternative sources such as rainwater, private tube wells, tanker water, public taps, private storage, and underregulated water markets. The aggregate costs of purchasing, pumping, treating, and storing water are estimated to increase household spending on water by up to threefold.[116] The economic burden of water scarcity also reveals the high revenue potential associated with improved public service delivery of water. The human capital costs of poor water supply and sanitation (WSS) are high; 36 percent of children under five are stunted and this rate is as high as 49 percent among children from the lowest quintile.[117]

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[107] ICIMOD (International Centre for Integrated Mountain Development). 2009. *Water Storage: A Strategy for Climate Change Adaptation in the Himalayas. Sustainable Mountain Development: Winter No. 56.*

[108] ADB 2020. Nepal has a score of 6.0 for rural household water security, 10.8 for economic water security, 9.7 for urban water security, 11.9 for environmental water security, and 10.2 for climate-related disaster security (out of 20 for each category).

[109] Bolch, T., J. M. Shea, S. Liu, F. M. Azam, Y. Gao, S. Gruber, W. W. Immerzeel, A. Kulkarni, H. Li, A. A. Tahir, G. Zhang, and Y. Zhang. 2019. "Status and Change of the Cryosphere in the Extended Hindu Kush Himalaya Region." In *The Hindu Kush Himalaya Assessment*, edited by P. Wester, A. Mishra, A. Mukherji, and A. Shrestha, 209–55. Switzerland: Springer, Cham; Immerzeel, W. W., A. F. Lutz, and M. Andrade. 2020. "Importance and Vulnerability of the World's Water Towers." *Nature* 577: 364–69. doi:10.1038/s41586-019-1822-y.

[110] Karki, R., S. Hasson, U. Schickhoff, T. Scholten, and J. Böhner. 2017. "Rising Precipitation Extremes across Nepal." *Climate* 5 (1): 4.

[111] Sharma, B., S. Nepal, D. Gyawali, G. S. Pokharel, S. Wahid, A. Mukherji, S. Acharya, and A. B. Shrestha. 2016. "Springs, Storage Towers, and Water Conservation in the Midhills of Nepal." ICIMOD Working Paper 2016/3, Kathmandu, Nepal, International Centre for Integrated Mountain Development.

[112] Bharati, L., P. Gurung, P. Jayakody, V. Smakhtin, and U. Bhattarai. 2014. "The Projected Impact of Climate Change on Water Availability and Development in the Koshi Basin, Nepal." *Mountain Research and Development* 34 (2): 118–130.

[113] Cosic, Dahal, and Kitzmuller 2017.

[114] Komatsu, S., Y. Yamamoto, Y. Ito, S. Kaneko, and R. P. Dhital. 2020. "Water for Life: Ceaseless Routine Efforts for Collecting Drinking Water in Remote Mountainous Villages of Nepal." *Environment, Development, and Sustainability* 22 (8): 7909–7925.

[115] Wali, N., N. Georgeou, O. Simmons, M. S., Gautam, and S. Gurung. 2020. "Women and WASH in Nepal: A Scoping Review of Existing Literature." *Water International* 45 (3): 222–245.

[116] Pattanayak, S. K., J-C. Yang, D. Whittington, and K. C. B. Kumar. 2005. "Coping with Unreliable Public Water Supplies: Averting Expenditures by Households in Kathmandu, Nepal." *Water Resources Research* 41 (2): W02012. doi:10.1029/2003WR002443.

[117] Joseph, George, and Anne Shrestha. 2022. *Glaciers, Rivers, and Springs: A Water Sector Diagnostic of Nepal.* Washington, D.C.: World Bank; Based on Demographic and Healthy Survey 2016 data.

Integrated water resources development will optimize water allocation for irrigation, drinking water, hydropower, and navigation. It is imperative to improve water resource management to overcome disparities in availability across time and space as well as for climate resilience. Floods, droughts, and poor WSS have been shown to contribute to the vicious cycle of poverty. Sustained water shortages affect human health, labor productivity, incomes, employment levels, and business revenue.[118]

As a first-order priority, water must be harnessed and managed to cope with growing climate variability and shocks. This includes surface water infrastructure schemes, such as multipurpose water storage and transfer, as well as viable groundwater schemes. The 2019 Irrigation Master Plan identifies several economically feasible multipurpose surface and groundwater schemes that could expand or rehabilitate irrigation systems in over 700,000 ha and 350,000 ha of arable land, respectively, over the next 15 years with significant hydropower co-benefits.[119] As for urban water supply, large cities need to plan for alternative water infrastructure combined with demand management to ensure reliable water provision. In Kathmandu, a comprehensive water security analysis showed that water demand has outstripped its utility's existing surface and ground water sources.[120] Surface water storage and transfer schemes are being explored to meet demand in Kathmandu.[121]

While the lack of water infrastructure is the primary impediment, there is scope for demand-side improvements, particularly in irrigation. Water use efficiency for principal crops in agency-managed systems (which represent about 49 percent of irrigation systems, and the rest are farmer managed) indicates about 30-40 percent irrigation system efficiency below the typical potential of 50–60 percent.[122] Improving system delivery of irrigation water, among other interventions, can enhance water use efficiency; adequate investment in and government spending (about US$3.6 million annually or US$10 per ha) on operations and management are crucial. Irrigation fee rates and collection efficiency need attention. In the long term, volumetric pricing of water should be pursued for irrigation rather than pricing based on farm size. However, farmers will be reluctant to pay without well-managed and well-timed water supply to meet cropping needs.

Integrated watershed management is vital to avoid preventable setbacks from water-induced disasters. As a first step, it is essential to understand river morphology and watershed ecosystems; define the right-of-way of rivers in coordination with land use classifications; plan for river training, horizontal drainage, forest quality, and slope bioengineering; and manage sediment. Infrastructure within the watershed, such as roads and waste processing sites, also needs careful consideration to avoid higher risk of disasters. However, institutional arrangements with policy and legal backing must first be developed.[123] This requires an umbrella act for water resources, which is currently being drafted, as well as a policy and an act to enable watershed and river management.

[118] Cosic, Dahal, and Kitzmuller 2017.
[119] GoN and ADB. 2019. *Irrigation Master Plan Preparation through Integrated River Basin Planning.* Kathmandu, Nepal: Water Resources Project Preparatory Facility Department of Water Resources and Irrigation, Ministry of Energy, Water Resources and Irrigation (MoEWRI).
[120] Thapa, B., H. Ishidaira, V. Pandey, T. Bhandari, and N. Shakya. 2018. "Evaluation of Water Security in Kathmandu Valley before and after Water Transfer from Another Basin." *Water* 10 (2): 224.
[121] The Kathmandu Valley Water Supply Management Board is assessing the extent of need for water security and exploring potential infrastructure options.
[122] GoN and ADB 2019.
[123] Watershed management and river management are not included in the draft Water Bill.

Recommendations for enhanced water resource management

- Develop the legal and institutional basis for integrated water resource management at the basin level by enacting the Water Act and follow-on regulations and procedures and establishing basin-level offices and ensuring autonomy of regulators, with authority to formulate and enforce river basin plans and approve water-related investments. To support this, the World Bank is helping the government prepare a River Basin Plan and Hydropower Development Master Plan and Strategic Environmental and Social Assessments.
- Expand availability of year-round irrigation and domestic water supply through investments in sustainable water schemes with storage, combined with integrated watershed management augmented water quantity and quality.
- Improve service delivery of water supply and irrigation through adequate support to municipalities and user groups to plan for supply-side interventions under climate variation and change as well as practice adequate demand management interventions that ensure resource use efficiency, including across agricultural and nonagricultural uses of irrigation water (for example, domestic and small industry uses).
- Draft policy and legislation for watershed and river management, aligned with the Water Act, defining the rules, roles, and responsibilities at each tier of governance required for outcomes such as flood control, river training, sediment management, usage, and pollution control.
- Develop programs for integrated watershed/landscapes management for soil conservation, landslide prevention, and improved water quantity and quality downstream.

4.1.2. Agriculture

The agriculture sector has high potential to support equitable economic growth and poverty reduction. Agriculture is central to the national economy and critical for poverty reduction. Approximately 80 percent of Nepal's population lives in rural areas, where the level of poverty is significantly higher than in urban areas.[124] Agriculture contributed 64 percent of employment and over 21 percent of GDP in 2019.[125] Yet, as of 2016, 4.6 million people were food insecure. Average annual growth of the agricultural sector for the last 20 years was around 3.2 percent but was characterized by significant fluctuations. [126] Growth in agricultural income contributed 16 percent to poverty reduction between 1995/96 and 2010/11. [127] Growth in nonagricultural income (industry and services, two-thirds agro-based) was the main driver of poverty reduction, contributing 44 percent.[128] Since the share of agriculture in overall employment is large, an increase in agricultural incomes is expected to stimulate equitable economic growth.[129]

Agriculture remains characterized by subsistence farming which, due to limited commercialization, small landholdings, relatively low farm input levels, and low productivity, is highly vulnerable to climate impacts. Enhanced productivity, commercialization, and improved governance remain

[124] United Nations Population Division. World Urbanization Prospects: 2018 Revision, accessed August 2022, https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2021&locations=NP&start=1960&view=chart

[125] World Development Indicators, accessed June 2022, https://data.worldbank.org/indicator.

[126] Ibid.

[127] Further, remittances contributed 17 percent and changes in household demographics 19 percent to poverty reduction. Source: World Bank. 2016. *Moving Up the Ladder: Poverty Reduction and Social Mobility in Nepal.* Nepal: World Bank Group.

[128] Thapa, G., A. Kumar, and P. K. Joshi, eds. 2019. *Agricultural Transformation in Nepal: Trends, Prospects, and Policy Options.* Springer Nature Singapore. https://doi.org/10.1007/978-981-32-9648-0

[129] A sectoral decomposition of growth and growth projections should be undertaken; climate vulnerability might vary across pathways and targeted interventions are needed to strengthen climate resilience.

development priorities in support of equitable growth and poverty reduction.[130] Urbanization and changing dietary patterns away from staple foods toward processed and high-value foods[131] (domestically as well as globally) provide incentives for the agriculture sector to increase productivity, diversification, and commercialization levels. Nepal's agro-ecological diversity provides a unique opportunity to harness these opportunities, to both meet local demand and reach demanding international markets. In addition to providing an enabling environment for private sector participation, policies and public and private investments need to consider the adverse potential effects of climate risks on sectoral growth to ensure the sustainability of this transition.

Rising temperatures, changes in precipitation, and increases in extreme weather events negatively affect agricultural production and food security. The direct economic cost of climate vulnerability in the agriculture sector in 2020 was 1.5-2 percent of GDP.[132] Rising temperatures, evaporation, and erratic precipitation at critical cropping times significantly affect crop growth, as do incidence of pests and diseases.[133] Reductions in soil moisture can lead to prolonged droughts resulting in productivity losses and crop failures.[134] Heavier precipitation contributes to erosion, landslides, and floods, resulting in the loss of arable land, accelerated soil degradation, and reduction in fertility. These effects are sometimes compounded by droughts followed by excess precipitation.

Climate change is posing new challenges to the sustainability of livestock production system with serious implications for the many people who depend on livestock for food, employment, and income. About 70 percent of the population engaged in agriculture also undertakes livestock farming; a large proportion of the labor is provided by women.[135] The Agriculture Development Strategy (2015–35) underpins the role of livestock in sustained agricultural and economic growth, poverty reduction, and improved food and nutrition security. However, major climate impacts on animal husbandry, such as pasture degradation and decreased forage productivity, increased transboundary animal diseases and parasites, heat stress and changes in reproductive behavior, and losses and damages through extreme events, are predicted. Low productivity and poor animal husbandry practices increase weather, production, and market vulnerabilities.

In addition to the sector's high climate vulnerability, agriculture contributes around 52 percent of Nepal's emissions, mainly from livestock (76 percent including manure) and paddy rice (14 percent). Other sources are crop residues and burning (4 percent), cultivating of organic soils (3 percent), and fertilizer (3 percent).[136] Agriculture emissions increased 38 percent from 1990 to 2014, mainly due to increased enteric fermentation. During the same period, the number of cattle increased by 16 percent. Emissions from rice cultivation grew very little while, from 1990 to 2014; emissions from synthetic fertilizers nearly doubled but represented a small share (3 percent) of the 2014 agriculture emissions.[137]

The private sector in Nepal can play an important role in promoting climate change mitigation and adaptation activities in agriculture supply chains. Over the years, awareness and knowledge around

[130] Ministry of Agricultural Development, GoN. 2013. *Agriculture Development Strategy. Part I (2015–2035).* Kathmandu: GoN. Accessed June 2022. http://www.dls.gov.np/uploads/files/ADS%20Final.pdf.

[131] Subedi, Y. P., D. Marais, and D. Newlands. 2017. "Where Is Nepal in Its Nutrition Transition." *Asia Pac J Clin Nutr.* 26 (2): 358–367.

[132] GoN 2021b.

[133] World Bank, FAO, and GoN. 2021. *Nepal Climate-Smart Agriculture Investment Plan*. Washington, D.C.

[134] For instance, yields of maize, potato, sugarcane, and lentil are expected to decline by 16 percent, 9 percent, 8 percent, and 5 percent, respectively, compared to a no-climate change scenario. Rice and vegetable yields are expected to decline, but the effect is expected to be small. Source: CIAT (International Center for Tropical Agriculture), World Bank, CCAFS (CGIAR Research Program on Climate Change, Agriculture, and Food Security, and LI-BIRD (Local Initiatives for Biodiversity Research and Development). 2017. *Climate-Smart Agriculture in Nepal. CSA Country Profiles for Asia Series.* Washington, D.C.: CIAT, World Bank, CCAFS, and LI-BIRD. p. 26.

[135] FAO. 2005. *Livestock Sector Brief.*

[136] CIAT; World Bank; CCAFS and LI-BIRD. 2017. *Climate-Smart Agriculture in Nepal. CSA Country Profiles for Asia Series*. International Center for Tropical Agriculture (CIAT); World Bank; CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); Local Initiatives for Biodiversity Research and Development (LI-BIRD). Washington, D.C. p. 26.

[137] USAID. 2019. *GHG Emissions in Nepal*; with data from World Resources Institute Climate Analysis Indicators Tool (WRI CAIT 4.0, 2017) and FAOSTAT.

climate change and its impact on agribusiness have been growing within the private sector in Nepal; however, there are limitations in design and implementation of projects. In mitigation, the private sector in Nepal has initiated resource efficiency projects (for instance, renewable power generation by sugar mills using bagasse), but industrywide adoption and replication are at a nascent stage. Similarly, in the case of adaptation, private sector response has been rather muted due to limited knowledge of a business case in climate change adaptation. The lack of advanced storage silos/cold-chain and warehousing infrastructure also leads to substantial post-harvest food losses. Production losses in agriculture can affect industrial production, as much of Nepal's industry is based on food production as well as consumption in urban areas.

Nepal recognizes that CSA can deliver productivity increases, GHG emission reductions, climate adaptation, and resilience, but implementation has been spotty. There are several promising CSA practices in crop and livestock systems with potential to increase returns and reduce GHG emissions.[138] For paddy rice cultivation, which is a large GHG emitter, the system of rice intensification (SRI) and alternate wetting and drying (AWD) are suitable CSA practices in Terai crop production systems and lowlands with potential to reduce emissions by 30–70 percent.[139] Climate-smart livestock practices have potential to increase productivity and resilience to climate change and improve GHG emission intensity, that is, emissions per unit of product. Improvement in animal nutrition, improved breeding and animal health services, or better integration of livestock-crop-agroforestry systems are promising strategies.[140] Given that only 48 percent of irrigable land is irrigated, expansion and modernization of irrigation systems are an integral part of climate-smart crop and horticulture production, including water harvesting, micro-irrigation suitable for hilly areas, piped canals, and inclusion of rain fed areas.

A weak enabling environment, including low capacity for planning and implementing CSA, is a limiting factor for scaling up CSA adoption. Local-level extension services are not well coordinated with agriculture research and development, which is under federal and provincial responsibility. A range of enabling factors are required to support the adoption of CSA at the farm level, including policy reforms which support CSA investments, access to finance, and risk management products for farmers (see Section 6.3); better coordinated supply chains; access to markets and services; commercially available planting materials, seeds, and agro-chemicals; and strengthened producer groups and industry platforms to coordinate value chains. While SRI and AWD are promising techniques, adoption rates among smallholder farmers are low because of unreliable water supply due to outdated irrigation infrastructure, poor water governance, and lack of knowledge.[141]

There are several recommendations to support the uptake of CSA, including an enabling environment and investments to support improved and climate-resilient production systems and

[138] Farm-level practices that are ready to be scaled up include improved water and soil management (for example, conservation agriculture, intercropping, and managing sloping land); improved nutrient managing, including organic fertilizers and targeted soil testing; improved access to irrigation and improved water management to stabilize hydrological flows, develop more predictable water supplies, and protect against damage from increasing landslides and floods; good pasture management with drought-resistant and drought-tolerant fodder which improves the access to feed, feed conversion; improved animal health services; and strengthened on-farm integration of livestock, crop, and agroforestry systems. Source: World Bank, FAO, and GoN 2021.

[139] SRI and AWD could increase yields by 40–50 percent, reduce seed requirements by 75 percent, and decrease water use by 50–75 percent. Labor for transplanting is reduced as well, while the cost of weeding increases by 50–60 percent. AWD can reduce methane emissions by 30–70 percent. Other estimates show that SRI/AWD could increase net returns by US$79 per ha compared to traditional practices. There are few incentives to adopt irrigation scheduling recommended by AWD (which includes completely draining the field) because unplanned lengthy drying periods could affect yields. Sources: World Bank, FAO, and GoN 2021; Khatri-Chhetri, A., T.B. Sapkota, B.O. Sander, J. Arango, K.M. Nelson, and A. Wilkes. 2020. *Financing Climate Change Mitigation in Agriculture: Assessment of Investment Cases.* Environmental Research Letters 124044; Howell, K. R., P. Shrestha, and I. C. Dodd. 2015. "Alternate Wetting and Drying Irrigation Maintained Rice Yields Despite Half the Irrigation Volume, but It Is Currently Unlikely to Be Adopted by Smallholder Lowland Rice Farmers in Nepal." *Food Energy Security* 4 (2): 144–157.

[140] Promising climate-smart livestock management practices are improving of animal nutrition through increased production and access to animal feed and fodder, restoration of degraded lands, facilitating of access to nurseries, and adoption of stall-feeding practices to improve manure and soil-nutrient management; integrated livestock-crop systems allow the promotion of waste management and renewable energy technologies and practices which can be combined with biogas digesters; improving of access to breeding services and breeds and animal health services through better feeding and digestions has the potential to reduce GHG emissions by −0.225 tCO_2e per cattle per year or −0.150 tCO_2e per goat per year. However, increased profitability of livestock and demand for livestock products also pose a risk that as herd size grows so do absolute emissions compared to a BAU scenario.

[141] Howell, Shrestha, and Dodd 2015.

value chains across agroecological zones.[142] Proposed investments to facilitate and mainstream CSA and support resilience building, adaptation, and mitigation in crops, horticulture, and livestock value chains are estimated at US$685 million.[143]

Recommendations for climate-smart agriculture

- Support climate-resilient rain-fed and irrigated crop and horticulture systems and the uptake of CSA and water management practices by (a) strengthening farmers' access to services and inputs, particularly for women farmers; (b) improving access to markets; and (c) providing finance, for example, through incentives to financial and insurance institutions for increased lending; and supporting innovative risk management products and lending mechanisms.
- Consider adjustments of agriculture public expenditures, including fertilizer and seed subsidy programs, to support climate-smart sector development.
- Remove agriculture-related sectors from the negative list for FDI to spur investments targeted at climate-smart and resource-efficient technologies and practices that build the resilience of farmers, both male and female, as well as agribusiness firms. Potential sectors include poultry, fisheries, fruits and vegetables, dairy, oilseeds, coffee, and spices.
- Support development of agri-logistics and cold chains by developing capacity among private sector companies on latest technologies and business models and, among farmers, improving the quality and quantity of commodities necessary to make such investments viable.
- Promote biomass energy policy to encourage bioethanol generation from molasses produced in sugarcane mills.
- Strengthen productive, resilient, and low-carbon livestock systems by supporting improved feeding and breeding, animal health, and integrated crop and livestock systems to enhance fodder production, manure management, biofertilization, and generation of renewable energy.

4.1.3. Forests

Forests are critical for climate change adaptation as well as water and food security. Forests play a crucial role in climate resilience by creating micro-climate conditions that maintain or improve vegetation productivity and regulate the hydrological cycle, effectively shielding local areas from global climate change.[144] Forests also act as a buffer against climate disaster risks, reducing drought, landslides and soil erosion, thereby mitigating climate vulnerability of other economic sectors and human settlements.[145] Current community management forestry practices in Nepal show that

[142] Detailed recommendations, including an estimate of investment cost and cost-benefits analyses, are available in World bank, FAO, and GoN (2021).

[143] Details are available in World Bank, FAO, and GoN (2021). Investment packages include (a) strengthening the enabling environment for mainstreaming CSA at the national level with investment cost of US$25 million; (b) supporting climate-resilient crop production systems on 781,000 ha rain-fed and irrigated land, with irrigation infrastructure on 115,000 ha, with an investment of US$420 million; (c) supporting climate-resilient and competitive horticulture on 50,000 ha land with an investment of about US$180 million; (d) promoting resilient agroforestry-based livelihoods on 350,000 ha, with an investment of US$20 million; and (e) supporting sustainable and resilient livestock production systems, with an investment of about US$40 million, targeting about 3 million cattle and 10 million poultry.

[144] Research funded by the Program on Forests has shown these and other dimensions of climate resilience in several low-income countries. See PROFOR. 2017. *How Forests Enhance Resilience to Climate Change.* https://www.profor.info/node/2032.

[145] Nabuurs, G. J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O. Krankina, W. A. Kurz, M. Matsumoto, W. Oyhantcabal, N. H. Ravindranath, M. J. Sanz Sanchez, and X. Zhang. 2007. "Forestry." In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, and L. A. Meyer. Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter9-1.pdf.

reduced climate vulnerability can result from enhancing adaptive capacity.[146] Forests are a vital source of income for rural communities and the importance of climate-resilient forest management cannot be overemphasized. Improved sustainable community-based forest management has been linked to significant poverty reduction in Nepal.[147]

Forests contribute directly to the national economy and support the energy, agriculture, tourism, and transport sectors. The share of forest income in the total income of rural households is second to agricultural income, amounting to about 20 percent.[148] Forests currently supply 75 percent of household energy needs.[149] They also play a critical role in supporting agriculture: between 3.5 and 6 ha of forestlands is required to support each ha of crop land in Nepal.[150] Land degradation—a growing problem in Nepal affecting 10 percent of cropland and 37 percent of pasture and rangeland—threatens these livelihoods.[151] Measures to improve forest cover concurrently aim to improve watershed management, agroforestry, SFM, community forest management, eco-tourism, and conservation. The establishment of the Annapurna, Kanchenjunga, Manaslu, and Api Nampa Conservation Areas has allowed for a comprehensive management plan encompassing all land use categories, water resource plans, infrastructure development, and promotion of clean energy.

Nepal's forests and soils also serve as an important carbon sink, counter-balancing emissions from agriculture, land use change, biomass burning, and other sources. Nepal has expanded its forest cover from about 29 percent in 1994[152] to more than 40 percent in 2015.[153] Nepal's NDC aims to maintain forest cover at 45 percent; this will help Nepal reach its GHG emission target while delivering resilience, adaptation, and local livelihoods benefits at the same time. Forest landscapes provide a wide range of ecosystem services including economic benefits, livelihoods, and jobs from timber and nontimber products as well as carbon retention benefits, modulation of water quality and quantity, sediment retention and water regulation services, weather and heat regulating services, biodiversity assets, and spiritual and tourism services from conservation.

The rich forest resources of Nepal have a significant untapped potential to contribute to Nepal's economy, creating employment and alleviating rural poverty through SFM and conservation. Over the past three decades, the government has gradually transferred government-owned forests to community-based forest management groups. Almost 22,000 community forest user groups manage approximately 1.88 million ha, about 34 percent of forests. The country has well-performing community-based forest management programs, yet forest-dependent communities are falling behind on socioeconomic indicators. Simultaneously, grassroots institutions have played an important role in supporting agriculture and livestock promotion and DRR. These groups reduce the transaction cost and risk of activity implementation and can thus be capacitated to use additional integrated approaches across landscapes. New regulations aim to ensure women and vulnerable groups, particularly indigenous peoples, retain access to forest resources. Promotion and monitoring of equity

[146] Paudel, P., S. Khadka, S. Rimal, S. Bolakhe, S. Tiwari, and B. Pokhrel. 2019. "Forestry Practices for Climate Change Adaptation in Kalikot District, Nepal." Research Seminar on Climate Change. https://www.researchgate.net/publication/349042287_Forestry_Practices_for_Climate_Change_Adaptation_in_Kalikot_District_Nepal.

[147] Oldekop, J. A., K. R. E. Sims, B. K. Karna, M. J. Whittingham, and A. Agrawal. 2019. "Reductions in Deforestation and Poverty from Decentralized Forest Management in Nepal." *Nature Sustainability* 2: 421–428. https://doi.org/10.1038/s41893-019-0277-3.

[148] Forest income for the average Asian country, including Nepal, sampled was found to be about 20 percent (Angelsen, A., P. Jagger, R. Babigumira, B. Belcher, N. J. Hogarth, S. Bauch, J. Börner, C. Smith-Hall, and S. Wunder. 2014. "Environmental Income and Rural Livelihoods: A Global-Comparative Analysis." *World Development* 64 (1): S12–S28. ISSN 0305-750X. https://doi.org/10.1016/j.worlddev.2014.03.006) and another study found that for Nepal forest environmental income was about 16 percent of total household income in rural areas (Chhetri, Bir. 2014. "Forest Environmental Income and Its Role in Welfare Outcomes: An Empirical Evidence from Rural Nepal." *FORMATH* 14: 1–10. https://www.researchgate.net/publication/276833524_Forest_Environmental_Income_and_Its_Role_in_Welfare_Outcomes_An_Empirical_Evidence_from_Rural_Nepal/link/59720feb0f7e9b40168e6b09/download).

[149] WECS (Water and Energy Commission Secretariat), GoN. 2014. *Energy Consumption Situation in Nepal (Year 2011/12).* Kathmandu, Nepal.

[150] MoFSC (Nepal Ministry of Forests and Soil Conservation). 2009. *Nepal: Fourth National Report to the Convention on Biological Diversity.* Kathmandu: MoFSC.

[151] Chalise, D., L. Kumar, and P. Kristiansen. 2019. "Land Degradation by Soil Erosion in Nepal: A Review." *Soil Systems* 3 (12).

[152] World Bank 2019a.

[153] World Bank 2018.

in management and access to forests are essential in building community resilience and livelihoods. More analysis is also required of traditional indigenous forest management systems to improve current management and conservation practices.

Infrastructure development holds a risk for forests. Development of infrastructure (roads, airports, transmission lines, dams, and others), if not well managed through a landscape approach, is a threat to forest cover as well as other land uses. Other threats to forest cover include illegal logging such as for high-value *Sal* timber, as is happening in the lower elevation areas of the country, due to forest governance challenges. These are some countervailing trends to the otherwise positive developments in terms of forest management.

The government has put in place strategies and policies to increase the contribution of forests to achieve and green Nepal's ambitious development goals. The 2015 Forest Sector Policy strengthens the contribution of forests to the economy and highlights the need for SFM. The new Forest Regulation approved in 2022 provides clarity to the handover process of forest areas to community user groups, including vulnerable groups, women, and indigenous people. The protocols for leasehold forests and benefit-sharing arrangements are expected to lead to private sector investment in restoration and protection, additional jobs, and management of degraded and encroached forests. The Forest Regulation also provides guidance on carbon finance and trade of emission reductions.

Recommendations for sustainable forest management

- Produce and implement provincial and municipal SFM plans and procedures for continuing the transition to a forest sector that sustainably delivers firewood, timber, and non-timber forest products, plus ecosystem services, including for female forest end users and producers.
- Establish an enabling and regulatory environment for small-scale forest-based enterprises.
- Introduce and promote agroforestry systems for smallholder farmers on private degraded, underutilized or marginal land and on degraded public lands in consultation with municipalities.
- Continue to develop demand-driven nature-based tourism, especially to meet higher-end market demand, that incentivizes conservation of forests and protected areas that can generate jobs, income, livelihoods, and ecosystem-based adaptation.

4.2. Disaster risk management, preparedness, and social protection

Climate change is increasing disaster risk, reversing gains in poverty reduction, and setting back development in the country. As changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, natural hazards such as droughts, heatwaves, landslides, river flooding, and GLOFs are all projected to intensify, potentially exacerbating disaster risks and placing human life at risk.[154]

[154] World Bank Group and Asian Development Bank 2021; NASA. 2020. "Climate Change Could Trigger More Landslides in High Mountain Asia." February 11, 2020. https://www.nasa.gov/feature/goddard/2020/climate-change-could-trigger-more-landslides-in-high-mountain-asia; Bajracharya, S. R., S.B. Maharjan, F. Shrestha, T.C. Sherpa, N. Wagle, A.B. Shrestha. 2020. *Inventory of Glacial Lakes and Identification of Potentially Dangerous Glacial Lakes in the Koshi, Gandaki, and Karnali River Basins of Nepal, the Tibet Autonomous Region of China, and India.* Research Report. ICIMOD and UNDP.

Comprehensive resilience building is required at the subnational level to address climate and disaster risks facing cities and towns. Efforts should build and expand on existing measures such as preparedness, humanitarian relief, post-disaster recovery and reconstruction, and risk-sharing and transfer mechanisms at the local, provincial, and national levels. It is critical that these processes and systems are inclusive and engage women and vulnerable groups in the design and management of interventions as well as in communications. Lessons from the 2015 earthquake highlight how many such groups were unable to access relief, and the new GESI strategy aims to address some of these gaps. Targeted interventions in labor-intensive climate adaptation and DRR activities would also provide much-needed jobs and economic recovery opportunities in the short to medium term while reducing disaster risks through structural and nonstructural measures.

The devolution of disaster risk mitigation, preparedness and response, decision-making, and financing is important due to the remoteness and isolation of many rural communities. Rural communities bear the brunt of disasters and climate change impacts, with a time lag between disaster occurrence and assistance arriving due to accessibility limitations. The 2015 Constitution devolves DRM to all tiers of governance, especially to municipalities. As local governments are relatively newly formed entities and the country has recently adopted a federal structure, it is essential that the federalization of the DRM agenda is supported to enable communities to enhance resilience—particularly through capacity building of local governments.

Strengthening climate information and early warning systems is pivotal to enable risk-informed decision-making. Hydrometeorological services are a basic decision-making, early warning, and planning tool for enhancing resilience in sectors important for jobs, climate resilience, and growth including energy, agriculture, water, tourism, and aviation. Scaling up investments in hydromet observation networks will lead to improved weather and climate information services which are critical for long-term adaptation and resilience planning and investments. Improved EWSs, with timely and accurate weather alerts, will also boost the disaster preparedness and response capacity of federal, provincial, and local governments.

It is imperative that disaster risk financing (DRF) mechanisms and instruments are implemented to realize a climate- and disaster-resilient society. The government currently has very few ex-ante DRF instruments in place in comparison to emergency response, recovery, and reconstruction requirements after major disasters (ex post).[155] The Prime Minister's Disaster Relief Fund is the major source of funding for disaster relief in Nepal. The National Disaster Risk Management Act called for the establishment of DRM funds at the federal, provincial, and local levels to facilitate DRM-related works; however, funds have not materialized sustainably. The development and implementation of a DRF strategy through a risk-layered approach is essential to support both ex ante and ex post DRF and enable mechanisms such as tax levies for the generation of financial sources for DRM funds at all levels of government. Moreover, a DRF strategy could also contribute to reduce the financial risk from disaster events by enabling disaster risk-informed budgetary allocation.

Social protection can help build the resilience of poor and vulnerable households to prepare for, cope with, and adapt to climate shocks. Current social protection systems in Nepal are not sufficiently developed and have limited adequacy and coverage of the poor and vulnerable. Only about 55 percent of households in the bottom quintile receive any social transfer in Nepal compared to the South Asia average of 80.7 percent.[156] Crucially, the current social protection system is not shock responsive. Delivery of relief to affected households is often ad hoc and fails to use the existing reach of programs and delivery systems. Social protection and DRM systems as well as humanitarian

[155] ADB. 2019. *The Enabling Environment For Disaster Risk Financing In Nepal - Country Diagnostics Assessment.* https://www.adb.org/sites/default/files/publication/521681/environment-disaster-risk-financing-nepal.pdf

[156] Central Bureau of Statistics. 2020. *Nepal Multiple Indicator Cluster Survey 2019, Survey Findings Report.* Kathmandu, Nepal: Central Bureau of Statistics and UNICEF Nepal.

assistance operate largely in parallel. The vulnerable are often identified post disaster following needs assessments. This means that disaster response is often delayed, beneficiary identification is contested, and not all who need assistance receive it. Single women and persons with disabilities often face difficulties in getting relief.[157]

The existing social protection system in Nepal can be mobilized for more efficient delivery of relief and recovery. Given the coverage gaps, simply delivering additional assistance to those already covered by social protection programs is not sufficient. Existing delivery systems can be leveraged and comprise information systems, outreach mechanisms, enrollment processes, payment systems, monitoring and evaluation, grievance redressal systems, and the institutional and human resource capacities of the programs. There are challenges in the current delivery systems. Mobilizing existing delivery systems can mean speed and efficiency of delivery in response and recovery by using existing registries to identify the vulnerable instead of collecting new demographic and spatial data, existing management information system instead of creating a new one, and existing bank accounts and digital payment infrastructure and deploying existing program implementation units at the local level for enrollment and monitoring.

Improving the resilience of the poor and vulnerable as well as the delivery of relief and recovery in response to shocks requires further strengthening of social protection delivery systems and mobilizing the systems by institutionalizing SRSP. It also includes the establishment of an integrated social registry, improvement of payments systems, and expansion of the coverage of the poor by operationalizing the social security allowances for the economically poor. The Prime Minister's Employment Program, while supporting resilience through transfers, could also improve small-scale adaptive infrastructure, such as water conservation and drainage, as demonstrated in Ethiopia and India. The Ministry of Home Affairs (MOHA) has approved a policy framework for the integrated social registry and is currently drafting operational guidelines for its implementation. In addition to transfers in the form of cash or cash for work, investment in CSA has the potential to improve the resilience of the rural poor and vulnerable, who depend on agriculture for their livelihoods as well as for many multi-local households, for whom food production provides a safety net (see Section 4.1.2). Applying a climate lens to social protection and jobs programs in India and Ethiopia has also enabled more small-scale infrastructure programs to support climate resilience (including irrigation, drainage, and water harvesting). The Prime Minister's Employment Program could similarly focus on climate resilient infrastructure.

In addition to social assistance, expanding the coverage of a range of insurance products would help promote household resilience post disaster. The insurance market in Nepal is still nascent and insurance penetration remains low due to a lack of suitable products as well as limited awareness regarding insurance.[158] Crop and livestock insurance is available and subsidized at an 80 percent premium rate; however, uptake remains low. A comprehensive strategy to combine social assistance and insurance schemes, including microinsurance products for the poor, is essential. This could include a customized insurance awareness program for disaster insurance, microinsurance, and digital financial services. A multi-hazard catastrophe insurance pool with Nepal Re-Insurance Company Limited as pool manager could also be established to facilitate climate and disaster resilience.

Institutionalizing SRSP entails establishing a policy framework to enable the mobilization of existing systems for relief and recovery, amendment of existing program guidelines to enable their flexibility to respond to shocks, and availability of contingent financing. The National Disaster Risk Reduction

[157] Slater, R., A. Ghimire, and D. Baur. 2018. *Strengthening Links between Social Protection and Disaster Risk Management for Adaptive Social Protection in Nepal (English).* Washington, D.C.: World Bank Group. http://hdl.handle.net/2436/622212.
[158] World Bank. 2022c. *Assessment of Contingent Liabilities from Natural Disasters in Nepal.*

and Management Authority (NDRRMA) is currently drafting SRSP guidelines to address these issues. While there has been some progress at the policy level, much remains to be done to implement these policy frameworks. This will require high-level government commitment and interministerial and intergovernmental coordination.

Recommendations to enhance risk management and preparedness and mobilize social protection

- Strengthen weather, water, and climate information systems and develop a robust EWS that also addresses the needs of different sectors to enable risk-informed decision-making.
- Mobilize private sector financing in climate and disaster risk through innovative financing tools such as blended finance, credit guarantees, vendor financing, guarantee funds, warehouse receipts, and private equity capital.
- Strengthen planning, investment management, and budget formulation to facilitate the integration of climate and DRM considerations with adequate resource allocation.
- Equip provincial and local governments with skilled human resources to effectively plan and implement climate and disaster-resilient interventions.
- Strengthen delivery systems including establishment of an integrated social registry and improvement of payments systems.
- Expand the coverage of the poor by operationalizing the social security allowances and scaling up the Prime Minister's Employment Program.
- Establish a policy framework to institutionalize SRSP and ensure that key existing social protection programs are scalable in design.
- Ensure contingent financing for shock response using social protection delivery systems.
- Promote coverage of insurance products, particularly for crops and livestock.

5. Key pathways to decarbonization

KEY MESSAGES

Nepal has among the world's largest hydropower potential that can enable its own decarbonization as well as that of higher-emitting neighbors. Under current plans, installed hydropower capacity will grow fivefold to over 7 GW by 2031, requiring an investment of US$5.5 billion. Electricity exports could earn Nepal the equivalent of 0.4 percent of GDP and 4 percent of projected non-energy exports each year. Together with solar, hydropower offers the potential to further transition the energy system by growing the market for electric mobility and green hydrogen.

The transport sector has been a key driver of economic growth but also of emissions. A more strategic approach to low-carbon trucking and urban transit is required. E-vehicles are starting to appear on Nepal's streets and offer a private investment opportunity if the charging infrastructure, incentives, and policies are aligned.

The combination of rapid urbanization and unsustainable and energy-inefficient construction is leading to higher urban emissions and increased vulnerability to climate shocks. Improved waste collection and disposal—including gas recovery and use—can reduce pollution and emissions; Nepal can also grow more resilient cities by introducing green building codes and urban water and sanitation facilities.

5.1. The energy transition

Over the last decade, Nepal has made great strides in providing improved and additional sustainable energy services to its people. The proportion of Nepal's population with access to electricity has risen from 53 percent in 2010 to 93 percent in 2021.[159] Between 2007 and 2017, Nepal experienced extended power outages that caused up to 14 hours of daily load shedding and cost an estimated 7 percent of GDP annually. Since 2017, Nepal has enjoyed near continuous supply throughout the year.[160] Much of this change can be attributed to private investments in hydropower generation, increasing installed capacity from 644 MW in 2010 to 1,397 MW in 2021. In the same period, the share of private ownership of hydropower plants increased from 26 percent to 58 percent. Power supply also increased due to extension of the countrywide distribution system allowing for the dispatch of this additional power to remote areas of the country. [161]

Nepal's energy transition hinges on further shifting consumption from traditional and fossil fuels to green electricity. In mid-2022, 68 percent of Nepal's primary energy supply comes from traditional fuels such as biomass and waste residues. The country imports liquefied petroleum gas (LPG) for household cooking, gasoline for cars, and coal for industrial uses; fossil fuels account for 28 percent of the energy balance and the second largest share of energy supply.[162] Only about 4 percent of the primary energy supply comes from grid electricity, with 2 percent from off-grid renewables (solar, biogas, mini/micro hydro).[163] In mid-2022, Nepal's peak electricity demand was 1964 MW. Hydro and solar installed capacity were 2080 MW and 55 MW respectively. Nepal imported of 180 MW from India during the dry season and exported 364 MW during the wet season.

[159] MoF, GoN. 2021. *Economic Survey 2020/2021*. Kathmandu: MoF.
[160] Timilsina, G., and J. Steinbuks. 2021. "Economic Costs of Electricity Load Shedding in Nepal." *Renewable and Sustainable Energy Reviews* 146.
[161] NEA Annual Report 2021. https://www.nea.org.np/annual_report.
[162] MoF 2021.
[163] Ibid.

5.1.1. Biomass and fossil fuel use

While Nepal has achieved rapid electrification, most people are still dependent on traditional and fossil fuels such as biomass, LPG, and petrol to meet their everyday needs. Burning firewood has an important environmental health burden. Of over 20 million people in Nepal, 82 percent lack access to clean cooking methods.[164] Improved biomass cookstoves (with better ventilation), biogas solutions, and electric cookstoves are economically viable and will lead to significant health benefits, particularly for women and marginalized groups. However, design issues (clean stoves) and up-front capital costs (biogas) need to be more systematically addressed. Nepal's NDC aims to address this challenge by installing 500,000 improved cookstoves by 2025, en route to achieving the target of 25 percent of households with electric stoves by 2030.

Economically viable applications to support the transition from biomass to electricity and better and more sustainable energy services exist. In economic terms, electric cooking is the most cost-effective method of cooking even without taking social costs into account. When the economic cost of CO_2 emissions is added, the argument for electric cooking is further strengthened and is compounded by averting the many harmful health effects of cooking with firewood or dung. However, uptake of clean cookstoves globally has been linked to the extent women are engaged in the design and marketing of stoves that meet their needs as well as changing social norms.

Industry (brick kilns and cement) is among the largest contributors to CO2 emissions and air pollution in Nepal due to combustion of poor-quality biomass and coal. The NDC highlights the importance of adoption of low-emission technologies by brick kiln and cement industries by 2030. It is vital to cap emissions from industry, either through mandating limits or incentivizing cleaner technologies, including for fuel switching, resource efficiency, and end-of-pipe technologies. Improved technologies such as induced draught zigzag kilns reduce air pollution and carbon emissions by about one-third.[165]

5.1.2. Expanding and safeguarding hydropower resources

Nepal has among the world's largest hydroelectric power resources, with over 42 GW of economically feasible potential.[166] Around 90 percent of Nepal's electricity generation is sourced from hydropower. Nepal's hydropower potential is predominantly run-of-river but numerous storage sites, such as the proposed Dud Koshi hydropower plant, are being studied. While this makes hydropower dispatch from Nepal less flexible, it limits emissions of methane (a potent GHG arising from typical hydropower reservoirs). Hydropower is not free of technical challenges, which include (a) high seasonality of supply with excess generation in the summer season due to monsoon rains and low generation in the winter season, (b) geological uncertainties, (c) high levels of sedimentation due to the underlying geology, and (d) lack of transmission and road infrastructure.

Building resilience of its hydropower sector against climate change impacts will be key for Nepal's energy security and energy future. Hydropower assets face climate risks due to erratic precipitation, glacial melting, and potential increases in the risks of high rates of runoff and erosion, landslides, and GLOFs. Run-of-river plant productivity fluctuates with river runoff volume and resilience is affected by sedimentation caused by natural processes and poor land and forest management as well as extreme weather events. Rising temperatures could result in a shorter dry season, as snow and glacial melt will precede the arrival of the wet season, with positive knock-on effects on the economic viability of hydropower.

[164] World Bank and International Energy Agency. 2015. *Sustainable Energy for All 2015: Progress toward Sustainable Energy*. Washington, D.C.: World Bank.

[165] Nepal, S., P.S. Mahapatra, S. Adhikari, S. Shrestha, P. Sharma, K.L. Shrestha, B.B, Pradhan, S.P. Puppala. 2019. "A Comparative Study of Stack Emissions from Straight-Line and Zigzag Brick Kilns in Nepal." *Atmosphere* 10: 107.

[166] Upadhyay, S. N., and P. Gaudel. 2018. "Water Resources Development in Nepal: Myths and Realities." *Hydro Nepal* 23.

Accelerated glacial and snow melt, combined with greater anticipated precipitation, strengthens the case for further development of hydropower. It also offers opportunities to increase the capacity and efficiency for hydropower generation. Hydropower dams can play a critical role in regulating water flows, providing flood protection, and serving as storage to supply water for agricultural, domestic, and environmental purposes (see Section 4.1). Integrated water resources management, river basin impact assessments, and further studies on the impact of climate change, most notably on the seasonality and variability of rainfall and hydrology as well as on geohazards, are required. Sustainable and optimal development of Nepal's hydropower potential can be based on the findings of these studies. Further, by incorporating climate-smart planning and resilience into existing and future projects, hydropower can generate additional social and economic benefits.[167] For these recommendations to translate into reality, an improved institutional framework is required with clearly defined roles and responsibilities, including for DRM, as well as adequate and consistent compensation for relocated communities.

There is a large shortfall in water storage; funding and investment resources, especially for larger-scale development, are limited. While funding from private and public sources including development assistance can be mobilized, it is important to optimize the benefits of investment and conduct careful planning. Some storage and hydropower facilities with revenue-generating potential are viable business propositions for the private sector. However, the real cost and value of the development must be fully evaluated, including hidden costs of environmental and social impacts and potential for multipurpose and integrated development with varied benefit streams. Policies and regulatory frameworks are needed to facilitate an ecosystem where private finance can be leveraged. Measures can include tax incentive programs, performance-based subsidies or conditional transfers, and dedicated offices for guiding and planning investments.[168] Actively engaging the private sector as a partner in integrated water storage planning is also important.

The role of the private sector in investments in hydropower has steadily grown. The 1992 Electricity Act and the 2001 Hydropower Policy encouraged private construction of hydropower projects as independent power producers (IPPs). As a result, Nepal's people have become shareholders in several hydroelectric projects and half the royalty generated from these projects returns to local levels.[169] The share of private ownership in hydropower is expected to grow (Figure 17).

Financial and climate-related risks to the hydropower sector have the potential to transmit material contingent liabilities to the sovereign, due to NEA's ownership of a significant share of the country's hydropower assets. The challenge is not only to assess average water availability in the future but also how the growing threat of natural hazards may potentially impact hydropower and dams.

A BAU forecast predicts that Nepal's installed hydropower capacity is anticipated to grow from nearly 1.4 GW in 2021 to over 7 GW in 2031, corresponding to an almost fivefold increase. Peak demand is expected to reach about 4.2 GW by 2031. Due to high seasonality in water inflow, there would be an excess of power supply relative to domestic demand produced during the wet season (Figure 17).

The investment need is substantial. The total hydropower generation investment required by NEA and the private sector in line with the BAU scenario is about US$9.1 billion from 2022 through 2040. From 2012 to 2021, the average annual investment (public and private) made in hydropower generation was US$424 million. From 2022 to 2040, the average annual investment of the BAU forecast rises slightly to US$482 million. A careful balance of public and private sector investments—

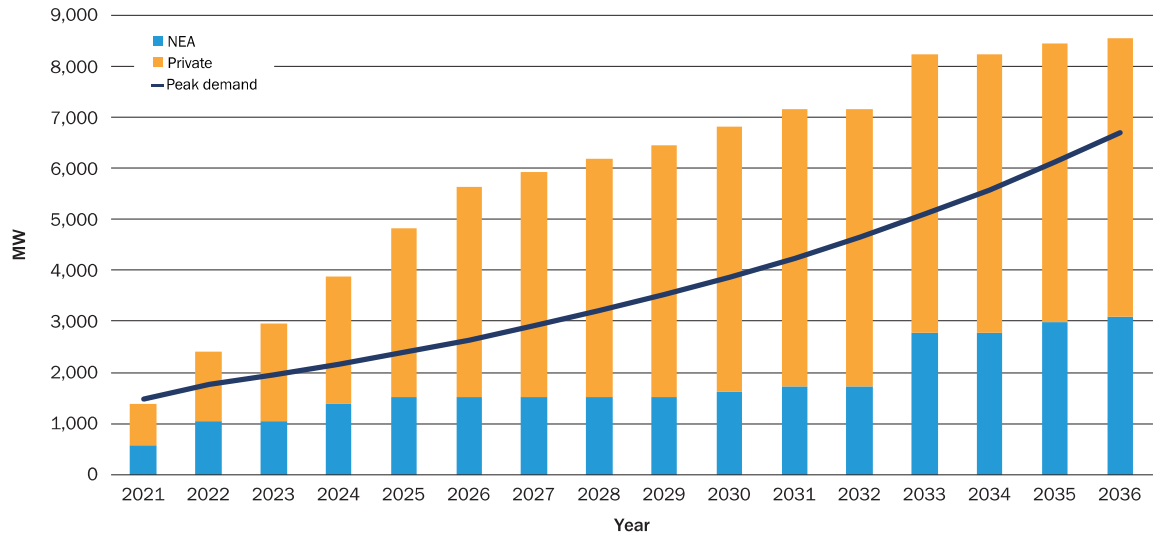
[167] Shrestha, S., A. R. Bajracharya, and M. S. Babel. 2016. "Assessment of Risks due to Climate Change for the Upper Tamakoshi Hydropower Project in Nepal." *Climate Risk Management* 14: 27–41. https://www.sciencedirect.com/science/article/pii/ S2212096316300274.

[168] World Bank. 2022d. *What the Future Has in Store: A New Paradigm for Water Storage.* Decision review version.

[169] Upadhyay and Gaudel 2018.

combined with guarantee and insurance financial products to bring financing costs down—is required to ensure that the power generated from investments retains the affordability that economic assessments predict.

Figure 17: BAU forecast of hydropower (installed capacity in MW) and projected electricity demand



Source: Based on World Bank staff analysis.

Box 1: Hydropower Investment Plan (2022–33)

For this CCDR, an updated hydropower investment plan was prepared for NEA and IPP projects under planning and construction. Only those IPPs for which NEA has signed a power purchase agreement (PPA) have been considered. Dedicated export-oriented hydropower projects (enclave projects) are not part of this investment plan and are treated separately in the macroeconomic analysis. Similarly, transmission and distribution projects are not included in the plan because these investments are implicitly part of the MFMod-CC.

There are projects totaling 2,781 MW under construction by IPPs and 943 MW by NEA. Among the IPPs, projects of about 1,851 MW have not yet closed their financing. Similarly, NEA has not closed financing for planned projects totaling 2,978 MW. Using 2021 constant prices, NEA's investment plan is based on project feasibility assessments while IPP project investment costs are inferred based on guaranteed offtake prices. The derived unit capacity cost is US$1,347 per kilowatt. Actual costs for IPPs are not in the public domain.

The annuitization of costs for projects, planned and under construction, is based on expected completion dates. As it is difficult to disaggregate the completion date of IPP projects, lump-sum annual amounts have been allocated on the assumption that IPP projects under construction would be completed by 2027 and planned projects by 2031. The completion date of planned projects is based on preliminary results of the least-cost generation expansion plan being prepared by NEA. Once results of the least-cost generation expansion plan and transmission and distribution master plan are available, the annual capital investment plan will be revised.

As Nepal expands its hydropower development, affected communities will need to be consulted and livelihood impacts addressed. Safeguards, including resettlement and environmental and social

management action plans, will be required. In addition, benefit-sharing mechanisms, including sharing of royalties, are already specified in the 2019 guidelines.[170]

5.1.3. Solar power

While Nepal is endowed with significant potential, solar power has a negligible share in electricity production. A 2020 assessment estimates that the technically feasible solar photovoltaic (PV) generation potential is 28 GW based on availability of suitable land and solar resources. Considering projects with potential larger than 20 MW, the total solar PV generation potential would be around 18 GW. The potential of rooftop solar PV in 10 municipalities with the highest building footprint is estimated at between 960 MW and 2 GW. The lack of clarity in financing and implementation mechanisms prevents expanded investment in rooftop grid-connected solar.[171]

Progress has been made in some applications, including solar irrigation pumps, PV at public institutions, and solar home systems. Solar energy is complementary to hydropower production since solar radiation peaks in the dry months when hydropower generation is at its lowest. In 2018, MoEWRI approved implementation guidelines for solar projects that allow solar energy producers to evacuate power into the grid. The private sector has installed 40 MW of operational solar assets; more than 1,000 MW of survey licenses have been granted.

A significant barrier to the development of additional solar resources relates to land rights. Lack of clarity on transfer of rights on public, governmental, or forest lands acquired on lease by investors is a barrier. In addition, foreign entities require permission from the government to mortgage land. In addition, most private land is classified as agricultural, and approval processes for land use change are challenging.

5.1.4. Green hydrogen

Green hydrogen presents medium- to long-term opportunities with the possibility of production during off-peak periods. Hydrogen can be processed and stored for later utilization, replacing existing fossil fuel use in transportation, electricity, and domestic sectors. Hydrogen as an energy source, however, is still a new technology, with concerns around economic viability of production and massive investments in pipelines and other infrastructure required for its safe transportation and efficient utilization.[172] While the theoretical prospects seem promising, a practical next step would be to map the value chains arising from green hydrogen production such as electricity to hydrogen and hydrogen to mobility.[173]

A potentially promising avenue is the use of hydrogen to produce ammonia. Ammonia has the potential to become a strategic product for Nepal. It can be a means to store energy, produced during the wet season when surplus electricity is available, to complement or offset purchased electricity in the dry season. Ammonia, as a fertilizer, could displace Nepal's urea imports; its export revenues could bs used to purchase urea and offset national account deficits. Ammonia has several applications, including use in cleaning products, pharmaceutical products, and explosives. NEA is conducting a feasibility study that should provide further details on whether and how ammonia production can be realized.

5.1.5. Shifting consumption to electricity: domestically and in the region

In mid-2022, Nepal found itself in the novel position of anticipating a surplus of green electricity supply in the coming years primarily due to increased privately financed hydropower generation.

[170] Guideline for royalty allocation at the local government level for FY2076/77 published in May 2019 by the National Natural Resources and Fiscal Commission.

[171] Shrestha, J. N., and D. B. Raut. 2020. "Assessment of Urban Rooftop Grid Connected Solar Potential in Nepal." *Journal of the Institute of Engineering* 15 (3): 285–91.

[172] Mali, B., D. Niraula, R. Kafle, and A. Bhusal. 2021. *Green Hydrogen: Production Methodology, Applications and Challenges in Nepal.* Page 68–76.

[173] Zhou, A., W. Zhou, and P. Manandhar. 2020. "A Study on the Prospect of Hydropower to Hydrogen in Nepal." *ADB South Asia Working Paper Series (73).*

Financing of private sector IPPs is secured through PPAs (between the developer and NEA), establishing take-or-pay commitments to purchase an agreed amount of power from the developer, usually on an annual basis. Some of the new supply is being absorbed by demand that would have otherwise been shed and by normal growth in electricity consumption.

There is potential for shifting energy demand from fossil fuels toward more efficient use of electricity. The government has been implementing tax measures and phasing out LPG subsidies to enhance these shifts. NEA has an effective demand-side management program to encourage energy efficiency and shift peak load. A time-of-day tariff has encouraged consumers to change their consumption patterns, resulting in reduction of peak demand and use of efficient lighting and appliances. This has improved the system load factor from 50 percent to 69 percent in 2021.[174]

While NEA seeks solutions for the secure sale of excess power, it has halted the signing of further PPAs to ensure that finances remain sound. A draft Energy Bill, currently under discussion, could allow private actors to move forward even if NEA cannot sign further PPAs, because private actors would have 'open access' to the electricity grid and trading licenses would be granted. Similarly, Nepal will only be able to expand hydropower generation when sufficient guarantees for its offtake can be provided.

Nepal's green electricity can be exported to India and Bangladesh. While seasonal excess power may be traded in India's wholesale market, this may be insufficient to guarantee financial security for the construction of additional power plants that would generate electricity in excess of domestic demand all year round.

Nepal is also using an export-only (or enclave) model for hydropower, whereby Indian promoters are building, operating, and selling the power to a dedicated Indian market. Nepal receives payment in terms of both equity shares and electricity. In mid-2022, the enclave projects included Arun 3, Arun 4, Lower Arun, and Upper Karnali hydropower projects, which jointly represent almost 3,000 MW and are expected to be commissioned between 2024 and 2030. Among other benefits, the projects are expected to provide 20 percent of electricity generated to NEA pro bono, representing an annual value of about US$140 million.

To help green India's and Bangladesh's energy sector, additional hydropower from Nepal could play a consequential role, if dedicated offtake arrangements were in place. The direct potential contribution to India's and Bangladesh's power supply is limited by Nepal's technical potential of about 80 GW, while the economically viable potential is estimated at about 42 GW. As per the Central Electricity Authority of India 'long-term electricity demand' forecast report of 2019, the peak demand in India under the BAU scenario would grow from 202 GW in 2022 to 398 GW in 2037. If the entire technical potential about 80 GW is developed, it would represent only about 20 percent of India's peak demand in 2037.

Hydropower from Nepal, together with regional storage solutions, can also indirectly support the development of intermittent renewables. Solar and wind require some form of ancillary services such as short-term storage to ensure a continuous supply of energy when the variable resource is not available. If hydropower plants in Nepal and Bhutan can hold back flows even for a few hours, this stored energy can provide a backup for solar and wind plants and allow all countries within the BBIN trading block (see Box 2) to increase the share of renewables in their generation mix. Access to 1 MW of hydro capacity could support an increase of between 2 and 6 MW in India's installed solar

[174] NEA 2021, NEA: A Year in Review Fiscal Year 2020/21 alias NEA Annual Report 2021.

capacity.[175] This can only be realized if appropriate regional financing models can be devised to secure financing for hydropower in Nepal. As power markets become more sophisticated, spot markets can be added to contractual agreements, and additional services such as frequency control and stabilization can be accommodated which are mutually beneficial to all parties involved. Power storage facilities should also be investigated to provide flexibility and reliability. Power is normally stored as a spinning reserve, through pumped water storage and, more recently, in large-scale batteries. Given that varied cost and availability of these solutions, regional interconnection and trade could allow for the optimal mix of storage facilities.

Box 2: The potential of regional power trade

The four countries that form a regional electricity trade nexus in South Asia are Bangladesh, Bhutan, Nepal, and India (BBIN). Nepal is expected to develop about 6.8 GW of hydropower generation capacity by 2030, while the country's average peak demand is estimated at 3.7 GW in 2030. Bhutan is also working toward exploiting its large hydropower resources, mostly for regional trade. Bangladesh, one of the fastest growing economies, aims to add more than 4 GW of renewable capacity by 2030. Its electricity mix is currently dominated by high-cost thermal generation (93 percent of energy mix out of which 52 percent is gas based), which hampers the country's ability to provide a predictable power price, address energy security, and meet its climate targets. India is moving toward a market-based model to support electricity trading and increase the share of renewable resources in the country's energy mix with a significant target of 500 GW of renewables by 2030. The four governments have been working on a framework of engagement for cross-border electricity trading since 2014.

Increasing power trade in the BBIN region makes sense in both economic and environmental terms. Asynchronies of demand and supply among the countries offer significant potential benefits from trade to all parties. The primarily fossil fuel-based systems of India and Bangladesh can use hydropower from Nepal and Bhutan to meet seasonal summer peaks while the latter can benefit from imports to firm up supply during the dry winter months when the output of hydroelectric generating stations is low. India and Bhutan have had an agreement for many years under which India imports approximately 1,400 MW of electricity annually, which reduces the need to use costly fossil fuel-based energy to meet demand. In turn, this has allowed Bhutan to develop its hydropower resources at a scale that would not be justified by domestic demand alone. Nepal and India have recently signed a memorandum of understanding which provides a similar framework for cooperation in cross-border electricity trade. Projected net electricity trade flows over the next decade are expected to generate significant annual economic benefits.

While cross-border exchanges have steadily increased over the past 10 years, interconnections and transmission lines between Nepal, India, and Bangladesh need to be expanded to unlock the potential for regional electricity trade. With adequate transmission interconnections, policy harmonization, and investment, Nepal can support neighboring countries in decarbonizing their electricity mix and earn substantial revenues in the process. Given large financing requirements, the private sector has a critical role to play. Policy makers need to frame regulations and procedures to enable opening markets for further private sector participation.

Existing regional institutions such as South Asian Association for Regional Cooperation (SAARC) and South Asia Subregional Economic Cooperation (SASEC) play an important role in facilitating regional electricity trade by offering a common platform to understand mutually beneficial policies.

The private sector has a critical role to play in enabling a sustainable regional electricity exchange development. Collaboration between private sector players in Nepal, India, and Bangladesh can realize a regional trading model in electricity while policy makers can facilitate it by framing regulations and procedures to open the market for further private sector investment. More efficient,

[175] Chattopadhyay, D., P. Chitkara, I.D. Curiel, and G. Draugelis. 2020. "Cross-Border Interconnectors in South Asia: Market-Oriented Dispatch and Planning." *IEEE Access* 8.

reliable power can therefore be ensured as well as protection of communities affected by resettlement programs.

Recommendations for the energy transition

- Increase green energy demand by (a) adopting policies and measures to support the shift of energy demand from traditional/fossil fuels to electricity; (b) substituting demand from traditional uses and traditional fuels to electricity (e-cooking); and (c) transitioning to cleaner vehicles, including e-vehicles.
- Make legal and institutional changes, including (a) enhancing electricity supply based on firm cost principles basis an agreed least-cost expansion plan focused on generation; administrative and regulatory frameworks are needed to advance license issuance, trading regulations, conduct of business rules, and contractual arrangements, among others, and (b) adopting basic principles of international legal best practice of managing electricity trade such as open grid access, competitive power trade rules; and cost- and quality-based generation licensing system.
- Advance regional power trade by working with SAARC and SASEC to (a) elaborate on a framework to provide the stable environment that energy investments need, jointly with BBIN should develop a regional understanding focused on jointly growing a green energy transition, and (b) establish procedures, guidelines, and timelines for the approval process. This will require a market monitoring and regulatory mechanism to oversee, report, and regulate domestic and international trade.
- Grow the market for solar, biogas, and green hydrogen by:
  - Developing a solar roadmap that optimizes the complementarity of domestic solar and hydropower development. The roadmap should explore adoption of legislation/rules that allow for feed-in of roof-top solar into the electricity grid; designation of suitable areas of land (including public land) for solar development; and assess the potential of hydro-solar hybrid projects;
  - Developing a hydrogen roadmap, using a holistic approach to process efficiencies, product substitutions, electrification, and finally hydrogen solutions; and
  - Conducting a feasibility assessment for an ammonia production plant, to prepare a pilot project.

5.2. The transport transition

Transport is a driver of growth for urban development. Economic growth, social transformation, and rapid urbanization have dramatically increased vehicle ownership and usage, with an annual growth rate of about 13 percent for passenger transport vehicles from 1996 to 2005 and 9 percent for freight transport vehicles for the same period.[176] This not only affects traffic congestion but also contributes to emissions, noise pollution, and traffic accidents.

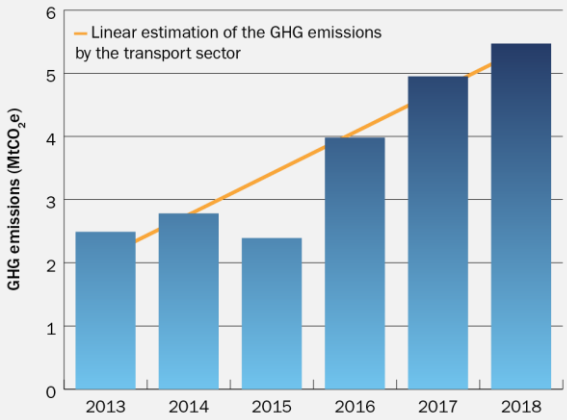
The transport sector is a source of rapid increase in GHG emissions and air pollution. Nepal's transport GHG emission growth is among the highest in the world, more than doubling over the five-year period from 2013 to 2018 (**Error! Reference source not found.**). The primary sources of e missions are heavy vehicles (trucks and buses), followed by personal vehicles. While two-wheelers

[176] GoN 2021a.

constitute approximately 79 percent of the total vehicle fleet, they only contribute 7 percent to the overall GHG emissions from the sector.[177]

Strategic urban planning, including advancement of greener urban transport, is urgently needed in urban areas. In key cities, shifting to sustainable multimodal public transport, including nonmotorized transport, requires coordinated efforts between the public and private sectors as well as between the federal and local government levels. A comprehensive approach that combines measures to reduce energy consumption using nonmotorized and shared modes, promotes a technological transition to cleaner vehicles, and reduces inefficiencies in trucking is required. The most critical priority would be to provide high-quality public transport and give precedence to public transport and safe walking and cycling in the design of roads.

Figure 19: GHG emissions in the transport sector in Nepal



Source: World Resources Institute, Climate Analysis Indicators Tool (WRI CAIT 4.0, 2017).

The development of e-mobility is an important avenue to explore. Nepal's new NDC set a target of 25 percent private passenger vehicle sales (including two-wheelers) and 20 percent four-wheeler public passenger vehicle sales by 2025. Electric vehicles can play a major role in the medium to long term in an enabling environment which includes policies that support charging infrastructure and systems, vehicle standards, and appropriate financing systems. Two- and three-wheelers (which make up 80 percent of vehicle traffic and where cost parity with internal combustion engines has been reached) should be the initial focus for electrification, followed by urban buses. In the trucking sector, the focus should be on supporting the evolution of a modern, bankable industry that can absorb new clean technology as it becomes financially feasible. Digital solutions that optimize use of trucks and reduce empty miles (for example, ride-sharing platforms) can play a role in this process.

[177] Ibid.

Recommendations to decarbonize the transport sector

- Decarbonize logistics and encourage the use of more carbon-efficient modes such as public transport and facilitate the modernization of the trucking fleet both along trade highway corridors and in major economic centers such as Kathmandu.
- Decarbonize passenger transport principally in major urban areas by (a) encouraging the use of sustainable multimodal public transport, including nonmotorized transport, with the Kathmandu Valley as a priority, (b) implementing more efficient land use regulations alongside transport planning; and (c) using travel demand management to appropriately price the negative externalities of vehicle use and nudge travel toward more sustainable alternatives.
- Facilitate adoption of innovative technologies by supporting the transition toward zero-emission vehicles/e-vehicles by (a) adopting an ecosystem-based policy package that covers the entire value chain from producers to end users and (b) providing effective incentives to support an electric vehicle market for both private users and public operators, including charging infrastructure, more affordable financing for users, and greater support for businesses along the electric vehicle value chain.
- Promote innovative business/financing models (for instance, battery as a service).

5.3. The urban transition

Nepal is the fastest urbanizing country in South Asia, with growth rates up to 5 percent per year. The rapid growth combined with inadequate urban management and financing has led to decreased livability. Nepalese cities are increasingly challenged with provision of satisfactory services to the expanding population and are becoming more congested and polluted. Nepal's NDC prioritizes low-carbon and resilient urban development, and the introduction of federalism combined with Nepal's relatively early stage of urbanization represents a unique opportunity for reaping the benefits of GRID.

Nepal's urban areas and cities can support its climate transition with innovation, job creation, and improved and more inclusive service delivery. The NDC includes specific actions to move Nepal toward greener, more efficient, and resilient cities. The country should facilitate integrated institutional architecture for urban development at the national, provincial, and local levels in the context of the transition from a unitary to federal government structure. Nepal also needs to address gaps in the investment framework for urban municipalities, including targeting of priority infrastructure investment requirements in strategic urban clusters. Finally, the government should support the emerging urban system by focusing on secondary cities as well as the Kathmandu Valley.

5.3.1. Municipal solid waste

Municipal solid waste in Nepal imposes significant environmental, health, and climate costs, undermining key sectors such as tourism. It is estimated that less than half of all waste generated in urban areas is collected.[178] Unmanaged solid waste causes pollution of soil and water, clogs drainage infrastructure and rivers, generates about 5 percent of Nepal's total GHG emissions, and releases toxic pollutants. Improvement of SWM to reduce emissions and negative health impacts is a priority in Nepal's NDC.

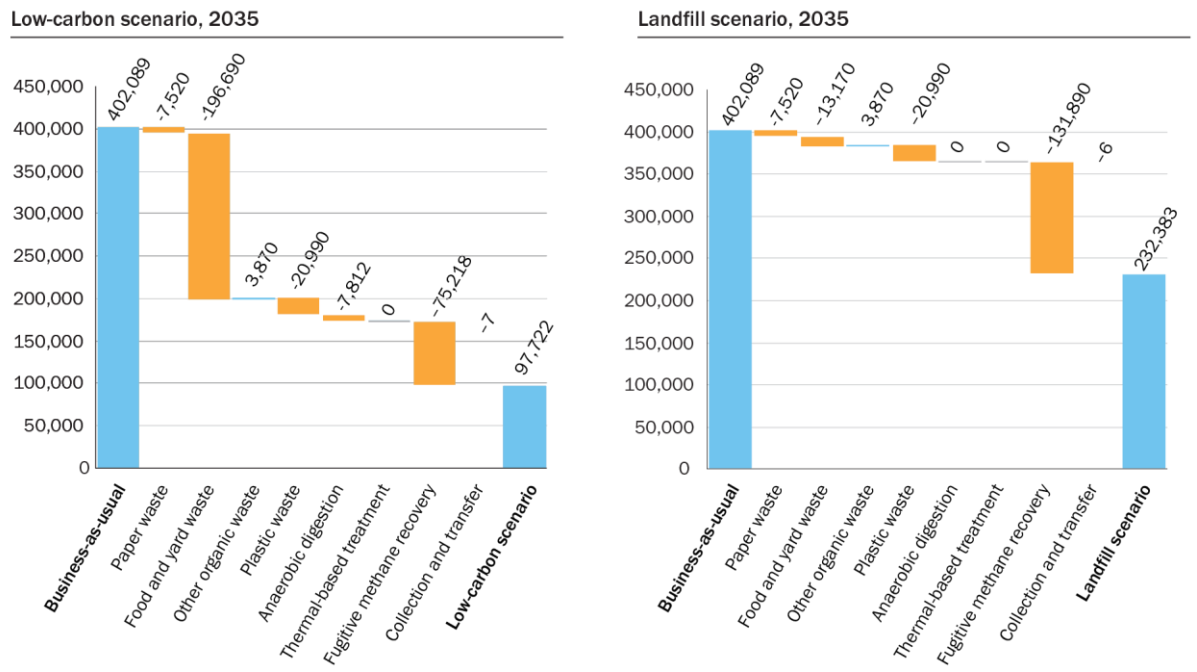
SWM is directly linked to growing urbanization, development, and climate change. As the urban population grows, the quantity of solid waste has increased across Nepal's cities that are responsible for waste collection, treatment, and disposal. For example, data show that 74 percent of municipal

[178] World Bank. 2020b. *Strategic Assessment of Solid Waste Management Services and Systems in Nepal.* Policy Advisory Note.

waste in the Kathmandu Valley is dumped, and 3 percent is burned, contributing to air pollution with negative impacts on human capital.[179] The Kathmandu Valley generated an average of 1,262 tons per day of municipal solid waste in 2021, more than 25 percent of the total municipal solid waste in Nepal. Pokhara Metropolitan City generates an average of 183 tons per day.[180] Growing population, urbanization, and per capita waste generation are estimated to result in the increase of municipal solid waste production in the Kathmandu Valley by 68 percent by 2041.[181]

By deploying disposal improvements and following a "landfill scenario", Nepal can reduce solid waste emissions by almost 50 percent compared with a BAU scenario.[182] As is evident from data from Kathmandu,[183] the current uncontrolled disposal practices result in major atmospheric emissions as well as emissions from waste collection and transportation vehicles. In an analysis conducted for this CCDR, a "low-carbon scenario" based on full-fledged modernization of the sector leads to about 75 percent GHG reductions, mainly from better management of biodegradable waste, reduced landfilling, and improved methane capture (Figure 20).

Figure 18: Contribution of respective actions to emission reduction in 2035 compared to the BAU scenario (tCO_2eq per year) in the Kathmandu Valley



Source: World Bank staff analysis, based on World Bank. 2022. Catalyzing Sustainable and Inclusive Urban Development in Kathmandu Valley: SWM Diagnostic and Policy Implications in KTMV. Washington, D.C.: World Bank; USAID. 2019. Greenhouse Gas Emissions Factsheet: Nepal. https://www.climatelinks.org/resources/greenhouse-gas-emissions-factsheet-nepal; GoN. 2021a.

The main drivers of emission reduction are improvement of biodegradable waste, source segregation, and smaller/better-managed landfills with methane recovery. Nepal's long-term SWM strategy along with revised targets and implementation will be primarily guided by the new SWM national policy which

[179] World Bank. Forthcoming. *Catalyzing Sustainable and Inclusive Urban Development in Kathmandu Valley: SWM Diagnostic and Policy Implications in KTMV.* World Bank (to be published in September 2022). The open burning figure is from Das, B., P. V. Bhave, A. Sapkota, and R. M. Byanju. 2018. "Estimating Emissions from Open Burning of Municipal Solid Waste in Municipalities of Nepal." *Waste management* 79: 481–490. Das et al. 2018.
[180] World Bank 2020b.
[181] World Bank, forthcoming.
[182] The model was applied for Kathmandu and Pokhara, respectively. These cities are the largest in Nepal and are thus representative.
[183] The biodegradable fraction was identified as the main cause for methane emissions as well as the largest fraction of the municipal waste stream, reaching 65 percent in residential waste, the major component of municipal solid waste of Kathmandu Metropolitan City. ADB. 2013. *Solid Waste Management in Nepal: Current Status and Policy Recommendations.* Mandaluyong City: Asian Development Bank; CPC/KMC (City Planning Commission/Katmandu Metropolitan City). 2020. *Baseline Study of Solid Waste Management in Kathmandu Metropolitan City.* CPC/KMC. August 2020.

was approved by Cabinet in April 2022.[184] The policy will be followed by adoption of a new SWM act and associated regulations to incorporate the roles of three tiers of governments, introduction of climate-smart solutions such as source segregation, enhanced collection coverage and rate, transformation of dumpsites into advanced landfills, and improved waste reduction through diversion of materials from landfills. A positive side effect of SWM reforms will be the creation of better and additional jobs in the sector. In the Kathmandu Valley alone, it is estimated that about 20,000 people are informally engaged in waste collection, indicating the huge potential in this area.

5.3.2. Buildings

The combination of rapid urbanization and unsustainable and energy-inefficient construction contributes to Nepal's climate vulnerability and GHG emissions. The government has identified the construction and building sector as a priority for future climate action. Nepal's second NDC has set low-carbon and climate-resilient urban settlement adoption targets. The 2017 National Urban Development Strategy estimated an acute need for upgrading the housing stock, lending urgency to a shift to more resilient and green housing and construction.

Federalization has created additional municipalities and provinces that have further increased the need for a green building policy and legal framework; there is an ample opportunity to ensure compliance through both fiscal incentives (taxes) and consistent monitoring. Substantial investments are allocated for the construction of public buildings to provincial and local governments. The anticipated large-scale construction could help contribute to the government's GHG emission target through greener construction that has a smaller environmental footprint in terms of carbon, water, natural resources, sustainable materials, and energy use.

The government has promoted green buildings and energy-efficient solutions through the 2012 National Urban Policy and 2017 Urban Development Strategy and is working on the preparation of green building guidelines and building codes. With rapid urbanization and associated construction of buildings, the design and implementation of a green building code and adoption and application of green building certifications (for example, for government and selected private buildings such as hotels) could help reduce emissions associated with construction, create green jobs, and support a climate transition for the construction sector. Likewise, NCCP (2019) and NAPA (2010) prioritize settlement as a key sector to enhance climate resilience and reduce the carbon footprint with green technologies and standards developed for infrastructure and buildings to integrate energy efficiency in construction practices. Mainstreaming green development in the urban sector, particularly in construction, a major contributor of emissions, and urban planning, is critical to help Nepal achieve the NDC's 2045 targets.

Only a few private sector companies explore affordable and resilient housing solutions. Private sector engagement is essential to accelerate the uptake of green solutions. This has relevance for the tourism sector, as policies could be set for the hospitality sector to adopt green building certifications as part of their green tourism efforts. To further expand the market, banks will need to provide financing, given the higher up-front cost.

Following the 2015 earthquakes, the government updated the National Building Code 105 (NBC105) on seismic resilience. The updated NBC105, endorsed in 2020, aims to prevent significant structural damage to new buildings during moderate intensity seismic events and complete collapse during high-intensity seismic events. The NBC105 governs seismic design of all types of buildings. The implementation of the updated code, however, is limited to government buildings designed and

[184] Reforms on SWM including the SWM policy and subsequently the SWM Act are supported under the World Bank GRID Development Policy Credit approved by the World Bank Board of Directors in July 2022. https://www.worldbank.org/en/news/press-release/2022/07/13/world-bank-approves-100-million-to-support-key-reforms-for-nepal-s-green-resilient-and-inclusive-development

constructed by and under direct supervision of the Department of Urban Development and Building Construction. The department is currently developing design manuals, guidelines, and handbooks and is planning to roll out training programs to enforce updated building codes at municipal levels. Going forward, designing, and implementation of a green building code will be a key element of making urbanization more climate resilient and green.

5.3.3. Urban water supply and sanitation services

Provision of climate-resilient safe WSS services to meet the rapidly increasing urban demand is proving to be challenge for Nepal. Ineffective functionality of the existing urban WSS infrastructure system severely impacts economic productivity of the cities. The lack of safe drinking water and basic sanitation is known to undermine efforts to combat poverty and disease, and the evidence in Nepal supports the finding. Currently, only 25 percent of piped water supply schemes function in Nepal and 32 percent do not have year-round supply.[185] Increasing urbanization and climate change-induced extreme water variations are likely to exacerbate pressures on the urban WSS infrastructure. This problem is severe for all cities in Nepal, including Kathmandu (see Section 4.1.1). Although secondary towns fare better in terms of drinking water consumption and supply hours per capita, their coverage rates are lower. Water supply efficiency is very low with average nonrevenue water for the 26 cities assessed at about 40 percent, leading to significant waste of valuable water and energy resources.[186] In addition, improvements in drinking water and sanitation services will remain incomplete and ineffective in improving health outcomes if proper fecal sludge and wastewater management is not implemented.[187] Enacting the WSS Act is a key step toward essential sector reforms to improve WSS service delivery.

Recommendations for the urban transition

- Formulate a national integrated SWM program based on the new SWM policy and upcoming SWM Act.
- Accelerate regulatory reform to develop and strengthen SWM standards and guidelines.
- Strengthen SWM institutions at the federal, provincial, and municipal levels and improve incentives and systems.
- Establish a sustainable public financing mechanism for SWM and leverage the private sector to create economic opportunities from using waste as a resource in the circular economy, identifying value chains from plastic alternatives and waste streams.
- Build on existing SWM systems based on informal workers, to regularize livelihoods and strengthen the private sector model.
- Strengthen regulatory arrangements and formalize partnerships with the private sector in SWM.
- Introduce and implement a green building code at all levels of government, explore partnerships with certification agencies for new buildings and for retrofit of existing buildings, and promote the application of new technologies for resilient housing solutions.
- Address the infrastructure gap and increase investments in climate-resilient urban water and sanitation facilities, to ensure safe and reliable water and sanitation services.

[185] GoN. 2014. *Nationwide Coverage and Functionality Status of Water Supply and Sanitation in Nepal.* National Management Information Project. https://dwssm.gov.np/wp-content/uploads/2019/05/Report-2014.pdf.
[186] GoN. 2016. *Water Service Providers: Capacity Assessment and Benchmarking 2014–15*. Kathmandu, Nepal: Ministry of Water Supply and Sanitation, Sector Efficiency Improvement Unit.
[187] Joseph and Shrestha 2021.

6. How to finance a resilient, green Nepal

KEY MESSAGES

Financing requirements for Nepal's climate objectives are substantial but not well-defined. The government estimates financing needs through 2050 of nearly US$50 billion for its NAP, nearly US$200 billion for its LTS, and US$36 billion for its NDC until 2030. These initial assessments vastly exceed the country's implementation capacity, the financial sector's capability, and available international development and climate finance, even under optimistic scenarios.

The country's planned investments in large-scale hydroelectric generation plants are estimated to require US$6.4 billion in financing through 2033, including both public and private investments. Nepal will have to balance its hydropower aspirations with other urgent investment needs to adapt to climate change, including the hardening of built infrastructure, irrigation expansion, and the provision of public services to respond to the challenges of a warming climate.

In the current business environment, private investment flows are unlikely to materialize without significant improvements to the regulatory framework. Limited domestic public funds should be used strategically. There are opportunities to mobilize concessional finance for adaptation and mitigation priorities, but these efforts will need to be supplemented with credit guarantees, vendor financing, guarantee funds, warehouse receipts, and private equity capital.

The government should prioritize improving the business environment to encourage private investment in climate solutions. Promising opportunities include tapping into carbon finance, assimilating climate-related risks into financial markets, and leveraging fiscal instruments for green development.

Development finance can help. Development partners are on board with Nepal's GRID approach and the government should build on the momentum and support among the international community.

6.1. Estimated investment needs and current finance flows

Financing requirements for Nepal's stated climate objectives are substantial. The government estimates that Nepal will require US$47.4 billion (133 percent of FY21 GDP) for adaptation and US$196.1 billion (552 percent of FY21 GDP) for mitigation over 2021–50.[188] However, the government lacks a defined strategy and capacity to scale up climate finance. Direct government investment in climate change is low and climate change priorities and strategies have not been mainstreamed into government planning and budgeting processes. Furthermore, given the current fiscal situation, there are important legal and practical barriers to attracting FDI and mobilizing the private sector.

Currently, funding for climate comes from the government and international development agencies, with a small contribution from private finance. Sources include the following:

- **Government funding through budgetary allocations:** The national climate budget has increased over the years from US$3.75 billion in 2017/18 to US$4.66 billion in 2021/22.[189] This amount includes both federal-level and provincial- and local-level initiatives as per Nepal's federalist structure, where more than 25 percent of government spending is executed at the provincial and local levels.

[188] A large portion of Nepal's commitments are contingent upon receiving financing from international sources.

[189] MoFE, GoN. Forthcoming. *Nepal's Climate Finance Strategic Roadmap 2022–2032*. This figure does not quite represent the large unknown funds that come to Nepal through philanthropic organizations including the private sector.

- **International climate finance funds and multilateral agency funding.** Nepal accesses funds through the international climate finance windows which are part of the United Nations Framework Convention on Climate Change. The country has received about US$300 million from international climate funds since 2010. In the latest data available, between 2013 and 2017, donors committed US$640 million for adaptation-related activities and US$563 million for mitigation.[190]

- **Multilateral development banks.** Nepal received approximately US$2.59 billion of climate financing from multilateral development banks between 2015 and 2020, with US$1.2 billion coming in 2020.[191]

- **Private financing.** Most domestic banks provide local currency debt to hydropower projects, but their ability to lend extensively is constrained as their deposit base is mostly short term. Annual investment by private IPPs in hydropower generation from 2017 to 2021 was approximately US$400 million.[192]

The government's call for concessional climate finance is justified and efforts to mobilize and provide such finance should be strongly supported. However, anticipated grant and concessional lending flows will likely continue to be insufficient to address the country's ambition unless realism and contingency are incorporated into planning. The country's priority is to invest in adaptation and resilience; therefore, the government should focus its financing efforts here, with a secondary focus on mitigation investments that deliver air pollution co-benefits.

6.2. Assessing the impacts of hydropower financing and investment needs

The expansion of hydropower generation capacity through 2033 is projected to boost growth and investment while incurring a relatively modest additional public debt (Table 2). The new investment required for this expansion is estimated at US$6.4 billion from 2022 to 2033 (an annual average investment of US$ 535 million). As a result, annual GDP is projected to expand by 0.47 percent by 2033, relative to the baseline projection (see Table 2). The composition of GDP is also projected to shift, pivoting slightly away from the services sector (shrinking from 64 percent to 61.3 percent of GDP) while the industrial sector expands (from 14.7 percent to 17.5 percent of GDP) by 2033.

Export earnings are projected to improve slightly with the new electricity export stream, rising 0.5 percentage points of GDP per year by 2030 relative to the baseline projection. The current account balance would improve as well, as by 2033, net exports are expected to remain 0.1 percentage points of GDP higher than in the baseline projection.

The fiscal impact of the investments is projected to be moderately low. Public debt would rise only 2 percentage points of GDP higher than in the baseline projection by 2033, of which 1.6 percentage points of GDP would come from external borrowing.

The modeling does not capture the important contribution that fulfillment of domestic electricity demand will have on domestic production. In the absence of load-shedding, households and businesses will experience productivity and competition gains. Unreliable access to power is consistently identified by firms as the greatest obstacle to their operations. Investment associated with the development of new hydropower plants, transmission lines, and distribution networks has

[190] Rai, S., R. P. Chhetri, and B. Dhital. 2020. *Climate Adaptation Finance Study Report: Nepal.* http://prc.org.np/assets/uploads/resource/2f8dd25ed34ed7e9d415cb4adeab47b1.pdf.
[191] MDB Joint Reports on Multilateral Development Banks' Climate Finance, 2015–2020.
[192] MoEWI estimate.

the potential to boost economic growth during the construction phase, improve economywide productivity through the continuous availability of electricity, and generate new fiscal revenues.[193] Implementing this hydropower investment plan would remove one of the principal constraints to economic growth in Nepal and unleash higher private sector productivity and growth.

Table 2: Macroeconomic impact of the hydropower investment plan through 2033

	Baseline				Hydropower investment (to 2033) *Deviation from baseline (percent or percentage points*)*			
	2020	2025	2030	2033	2020	2025	2030	2033
Average growth (%)								
Real GDP	4.20	6.30	5.60	4.70	0.00	0.36	0.47	0.47
Real GDP per capita	2.70	4.50	4.50	4.00	0.00	0.36	0.47	0.47
Per Capita Income and Consumption (constant 2020 US$)								
Real GDP Per Capita	1,113	1,388	1,729	1,955	0.00	0.36	0.47	0.47
Real Household Consumption Per Capita	948	1,115	1,435	1,654	0.00	-0.79	-0.88	-0.13
Shares in GDP (% of GDP)								
Private Consumption	80.70	76.10	78.60	80.10	0.00	-0.87	-1.06	-0.48
Government Consumption	8.40	11.30	11.50	11.60	0.00	-0.01	-0.02	-0.04
Private Investment	26.00	29.10	30.40	30.80	0.00	0.55	0.28	-0.14
Government Investment	8.80	9.10	9.30	9.50	0.00	0.07	0.28	0.41
Net Exports	-32.50	-37.10	-38.50	-39.60	0.00	0.17	0.38	0.10
Sectoral shares in GDP (% of GDP)								
Agriculture	30.60	26.30	22.90	21.30	0.00	-0.05	-0.05	-0.05
Industry	15.50	15.10	14.90	14.70	0.00	2.42	2.64	2.79
Services	54.00	58.60	62.20	64.00	0.00	-2.38	-2.59	-2.74
External balance (% of GDP)								
Exports, Goods and Services	6.80	6.20	5.30	4.80	0.00	0.35	0.55	0.24
Imports, Goods and Services	34.10	42.20	38.50	36.90	0.00	-0.11	-0.05	0.15
Current Account Balance	-0.90	-6.30	-6.20	-5.40	0.00	0.08	0.34	0.18
Fiscal Aggregates (% of GDP)								
Fiscal revenue (incld. Grants)	22.20	25.80	25.40	25.30	0.00	0.26	0.37	0.46
Fiscal expenditure (incld. Transfers to SNGs)	27.60	31.90	31.30	31.20	0.00	0.06	0.35	0.59
- o/w Interest payments	0.70	0.90	0.80	0.70	0.00	0.00	0.00	0.01
Budget deficit	-5.40	-6.10	-5.90	-5.80	0.00	0.17	-0.02	-0.14
Public debt	36.90	45.40	39.20	38.40	0.00	-0.41	0.70	2.07
- o/w External Public Debt	21.10	22.10	17.40	16.30	0.00	-0.07	0.79	1.61
Emissions								
Emissions (Mtons CO_2)	0.10	0.10	0.10	0.10	0.00	0.05	0.06	0.05
Emissions per unit of output (tons CO_2)	0.00	0.00	0.00	0.00	0.00	-0.32	-0.41	-0.41
Impact (% of GDP)								
Total*					0.00	0.36	0.47	0.47
Memorandum items								
Population (Millions)	30.0	32.7	34.4	35.0				

Source: World Bank projections based on the MFMod-CC model.
*Note: * Deviations from baseline are expressed as percent of baseline level for real GDP per capita, emissions, and carbon price. For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.*

[193] Cosic, Dahal, and Kitzmuller 2017.

6.3. Fiscal reforms and creating a more attractive environment for private investment

In the current business environment, private investment (domestic and external) flows are unlikely to reach the magnitudes that the government aims to mobilize. The government can initiate fiscal reforms that make climate-smart investments more attractive. This includes more effective targeting of subsidies for LPG and fertilizers and proper pricing policies for SOEs, especially public utilities. In addition, the removal of barriers to private investment would attract investment flows.

6.3.1. Fiscal incentives and public sector reforms

There is a limited opportunity for levying carbon taxes on the transport and brick production industries. Given Nepal's energy and emission mix, negligible fiscal revenues will be generated by carbon taxes. Nepal's NDC targets 90 percent of newly registered vehicles being electric vehicles by 2030. In the FY22 budget, the government reduced custom duties on electric vehicles from 80 percent to 10–40 percent, depending on the vehicle type and electric motor capacity. The relative price of electricity and fossil fuels is a critical lever for ensuring the transition takes place; a carbon tax could play a supporting role. Brick production is a major contributor of GHGs; a carbon tax would catalyze the uptake of emission reduction technologies. If carbon taxes are pursued, revenues should be set aside to compensate vulnerable households and communities for any higher costs they might face.

In contrast to many other countries, petroleum products are not subsidized and are subject to value-added tax as well as excise and customs duties in Nepal.[194] Since 2014, the National Oil Corporation has determined retail petroleum product prices, using an automated pricing mechanism that links retail to international benchmark prices without adding a subsidy. Retail prices for petroleum products reflect customs duties at a rate of NPR 2.3 per liter (US$ 0.02)[195] and the standard 13 percent value added tax rate. Petroleum products are also subject to specific excise taxes; key taxes include an NPR 10 per liter (US$ 0,08) infrastructure tax, an NPR 0.5 per liter (less than US$ 0.01) pollution tax, and an NPR 3–5 per liter (US$ 0.02-0.05) road maintenance tax. Nepal also maintains a price stabilization fund, financed through a small per-unit fee on petroleum products, to help insulate consumers from price volatility. The National Oil Corporation collects most petroleum tax on the government's behalf, remitting it to the revenue administration. Fiscal proceeds from taxing petroleum products are substantial; during FY19, the corporation transferred NPR 63.85 billion in taxes to the government, about 1.8 percent of GDP and 7.4 percent of total tax revenue.[196] All considered, wholesale fuel prices account for less than half of total retail prices for all petroleum products apart from LPG.

While the government aimed to increase agricultural production through a fertilizer subsidy program (FSP), in the last decade, the sector has not seen notable productivity growth and remains vulnerable to climate change. A large share of the agricultural budget is dedicated to the FSP. In FY2020/21, the Ministry of Agriculture and Livestock Development's budget was US$356 million, 2.8 percent of the national budget. The budget allocated to the FSP was US$95 million or about 27 percent of the ministry's budget. While the FSP budget has tripled since its inception in 2008 and became one of the most significant spending items in the sector, its effectiveness is in question. Crop productivity has only increased marginally in the last 10 years.[197] FSP primarily benefits larger farmers and, while the program has increased supply, many farmers cannot buy enough fertilizer. The program is poorly coordinated with agricultural research and extension, and it supplies mostly urea

[194] Adapted from "Chapter 4: Environmental Fiscal Policy: Air Pollution, Energy, and Climate Change" of World Bank 2021.
[195] All conversions in this paragraph are based on the exchange rate of US$1 = NPR 127.5.
[196] IMF. 2020 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for Nepal. Technical report. Washington, D.C.: International Monetary Fund; Prasain, K. 2020. "Government balks at deregulating the money-making petroleum sector." Kathmandu Post, January 12.
[197] Karkee, M. Forthcoming. "Assessment of Fertilizer Subsidy Programme in Nepal." Unpublished Working paper.

fertilizer and encourages unbalanced use of fertilizer, decreasing its effectiveness and leading to increased GHG emissions and other environmental impacts.

6.3.2. FDI framework, business environment, and climate finance

To strengthen the framework for private sector climate engagement, Nepal should appreciably improve its business environment, notably to encourage long-term financing. Poor infrastructure, governance challenges, and regulatory constraints have hampered private investment. Complex and often redundant regulatory compliance requirements, weak institutional capacity, lack of information transparency, and poor coordination among regulatory bodies make government-to-business service delivery difficult. Overall FDI inflows into Nepal are negligible and are concentrated in a few sectors from a small number of source countries. Approvals on FDI in Nepal are governed by the Foreign Investment and Technology Transfer Act (FITTA). There are provisions for some sectors to undergo a simpler process of approval, termed the automatic approval route. The act also has a negative list, which sets out industries where foreign investment is restricted. Several entry barriers exist for FDI including sector caps and restrictions on non-equity modes of investment. Offshore funds and onshore vehicles with foreign shareholders are both considered foreign investors and require FDI approval for every new investment in a Nepalese company.

Key changes to the FDI framework are required. The government should ensure effective implementation of the recent reduction in the minimum FDI threshold designed to attract more financing for small businesses. In addition, it should encourage fast-track approval through the automatic route for as many sectors as possible. According to FITTA, only Nepalese entities that have foreign equity stake can borrow from foreign lenders. This effectively excludes Nepalese companies with 100 percent local shareholding from accessing foreign loans. Removing the requirement and reforming FITTA will help Nepalese companies access the required foreign capital. Reduction in the negative list for FDI investments and streamlining the creation and enforcement of security interests for foreign lenders would help attract more capital.

Undertake broad-based reforms for capital markets. There is a need to deepen capital markets especially corporate bonds. Diversification of the investor base should include, for example, insurance and pension funds on a larger scale. Introduction of risk management products for investors, which can protect against adverse movements in interest and exchange rates, would also help.

Further encourage equity-based growth financing. Improvement in the existing regulatory framework will help attract larger private equity or venture capital funds. Regulators have formulated the Specialized Investment Fund rules to encourage fund-based investments. However, additional changes are required, for instance, provisions for venture capital funds which may be the preferred vehicle for impact funds.

Nepal's financial system is dominated by banks and many SMEs cite access to finance as a major constraint. Commercial banks actively advance short-term loans, but long-term financing is constrained. Banks face asset-liability mismatches while lending to long-term projects and there is excessive dependence on immovable collateral for loans, which businesses find difficult to provide. As discussed in Chapter 2, the lack of a green taxonomy and lack of a viable green project pipeline are also key limitations. Nepal's capital markets are at a nascent stage with limited products and investors. As described earlier, understanding about impact of climate risks on the financial sector needs to be boosted. Disclosure and monitoring frameworks are also underdeveloped. Insurance penetration in Nepal is very limited—less than 1 percent. While some preliminary models exist for earthquake catastrophe risk modeling, such models are not yet in place for flood risks.

Regulators have begun to lay the foundation for green finance. Nepal Rastra Bank recently amended the unified directives requiring banks and financial institutions (BFIs) to report on the climate exposures of borrowers. In recognition of the growing importance of the climate agenda to financial markets, the 2022–26 Financial Sector Development Strategy has a specific focus on the medium-term reform agenda to achieve this goal. Similarly, in the securities and insurance markets, regulators are putting in place climate risk guidelines with reporting and disclosure requirements. In 2021, the government approved a DRF strategy and, in early 2022, an associated Implementation Plan for Market-based Financial Instruments initiative designed to crowd in private finance to address disaster and climate events. The steps being undertaken are encouraging; however, there is a need to accelerate this momentum. Capacity-building measures are required within supervisory authorities and financial institutions to better assess climate risks, both physical and transition. If the domestic insurance industry can incorporate risk-based pricing for premiums, then re-insurance terms from international markets will also improve. Once the models are in place to quantify physical risks, they can be introduced into climate models to potentially estimate transition risks as well.

Against the backdrop of limited financing availability, policy should aim to improve overall business climate, develop capital markets, and use limited funds judiciously to balance adaptation and mitigation priorities. For example, vendor financing instituted by the Alternative Energy Promotion Council was used effectively by farmers in the Terai region for solar pumps in irrigation projects. This CCDR has outlined priority areas for investment across mitigation and adaptation objectives such as water storage for irrigation and urban water supply, resilient road transport, and CSA. To further enhance access to finance for farmers, it is critical to provide incentives to financial and insurance institutions to increase lending and development of innovative risk management products, including Weather Index-based insurance and lending mechanisms such as matching grants, guarantee funds, warehouse receipt, leasing, value chain finance, and capital and equity finance. Another area that shows promise is tourism. Introduction of green building certifications and eco-tourism labels would help attract a different set of responsible tourists. The industry also has strong potential to adopt sustainable practices such as mandatory waste recycling, off-grid solar panels for electricity in remote locations, and links to sustainable agriculture value chains. Nepal has a good track record in community forest services and these feedback loops can be better leveraged to encourage more environmental-friendly tourism in protected forests and conservation areas.

There are opportunities to attract greater private investment in adaptation and resilience. There has been recent success in attracting private finance by de-risking through blended finance and credit guarantees. The government should continue to use these and other tools such as vendor financing, guarantee funds, warehouse receipts, and private equity capital. Currently, blended finance is used mostly in large hydro investments in Nepal (for example, the Upper Trishuli 1 Project). Other solutions merit a closer look. Green bonds are also being explored by some local commercial banks, and MOF could help set the stage for private issuances by releasing a local currency sovereign green bond, proceeds from which can be used for resilience goals. Private equity and venture capital funds are also well placed to invest in these activities, especially in CSA. Funding available for adaptation from climate funds is more limited than that for mitigation projects and, therefore, can be used to support small-scale water storage interventions such as water harvesting, small irrigation, micro dams, and landscape-related investments.[198] The government also needs to better assess the challenges that consumers and businesses face in making adaptation investments, for example, lack of information, credit constraints, and subsidies, to design a targeted response. Further, the introduction of a climate risk assessment into the financial system and economy could compel financial markets to factor climate risks into the prices of their products, which would facilitate adaption responses. Finally, an area that could be explored is recognizing the benefit of averted future loss due to climate adaptation

[198] CFU database, 2022, Climate Funds Update (accessed March 10, 2022), https://climatefundsupdate.org/data-dashboard.

investment. The government could facilitate investments by providing robust data and analytics to inform climate resilience mainstreaming through climate screening and risk assessment.

Mitigation investments should be evaluated using the lens of attractive propositions for the private sector in the market. The Alternative Energy Promotion Council had established a Central Renewable Energy Fund to de-risk renewable energy investments and attract private sector by using instruments such as partial credit guarantees and soft loans. There is a potential to scale up green loans and green guarantees in Nepal if BFIs adopt the International Capital Market Association's Green Loan Principles. Commercial banks such as NMB Bank have already initiated this by financing projects in sectors such as solar, biogas, clean cook stoves, and improved water mills. They also have customized green liability products such as green fixed deposits. Green lending by banks and even microfinance enterprises can be potentially invested in other sectors such as electric mobility, municipal solid waste, and green buildings.

Development finance can catalyze adaptation and mitigation investments. Development partners in Nepal are on board with the GRID approach and have identified more than US$7 billion from current portfolios and pipelines over the next three to five years in support of this agenda. The GRID Strategic Action Plan currently under development will help prioritize, convene, and coordinate investment and policy action on climate resilience and low-carbon pathways. The quality of investment and implementation progress will also be important. While trying to expand and leverage private finance, it should build on the momentum and support among the international community for its GRID approach.

The use of compliance and voluntary carbon markets could provide access to new sources of financing for climate-related projects in Nepal through the sale of emission reduction credits. At COP26, Parties agreed on the modalities, procedures, and guidelines for the implementation of carbon markets under Article 6 of the Paris Agreement. Article 6 markets are a form of international 'compliance' markets, that is, governed by international climate treaties and authorized by governments. This agreement is a major milestone, creating a path for international carbon market mechanisms to contribute to meeting NDC goals and support scaling up of climate ambition through voluntary cooperation. In this context, the World Bank has supported activities in the country to enable clean energy access while generating emission reduction credits to be used as a source of income to improve a project's financial viability.

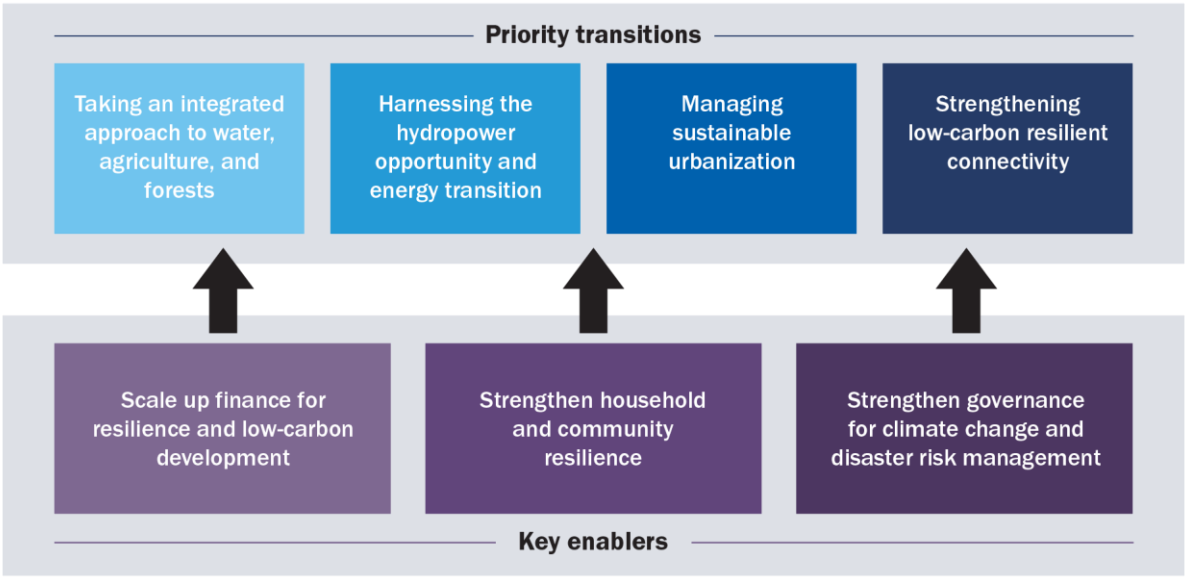
Recommendations for financing a green, resilient Nepal

- Prioritize efficiency of public expenditure to maximize climate and development benefits.
- Formulate and implement an integrated national roadmap for private sector green finance. Ongoing improvements in the regulatory framework with green finance need to be combined with capacity building for both regulators and market operators. Overall private sector business environment especially for FDI needs to be strengthened to encourage long-term financing.
- Develop a clear and concise taxonomy to enable BFIs to identify and enhance green assets in their lending portfolios.
- Introduce climate risk assessment into the financial system and the economy as a whole. Build climate risk assessment capacity within supervisory authorities and financial institutions and consider developing supervisory guidance and technical guidelines to help financial institutions assess, manage, and monitor climate and environmental financial risks.
- Introduce risk-based models and pricing to scale up the insurance sector for resilience and climate mitigation.
- Facilitate the provision of political risk guarantees for green FDI.
- Scale up blended finance through improved engagement with various sources such as development finance institutions and philanthropic/impact investors to de-risk green investments.
- Strengthen institutional capacity for participating in carbon markets, including scaling up carbon credit usage and deepening capital markets, building on Nepal's experience from the new Emissions Reduction Program under the Forest Carbon Partnership Facility.
- Mandate greater disclosure and accountability, for example, through the Securities Board of Nepal improving market transparency by mandating environmental, social, and governance-related disclosures.

7. From analysis to action

The previous chapters have provided in-depth sectoral analyses and recommendations for building a green, resilient, and inclusive Nepal. Considering the country's limited resources and capacity, this chapter prioritizes and places the recommendations in a coherent framework for action over the next five years.[199] This framework is based on four priority transitions that emerged from the analyses of the previous chapters (Figure 19): (a) an integrated approach to water, agriculture, and forests; (b) harnessing of Nepal's hydropower opportunity and energy transition; (c) sustainable urbanization; and (d) low-carbon resilient connectivity. To support these transitions, Nepal needs to prioritize three key enablers: scaled-up finance for resilience and low-carbon development; strengthened household and community resilience; and improved governance for climate change and DRM.

Figure 19: Priority action framework for a climate-adaptive development pathway



Source: World Bank.

To move from analysis to action, this CCDR identifies the following seven 'policy packages'—one for each priority transition and each key enabler. These policy packages entail recommended policy changes (marked with a '' symbol) and investments (marked with a '' symbol) that will aid Nepal in making and enabling the transitions that are aligned with the Nepal's climate commitments. If these policy packages are implemented, they can help Nepal meet the adaptation and resilience priorities identified in its NDC and NAP as well as its GHG emissions reduction targets. Each policy package presents a brief set of actions, rated by impact and feasibility. It also presents key considerations, including challenges, synergies, trade-offs, and co-benefits associated with the recommended action.[200] Table 3 present the prioritization criteria applied. As part of the prioritization, 'low' impact and 'low' feasibility actions have been excluded.

The design of the seven policy packages has carefully considered alignment with the government's development and climate priorities. In addition to discussions with relevant government agencies as well as the private sector and development partner stakeholders on their respective priorities, the actions contained in the packages have been specifically assessed for their alignment with the 15th

[199] Many of the policy areas identified in the framework will need to be differentiated at design and implementation to be responsive to the considerable spatial heterogeneity in natural endowment, exposure to different types of climate risks, and implication for welfare and resilience. This has been beyond the scope of this report due to data and space limitations and remains on the agenda for future analytical work.

[200] Further analysis of financial trade-offs and prioritization based on the cost-effectiveness of interventions has been hampered by the lack of data and detailed costing of the priority actions and financing needs identified by the government.

Periodic Plan (2019/20–2023/24), 2019 NCCP, NDC, and NAP. The assessment found that 27 out of 32 actions (84 percent) are strongly aligned with and are thus directly linked and contribute to an objective in at least one of the four government plans, with 21 (66 percent) being strongly aligned with two or more plans; others are moderately or partially aligned.

Table 3: Prioritization criteria

Feasibility	Impact	
	High Immediate impact and enables other development objectives	**Medium** Impacts that are realized over several decades
High Corresponds to administrative and financing capacity	Actions that cannot be postponed and will produce a high and immediate impact (quick wins)	Actions that may need long-term planning and mobilization of political capital and financing
Medium Substantial additional financing or capacity required	Actions that require time to conceive and implement but may deliver high impact	Actions that require time to conceive and implement with uncertain impacts

Nepal CCDR policy packages

Type	Action	Impact/ feasibility	Challenges/synergies/trade-offs/co-benefits
Policy Package 1: Taking an integrated approach to water, agriculture, and forests			
	Adjust and repurpose agriculture public expenditures, including fertilizer and seed subsidy programs, to support inclusive climate-smart sector development and leverage private sector participation in input supply, food processing, and exports.	Impact: High Feasibility: High	Co-benefits: Augmented local capacities for improved expenditure tracking and implementation
	Invest in integrated community-based local development programs for natural resource and watershed management (water, agriculture, forest, and energy) and climate risk reduction to secure sustainable, resilient, and inclusive livelihoods.	Impact: High Feasibility: Medium	Challenges: High need for coordination; low capacity Synergies: Builds local capacity for economic development and service provision
	Develop the legal and institutional basis for integrated water resource management by (a) enacting the Water Act and follow-on regulations and procedures drafted by MoEWRI and (b) establishing basin-level offices and ensuring their autonomy as regulators with authority to formulate and enforce river basin plans and approve water-related investments. The reform should also ensure representation of relevant sectors, provincial, and local governments in the commission.	Impact: High Feasibility: Medium	Synergies: Improved resource allocation toward food, water, and energy security
	Prioritize CSA support for agricultural growth by establishing an adequate financing and coordination framework to increase subnational and private sector investments (in production, processing, and services). Income generation in climate-resilient rain fed and irrigated crop, horticulture, and livestock systems requires improving access to inputs and services, strengthening the links between research and development and the private sector (for example, seed cooperatives, soil monitoring, and local innovations along value chains), incentivizing pluralistic advisory services (including digital services), and improving access to markets by building links between producer groups and markets.	Impact: High Feasibility: Medium	Co-benefits: Improved human development outcomes and jobs; contribution to the resilience of livelihoods and food security

Type	Action	Impact/ feasibility	Challenges/synergies/trade-offs/co-benefits
	Expand year-round irrigation and domestic water supply through (a) investments in sustainable water infrastructure (such as multipurpose storage, ponds, lift, and groundwater schemes) and (b) integrated watershed/landscapes management for soil conservation and augmented water quantity/quality downstream (such as spring rehabilitation, land use zoning, vegetation/forest restoration for slope stabilization, yield optimization, horizontal drainage, and river management).	Impact: High Feasibility: Medium	Challenges: High need for coordination; low capacity Synergies: Builds local capacity for economic development and service provision
Policy Package 2: Harnessing the hydropower opportunity and energy transition			
	Adopt policies and measures to support the shift of energy demand from traditional/fossil fuels to electricity, while rendering demand more energy efficient: (a) substitution of demand from traditional uses and traditional fuels to electricity (e-cooking); (b) transition to cleaner vehicles, including e-vehicles; (c) distribution network investments; and (d) development of a solar and hydrogen roadmap.	Impact: High Feasibility: Medium	Challenges: Policies and measures are partially already under way but need to be rendered more effective and cross-checked against best practices elsewhere
	Further develop hydropower in Nepal and Bhutan as the backbone of Bangladesh-Bhutan-India-Nepal trade. To move forward, this requires (a) further elaboration of a trade framework to provide for the stable environment that energy investments need and (b) furthering of jointly developed regional cooperation agreements focused on enabling joint green growth to provide market stability and credible offtake agreements.	Impact: High Feasibility: Medium	Challenges: Depends on finding viable offtake arrangements to ensure the bankability of future hydropower, which will require regional offtake from India and/or Bangladesh
	Improve the domestic electricity market to ensure that the development of green, bankable, least-cost generation is developed. This requires (a) an agreed least-cost expansion plan; (b) cost- and quality-based, rationalized award of generation license issuance; (c) a fair platform for electricity trade within Nepal; and (d) adoption of best practices such as open grid access.	Impact: High Feasibility: Medium	Challenges: The steps required to bring about this change are known but a champion within the government must drive the agenda forward
Policy Package 3: Managing sustainable urbanization			
	Formulate a national integrated SWM program and accelerate regulatory reform to develop and strengthen standards and guidelines.	Impact: High Feasibility: Medium	Synergies: With the recent Cabinet adoption of the SWM policy and the upcoming completion of the new SWM Act, the regulatory framework for the delivery of an SWM program is in place Challenges: Given the social and environmental challenges associated with SWM, implementation will be complex
	Introduce a green building code and explore partnerships with certification agencies for possible retrofitting of buildings including hotels as well application of new technologies for resilient housing solutions	Impact: High Feasibility: Medium	Challenges: Pushing a new building code through the review and approval process will take time, and the implementation of the Act will not be simple, given experience of existing building codes Synergies: A green building code will create importance synergies with the construction sector, and will generate new jobs; it will contribute to a greener urbanization in Nepal

Type	Action	Impact/ feasibility	Challenges/synergies/trade-offs/co-benefits
	Address the infrastructure gap and increase investments in climate-resilient urban water and sanitation facilities, to ensure safe and reliable water and sanitation services.	Impact: High Feasibility: Medium	Challenges: In the current macro environment, additional investments in infrastructure that are more cost intensive may not be immediately viable Synergies: Advancing climate resilient infrastructure will reduce the costs of climate hazards on the economy, and will create positive synergy for more inclusive urbanization
	Establish a sustainable financing mechanism for SWM and leverage the private sector.	Impact: Medium Feasibility: Medium	Synergies: With reforms in the intergovernmental fiscal framework and revisions to the public-private partnership framework, opportunities for capital investments in SWM can be enabled Trade-offs: In the current macro environment, the immediate adoption of a new financing mechanism for SWM is unlikely
	Regularize livelihoods and strengthen the private sector model based on the existing system of informal SWM workers.	Impact: Medium Feasibility: Medium	Challenges: This action will require political will and acceptance of slightly increased costs in the short term, given the introduction of fixed salaries and safety protocols
Policy Package 4: Strengthening low-carbon resilient connectivity			
	(a) Develop a network-level risk-based planning approach to identify the most critical transport assets of the SRN; (b) implement new cost-efficient and nature-based engineering measures; (c) adopt a climate-smart asset management approach to road maintenance; and (d) protect identified assets through relevant DRF strategies.	Impact: High Feasibility: Medium-High	Challenges: Requires decisive engagement from the government, including leadership from MOF to implement the DRM Financing Strategy in the transport sector Co-benefits: Offers economic growth opportunities, improved access to key services, jobs, health, and welfare
	Invest in resilience measures for key transit corridors and critical SRN road links like the North-South and East-West Highways and explore opportunities for leveraging the private sector for maintenance.	Impact: High Feasibility: Medium	Challenges: A large maintenance funding gap needs to be addressed; this could be done through private financing, tolling, or new vehicle/fuel taxes; a viability analysis to attract private investors would be required
	Encourage and enable provincial and local governments to invest in resilience measures for key rural roads.	Impact: High Feasibility: Medium	Challenges: Low capacity
	Decarbonize passenger transport principally in major urban areas by: (a) encouraging the use of sustainable multimodal public transport, including nonmotorized transport, with the Kathmandu Valley as a priority; and (b) implementing more efficient land use regulations alongside transport planning, using travel demand management to appropriately price the negative externalities of vehicle use and nudge travel towards more sustainable alternatives.	Impact: High Feasibility: Medium	Challenges: Requires regulatory reforms, stronger coordination between municipal level and central government level stakeholders and a major shift in urban planning practices and the prioritization of road space use Co-benefits: Reduction of GHG emissions and air-pollution, with positive health impacts
	Develop a network-level risk-based planning approach at the provincial and local levels to identify the most important transport assets of the local roads network; institutionalize joint implementation mechanisms and collaboration for critical road links.	Impact: Medium-High Feasibility: Medium	Challenges: Low capacity of provincial/local governments; requires collaboration between the different levels of government Synergies: Strengthens institutions in the context of federalism, builds redundancy, and ensures year-round connectivity, with jobs and economic benefits
Policy Package 5: Scale up finance for resilience and low-carbon development			
	Formulate and implement an integrated national roadmap for private sector green finance. Ongoing improvements in the regulatory framework with green finance need to be combined with capacity building for both regulators and market operators. Overall private sector business environment especially for FDI needs to be strengthened to encourage long-term financing.	Impact: High Feasibility: Medium	Challenges: Will require substantial capacity building across stakeholders

Type	Action	Impact/ feasibility	Challenges/synergies/trade-offs/co-benefits
	Introduce climate risk assessment into the financial system and the economy as a whole. Build capacity within supervisory authorities and financial institutions to better assess climate risks, both physical and transition risks. Encourage domestic insurance industry to move toward incorporating risk-based pricing for premiums.	Impact: High Feasibility: Medium	Challenges: Will require substantial capacity building, the introduction of risk pricing models, and enforcement of disclosure guidelines Synergies: More transparency and disclosures will enable better pricing of lending instruments; pricing of insurance and re-insurance premia will improve and widen coverage
	Scale up carbon credit usage and deepen capital markets, building on Nepal's experience from the new Emissions Reduction Program under the Forest Carbon Partnership Facility.	Impact: Medium Feasibility: Medium	Challenges: Requires substantial changes in regulations and market dynamics Synergies: Can help finance activities in forestry, efficient cookstoves, cross-border trade, and so on and serve as an important financing resource; undertaking capital market reforms will help businesses tap local funding and use domestic saving more productively
Policy Package 6: Strengthen household and community resilience			
	Develop policy guidelines for climate-smart education to increase resilience and enhance mitigation potential through green/environmental-friendly and sustainable designs.	Impact: High Feasibility: High	Synergies: Efforts are under way to support the revision of school construction guidelines to be supported under the new School Education Sector Program
	Establish a mechanism for locally led climate action through devolved climate finance and participatory planning with a focus on strengthening resilience of individuals, localities, and areas through small infrastructure development and livelihoods support, especially in the most vulnerable areas.	Impact: High Feasibility: Medium-High	Synergies: Consistent with principles of devolution under the federalism system, support for locally led climate action would enhance subnational adaptation capacity, integration, and resilience, allowing for sustainable solutions, customized to area needs
	Investigate the push and pull factors for internal migration and implications for sectoral policies around urbanization, balanced spatial development, and household food security.	Impact: High Feasibility: Medium	Challenges: Requires an integrated cross-sectoral approach
	Enhance financing to cover climate-related health risks. The government could allocate a proportion of national health funding earmarked for health-related adaptation and mitigation policies, pool health funds to cover climate-related health risks, and ensure strategic purchasing includes climate considerations.	Impact: High Feasibility: Medium	Challenges: Requires clear budgetary allocations and capacity for adoption of new funding mechanisms, alongside health financing knowledge and skills to support this Co-benefits: Should result in improved resource allocation toward anticipated burden of disease changes and incorporating climate into risk pooling mechanisms should reduce risks of vulnerable groups being left behind and avoid consequent health inequities
	Strengthen health information and surveillance systems. Ensure climate-related risks are integrated into developing platforms for disease monitoring and ensuring these are multisectoral in nature; strengthen health integration in current EWSs and response mechanisms (specifically flood EWS and support nationwide rollout of extreme temperature EWS currently in nascent stage); establish a national risk register for climate-related health risks with seasonal climate outlooks to inform health sector programming; introduce a systematic approach to monitoring of climate and health vulnerabilities; and fill climate and health research gaps with a focus on informing policy, for example, climate impacts on air pollution and mental health.	Impact: High Feasibility: Medium	Challenges: Would require effective multisectoral coordination by the MoHP with other DRM sectors such as Department of Hydrology and Meteorology (DHM) and NDRRMA Synergies: Should lead to a better understanding of risks, helping to prevent and mitigate the morbidities and mortalities associated with climate-related hazards and disasters

Type	Action	Impact/ feasibility	Challenges/synergies/trade-offs/co-benefits
	Improve overall health service delivery. The government could assess the climate-readiness of current health infrastructure and plan for future investments to climate-proof infrastructure and technologies; engage communities and strengthen primary health care including through behavior change interventions to establish a climate-informed health system at a subnational level, especially in remote communities; enhance contingency planning for deployment and response for acute climate shocks at all administrative levels; and conduct health technology assessments targeted at understanding health sector carbon footprints and benefits of adaptation measures in the health sector.	Impact: High Feasibility: Medium	Challenges: Would require resources, capacity including allocation at all levels of government, and coordination between stakeholders Co-benefits: Should result in climate-resilient health infrastructure and health care system, leading to promotion of healthier and lower-carbon behaviors that create a virtuous cycle of reduced demand on the health system and the environment
	Institutionalize SRSP and expand social protection programs' coverage by (a) establishing a policy framework for SRSP; (b) operationalizing the Social Security Allowance for the economically poor and scaling up the Prime Minister's Employment Program; (c) establishing an integrated social registry as a key element of strengthening the social protection delivery system; and (d) expanding coverage of microinsurance for crop and livestock insurance.	Impact: High Feasibility: Medium	Challenges: Requires high-level political commitment, continued investment, and effective interministerial and intergovernmental coordination
	Develop pathways to mainstream climate education and green skills into education and training programs.	Impact: High Feasibility: Medium	Challenges: Some efforts are under way but require a systems approach and leadership of concerned stakeholders, including relevant line ministries, education institutions, and employers
	Strengthen the government's ability to conduct environmental and social impact assessments and gender equality and social inclusion plans to ensure policies and programs are inclusive and do not undermine resilience of vulnerable and marginalized groups.	Impact: Medium Feasibility: Medium	Challenges: Requires resources and high-level commitment to bring in qualified and experienced analysts along with cross-sectoral oversight and monitoring at senior levels
Policy Package 7: Strengthen governance for climate change and DRM			
	Federalize climate and DRM governance by strengthening existing climate change and DRM-related legal and administrative/procedural provisions for effective coordination, planning, and implementation across all levels of government and key stakeholders.	Impact: High Feasibility: Medium	Challenges: Requires strong will of the Office of the Prime Minister and Council of Ministers (OPMCM) and key agencies at the federal, provincial, and local levels
	Scale up the technical, analytical, and implementation capacities at all levels of government through a National Capacity Development Program on Climate Change and DRM and the provision of adequate human resources for climate and disaster-resilient planning and implementation.	Impact: High Feasibility: Medium	Challenges: Capacity constraints, especially in subnational governments

Annex 1: Macroeconomic forecasts under climate scenarios

	Baseline				RCP 2.6				RCP 4.5				RCP 8.5			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
					Deviation from baseline (percent)*				Deviation from baseline (percent)*				Deviation from baseline (percent)*			
Average Growth (%)																
Real GDP	4.20	5.90	4.80	3.90	0.00	-1.65	-2.63	-3.33	0.00	-1.87	-3.24	-4.46	0.00	-2.36	-4.55	-6.92
Real GDP per capita	2.80	4.50	4.40	3.80	0.00	-1.65	-2.63	-3.33	0.00	-1.87	-3.24	-4.46	0.00	-2.36	-4.55	-6.92
Per Capita Income and Consumption (Constant 2020 USD)*																
Real GDP Per Capita	1113	1729	2656	3841	0.00	-1.65	-2.63	-3.33	0.00	-1.87	-3.24	-4.46	0.00	-2.36	-4.55	-6.92
Real Household Consumption Per Capita	948	1435	2322	3441	0.00	-1.77	-2.75	-3.43	0.00	-2.01	-3.38	-4.59	0.00	-2.54	-4.75	-7.11
Shares in GDP (% of GDP)																
Private Consumption	80.70	78.60	82.80	84.80	0.00	-0.10	-0.10	-0.10	0.00	-0.11	-0.12	-0.12	0.00	-0.14	-0.17	-0.17
Government Consumption	8.40	11.50	11.80	11.70	0.00	0.01	0.02	0.04	0.00	0.01	0.03	0.05	0.00	0.02	0.05	0.08
Private Investment	26.00	30.40	31.40	31.50	0.00	-0.05	-0.04	-0.03	0.00	-0.05	-0.05	-0.05	0.00	-0.07	-0.08	-0.09
Government Investment	8.80	9.30	9.60	9.60	0.00	0.01	0.02	0.03	0.00	0.01	0.02	0.04	0.00	0.01	0.03	0.06
Net Exports	-32.50	-38.50	-41.10	-41.40	0.00	0.61	1.03	1.31	0.00	0.69	1.27	1.75	0.00	0.88	1.78	2.71
Sectoral shares in GDP (% of GDP)																
Agriculture	30.60	22.90	18.00	14.80	0.00	0.21	0.26	0.26	0.00	0.24	0.32	0.36	0.00	0.30	0.45	0.57
Industry	15.50	14.90	14.40	14.20	0.00	0.01	0.02	0.01	0.00	0.01	0.02	0.02	0.00	0.02	0.03	0.03
Services	54.00	62.20	67.60	71.00	0.00	-0.22	-0.27	-0.28	0.00	-0.25	-0.34	-0.38	0.00	-0.32	-0.48	-0.60
External balance (% of GDP)																
Exports, Goods and Services	6.80	5.30	3.80	3.00	0.00	0.08	0.09	0.09	0.00	0.09	0.11	0.13	0.00	0.12	0.16	0.20
Imports, Goods and Services	34.10	38.50	35.90	37.00	0.00	-0.21	-0.29	-0.38	0.00	-0.24	-0.36	-0.52	0.00	-0.31	-0.52	-0.83
Current Account Balance	-0.90	-6.20	-6.60	-8.90	0.00	0.17	0.26	0.36	0.00	0.19	0.32	0.47	0.00	0.23	0.44	0.72
External balance (% of GDP)																
Exports, Goods and Services	6.80	5.30	3.80	3.00	0.00	0.08	0.09	0.09	0.00	0.09	0.11	0.13	0.00	0.12	0.16	0.20
Imports, Goods and Services	34.10	38.50	35.90	37.00	0.00	-0.21	-0.29	-0.38	0.00	-0.24	-0.36	-0.52	0.00	-0.31	-0.52	-0.83
Current Account Balance	-0.90	-6.20	-6.60	-8.90	0.00	0.17	0.26	0.36	0.00	0.19	0.32	0.47	0.00	0.23	0.44	0.72
Fiscal Aggregates (% of GDP)																
Fiscal revenue	22.20	25.40	25.40	25.90	0.00	-0.06	-0.08	-0.10	0.00	-0.07	-0.10	-0.14	0.00	-0.09	-0.14	-0.22
Fiscal expenditure	25.00	28.50	28.20	28.20	0.00	-0.03	-0.03	-0.03	0.00	-0.03	-0.03	-0.04	0.00	-0.04	-0.05	-0.07
- o/w Interest payments	0.70	0.80	0.70	0.60	0.00	0.01	0.01	0.01	0.00	0.01	0.02	0.02	0.00	0.01	0.02	0.03
Budget deficit	-2.8	-3.1	-2.8	-2.3	0	-0.03	-0.05	-0.07	0	-0.04	-0.06	-0.09	0.00	-5.00	-9.00	-1.50
Public debt	36.9	39.2	35.4	31.7	0	0.02	0.31	0.56	0	0.01	0.35	0.69	0.00	1.00	4.30	9.70
- o/w External Public Debt	21.1	17.4	13.9	11.8	0	-0.01	0.1	0.19	0	-0.02	0.11	0.24	0.00	-0.03	0.14	0.34
Emissions																
Emissions (Mtons C02)	0.1	0.1	0.1	0.1	0	-0.72	-1.55	-2.24	0	-0.82	-1.88	-2.94	0	-1.04	-2.6	-4.47
Emissions per unit of ouput (tons C02)	0.00	0.00	0.00	0.00	0	0.94	1.1	1.12	0	1.07	1.4	1.59	0.0	1.36	2.05	2.64
Damages (% of GDP)																
Total*					0	-1.65	-2.63	-3.33	0	-1.87	-3.24	-4.46	0	-2.36	-4.55	-6.92
-o/w Agriculture					-0.01	-0.68	-0.81	-0.8	-0.01	-0.72	-1.02	-1.22	-0.01	-0.83	-1.51	-2.24
-o/w Heat					0	-0.03	-0.17	-0.34	0	-0.16	-0.4	-0.66	0	-0.48	-0.95	-1.43
-o/w Flooding					0	-0.95	-1.7	-2.25	0	-1	-1.89	-2.66	0	-1.07	-2.21	-3.45
Memorandum items																
Population (Millions)	30	34.4	36	36.4												

*Notes: * = Deviations from baseline are expressed as percent of baseline level for Real GDP Per Capita, Emissions, and Carbon Price. For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario. Damages are not additive.*

Source: World Bank projections using the MFMod-CC model

Annex 2: Kathmandu Declaration on Nepal's Green, Resilient, and Inclusive Development

Government of Nepal and International Development Partners

Kathmandu Declaration on Nepal's Green, Resilient and Inclusive Development

The Government of Nepal, having recognized the triple threats of COVID-19, climate change and rising inequality, and in the spirit of mutual collaboration to achieve the Sustainable Development Goals, today calls on all stakeholders including its international Development Partners to support the joint development and delivery of Nepal's Green Resilient and Inclusive Development Strategic Action Plan (GRID-SAP).

The GRID-SAP is expected to be based on our joint determination that Nepal's recovery from COVID-19 cannot be at the cost of long- term increases in climate vulnerability, emissions, or unsustainable development of Nepal's natural and human capital.

The Government of Nepal recognizes that a durable recovery from the pandemic requires mobilization of investment to protect lives and secure jobs and livelihoods, while building resilience, strengthening inclusion, enhancing sustainability, and promoting efficiency of resource use. In response, Nepal's Development Partners have already committed $3.2 billion in resources and intend to continue to commit further resources in support of Nepal's GRID ambitions; several International Development Partners have already identified up to $4.2 billion in potential future support.

Based on these shared interests the Government of Nepal, International Development Partners, and other international organizations present today hereby decide to develop and implement the GRID-SAP, working within their areas of expertise and building on Nepal's 15th Development Plan and Nationally Determined Contribution, and inviting cooperation with new partners, to address the following areas:

1. Natural capital for growth, climate benefits, decent job creation, and food and water security, particularly involving agriculture, sustainable forest management, biodiversity, resilient ecosystems, eco-tourism, irrigation, and land and water resources management,
2. Green and low-carbon disaster resilient infrastructure such as renewable energy, transport, and urban development, complemented with nature-based solutions and environmental governance, that create quality jobs and protect health and people,
3. Increasing resilience to future pandemic, climate and earthquake risks, by strengthening key systems including disaster risk management, health, shock-responsive social protection, sustainable land management, and skills and education for the green transition, and
4. Ensuring that the recovery does not leave anyone behind. A more inclusive economy reduces disparities in opportunities and outcomes and helps excluded groups--such as the poor, women, youth, informal workers, and least accessible communities due to geographical location--realize a fair share of development benefits.

To support the implementation of the GRID-SAP, Nepal's Development Partners also intend to help Nepal apply the next generation of low-carbon and climate resilient technologies and relevant digital services.

In addition, the Government of Nepal and Development Partners intend to work together to mobilize the private sector to support Nepal's GRID ambitions, centered on green investment and support for

small and medium enterprises and businesses in areas with potential for jobs and growth such as finance, tourism, renewable energy, waste management, forestry, and agriculture.

Furthermore, in the development of the GRID-SAP the Government of Nepal and International Development Partners have jointly committed to continue our collaboration. The needs and views of local and provincial governments are well represented, and capacity is strengthened for decentralized implementation.

Signed by:
For the Government of Nepal
Janardan Sharma, Minister of Finance, Nepal

Annex 3: Climate change and DRM-related policies, plans, and regulations

Policies, plans, and regulations	Summary
Constitution of Nepal 2015	Article 30: Right to the clean environment (Fundamental Right) 1. Every citizen shall have the right to live in a clean and healthy environment 2. The victim shall have the right to obtain compensation, in accordance with the law, for any injury caused by environmental pollution or degradation Article 51 (g): Policies related to protection, promotion, and use of natural resources To make an advance warning, preparedness, rescue, relief, and rehabilitation to mitigate risks from natural disasters
National Adaptation Programs of Action (NAPA), 2010	The NAPA identified nine urgent and immediate climate change adaptation priority programs related to six thematic sectors (agriculture, forest biodiversity, water resources, health, infrastructure, and disaster). The first comprehensive government response to climate change, the NAPA also specified a coordination mechanism and implementation modality for climate change adaptation programs in Nepal
Climate Public Expenditure and Institutional Review (CPEIR), 2011	CPEIR was conducted to facilitate the integration of climate change into the budgetary process including as part of budget planning, implementation, expenditure management, and financing. CPEIR highlighted the need for improvement of the institutional and financial management system at the local level to help the local governments manage climate finance. Further, district-level CPEIR was conducted in five representative districts which provided a recommendation on sector-specific climate change relevant assessment criteria to be used by the provincial and local governments
Climate Resilient Planning Tool, 2011	The National Planning Commission (NPC) developed a climate resilience framework to guide the country in implementing development plans. It recommends methods, tools, and approaches for guiding climate-resilient planning
Climate Change Budget Code, 2013	The budget code is developed in accordance with the 11 criteria identified to assess whether the budget is directly, indirectly, or neutral to climate change. The criteria include sustainability of natural resources and greenery promotion; land use planning and climate-resilient infrastructures; climate change-induced health hazards, climate change-induced hazards to endangered species; GHG emission reduction; sustainable use of water resources; food safety and security; low-carbon emission through renewable and alternate energy; climate-induced DRR; awareness, education and database creation, policy, legislation; and plan of action for climate change
Climate Change Financing Framework, 2017	The CCFF aims to mainstream climate change in planning and budgeting at all levels of government. It focuses on reforms in three broad areas; (a) integration of climate change in the planning and budgeting cycle; (b) monitoring, reporting, and verification of climate change financing; and (c) improved accountability for climate change financing
Disaster Risk Reduction and Management Act 2017	• Incorporates the whole spectrum of DRR cycle (disaster preparedness, response, rescue, relief, recovery, and rehabilitation) and the diversity of disasters • Disasters are defined distinctly as natural and human induced • Provides for a detailed action plan from the federal government to the district and local levels to draw, implement, and execute a DRM plan • Provision of the establishment of the national council on DRR and management under the chair of Prime Minister • Provision of the establishment of the multi-stakeholder executive committee on DRR and management under the chair of Home Minister • Provision of the establishment of NDRRMA under MOHA • Provision of the establishment of a District and Local Risk Reduction Committee • Defines the roles of security forces, fire brigades, public and commercial institutions • Provision of the establishment of Disaster Management Fund at the national level, and at the provincial and local levels, provision of commencement of disaster emergency in case of any disaster causing heavy damage by the national government
Local Government Operationalization Act 2017	• Provision of formulation of the local law, policy, standards, and plan on environmental conservation and biodiversity and their implementation, monitoring, and regulation • Provision of mitigation of environmental risk at the local level • Provision of adoption of low-carbon and environment-friendly development at the local level • Provision of formulation of the local law, policy, standards, and plan on alternative energy and their implementation and regulation • Provision of formulation of policy, plan, and program on safe settlements and their implementation, monitoring, and regulation • Provision related to disaster management at the local level • Provision of consideration of the environment, climate change adaptation, and disaster management, among others, while formulating the plan at the local level in coherence with the national and provincial plan and policies
National Disaster Risk Reduction Policy, 2018	• Provision of inclusion of all of society in the DRR and management • Provision of building coherence of DRR with Sustainable Development Gals, food security, health, climate change adaptation, environmental management • Provision of promotion of public, cooperative, and private sector financing in the DRM • Provision of the establishment of 'National Disaster Risk Reduction Research and Training Centre' • Provision of developing guidelines on climate adaptive, flood and earthquake-resilient buildings, roads, bridges, powerhouse, industries, etc. • Provision of formulating regulation for the mandatory assessment of DRR and climate change while formulating and designing developmental activities • Provision of National Disaster Management Authority

	• Provision of formulating regulation to enable the investment of the private sector, cooperatives, insurance, companies, and bank in the DRM • Provision of allocation of at least 5 percent of the annual budget of any public institution in the DRM • Provision of the establishment of DRM fund at the federal, provincial, and local levels • Provision of publishing 'National Disaster Report' on an annual basis
Disaster Risk Reduction National Strategic Plan of Action 2018–30	• Considered climate-induced hazard and GLOF hazard under the priority area 1 for the assessment of hazard • Focused on research and development regarding opportunities and challenges on DRR and climate change adaptation (LTS) • Provision of establishing of coordination mechanism representing MOHA and MoFE to implement the DRR, climate change adaptation, and environmental conservation activities in an integrated way (short term) • Provision of appointing of focal person, section, and division on DRR in thematic ministries and departments (short term) • Provision of development of guidelines on mainstreaming of DRR in sectoral development plans (short term) • Provision of inclusion of disaster risk impacts assessment in the Environmental Impact Assessment and EPA (short term) • Provision of preparation of initial and detailed risk evaluation framework considering disaster and climate risk for the selection of major projects and inclusion of the framework in the guidelines (short term) • Provision of development of integrated guidelines of existing guidelines such as LAPA, Community Adaptation Plan of Action, local DRM plan, and Disaster Preparedness and Response Plan (short term) • Provision of development of drought management guidelines (long term) • Provision of promotion of CSA (long term) • Provision of development of climate-smart villages and cities (long term) • Provision of the establishment of ecosystem-based DRR and Management Fund from the federal to local level (long term)
National Adaptation Plan: Summary for Policymakers 2021–50	NAP Summary for Policymakers developed in 2021 has identified 64 prioritized adaptation programs for all the eight thematic and one cross-cutting thematic sectors identified by the NCCP 2019. These adaptation programs were identified for short (until 2025), medium (until 2030), and long term (until 2050). The NAP was formulated to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience and facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programs, and activities, particularly development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.
Sustainable Development Goals Status and Roadmap: 2016–30	The roadmap proposed key actions to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters such as having a climate change adaptation plan and putting forward the idea of climate-smart villages and climate-smart farming as well as climate change education in schools
National Climate Change Policy, 2019	The goal of this policy is to contribute to the socioeconomic prosperity of the nation by building a climate-resilient society. This policy has the following objectives: 1. Enhance climate change adaptation capacity of persons, families, groups, and communities vulnerable to and at risk of climate change. 2. Build resilience of ecosystems that are at risk of adverse climate change impacts. 3. Promote a green economy by adopting the concept of low-carbon emission development. 4. Make judicious mobilization of international financial resources for climate change adaptation and mitigation. 5. Make research, technology development, and information service delivery related to climate change effects. 6. Integrate the climate change issues into policies, strategies, plans, and programs of all state levels and clusters. 7. Mainstream GESI into climate change adaptation and mitigation programs.
15th Periodic Plan (2019/20–2023/24)	The plan considered conservation and promotion of natural and resilient development as one national strategy whereas climate change is considered as one of the cross-cutting sectors with a vision to develop a climate-resilient society through building climate change adaptive capacity and reducing the negative impacts of climate change.
National Framework for Local Adaptation Plans for Action 2019	The LAPA framework was first developed by the government in 2011 as an operational instrument to implement NAPA prioritized adaptation actions. In 2019, it was revised considering the learnings and the federal governance structure of the country. LAPA aims to develop a climate-resilient society through facilitating the integration of climate change adaptation and DRR and management into development planning and resource allocation.
Environment Protection Act, 2019	The EPA incorporated the provisions related to climate change in Chapter 4 which legalize the periodic study and assessment of climate change impacts in the country and prepare adaptation plan thereof by the federal, provincial, and local governments on the need basis. Additionally, among others, the act provides a basis for the enactment of necessary policies and technical standards for the development of technology in the sectors identified.
Second Nationally Determined Contribution 2020	The Second NDC target is to have climate-resilient and gender-responsive adaptation plans in all the 753 local governments by 2030. Furthermore, the Second NDC has specifically outlined the timeline for the NAP update (every 10 years) and national-level vulnerability and risk assessment (every 5 years). Additionally, a national strategy and action plan on loss and damage associated with climate change impacts are expected to be prepared by 2025 under the Second NDC adaptation targets.
Local Level Development Planning Guideline 2021	The Local Level Development Planning Guideline prepared by the National Planning Commission aims to enable local government to undertake holistic planning while also considering climate change and disaster risk in the development planning processes.

Annex 4: The Macro-Climate Model

The World Bank MFMod-CC extends the core MFMod macrostructural model, including a standard set of variables and equations necessary for forecasting, economic policy, and budget planning analyses typically conducted by central ministries. A detailed technical description of MFMod is provided in Burns et al. (2019),[201] while Burns et al. (2021)[202] describe some of the climate change extensions included in the MFMod-CC.

The long-run behavior of the model is determined by a mixture of calibrated and estimated parameters following a neoclassical framework, while the short-run out-of-equilibrium behavior is primarily data driven. External and domestic shocks perturb the economy away from equilibrium based on the historical adjustments of the economy. The functional forms of the equations are derived from economic theory where household tends to optimize consumption decisions to maximize utility, and firms minimize costs by adjusting their use of factor inputs. Although not fully micro-consistent in the way that computable general equilibrium or dynamic stochastic general equilibrium models are, it is a general equilibrium model that covers the entire macroeconomy by linking various accounts through a set of identities and behavioral equations.

The model's climate extensions draw from the existing climate literature to introduce emission and pollution modules; damage functions from higher temperatures, pollution, and flooding; and an adaptation module to analyze the economic benefits of adaptation investments to adjust to climate change. Specifically, the extended model incorporates

- **A more disaggregated energy sector,** integrated into both the production and consumption sides given the importance of hydrocarbons as a source of GHG emissions and particulate pollutant;
- **An emission and pollution module,** added to capture the main channels by which economic activity affects climate outcomes;
- **Damage functions,** introduced to capture how higher temperatures and flooding impact agricultural productivity, worker productivity, and capital stock; and
- **Adaptation investment functions,** introduced to explain how investments to increase the climate resilience of the economy can reduce damages that might otherwise occur.

Annex 1 presents the long-term forecast for the Nepali economy under a baseline (no additional warming) and three warming scenarios. The macro modeling focuses on analyzing the economic impact of climate change rather than mitigation scenarios, as Nepal is a low-carbon emitter and a country that relies largely on hydropower and biofuels as the primary sources of energy.

There are significant limitations to our knowledge of climate impacts. The modeling is carried out under great uncertainty regarding future climate outcomes, technologies, policies, and development paths. It quantifies results under a large set of assumptions to help assess the challenges and trade-offs, but the results do not provide definitive answers and specific numbers should be used cautiously.

[201] Burns, A., B. Campagne, C. Jooste, D. Stephan, and T.T, Bui. 2019. "The World Bank Macro-Fiscal Model Technical Description." World Bank Policy Research Working Papers. Washington, D.C.: World Bank.

[202] Burns, A., C. Jooste, and G. Schwerhoff. 2021. "Climate Modeling for Macroeconomic Policy: A Case Study for Pakistan." World Bank Policy Research Working Papers. Washington, D.C.: World Bank.

Annex 5: Unpacking Policy Package 7—Strengthen governance for climate change and DRM

Action	Impact and feasibility	Challenges/synergies/ trade-offs/co-benefits	Responsible agencies
Federalize climate and DRM governance by strengthening existing climate change and DRM-related legal and administrative/procedural provisions for effective coordination, planning, and implementation across all levels of government and key stakeholders.			
Amend the Environment Protection Act and Regulations at the federal and provincial levels by: • Specifying and clarifying the functional mandate, roles, and responsibilities of sectoral ministries, provincial and local governments, SOEs, the private sector, CSOs, and others as required for effective climate action; • Including local government representation in vertical and horizontal coordination mechanisms such as the EPCCMC; • Specifying the coordination mandate of IMCCCC and PC4 to ensure the mechanisms are legally binding; and • Ensuring coordination mechanisms consist of relevant multi-stakeholders (beyond existing structure and including CSOs, the private sector, development partners, and media).	Impact: High Feasibility: High	Challenges: requires strong will of the OPMCM and key agencies at the federal, provincial, and local levels	MoFE, Ministry of Federal Affairs and General Administration (MoFAGA), provincial and local governments
Amend the Local Government Operations Act by • Specifying functional mandate, roles, and responsibilities of local governments for integrated climate action that also includes environment and DRR; • Specifying required coordination mechanisms for coordination within different units of each local government; • Ensuring coordination mechanisms consist of relevant multi-stakeholders, including CSOs, the private sector, development partners, and the media; and • Recognizing the provincial and local government representative associations for stakeholder engagement in the coordination mechanism.	Impact: High Feasibility: High		MoFAGA, provincial and local governments
Strengthen the climate information system to enable climate profiling for the three tiers of government by • Providing a legal mandate to the DHM through a separate hydromet law and regulations for effective weather, water, and climate-related data collection, analysis, and dissemination based on sectoral needs; • Developing a hydromet master plan to modernize hydromet observation stations and network for producing weather, water, and climate information to risk-inform development and sectoral plans; and • Downscaling climate information to each local level for capturing micro-climatic and altitudinal variations through comprehensive network of stations spread across all the municipalities.	Impact: High Feasibility: Medium		MoEWRI, DHM
Develop country-specific emission factors following the IPCC guidelines.	Impact: High Feasibility: Medium		MOFE, NPC, sectoral ministries, Central Bureau of Statistics, private sector
Develop local-level specific integrated climate action plans, based on individual climate profiling (assessment of climate changes, vulnerabilities, and risks).	Impact: High Feasibility: Medium		Local governments, MOFAGA, MoFE, MOHA/NDRRMA
Mainstream climate action required for achieving the national targets into the national development plan, sectoral plans, MTEF, project	Impact: High Feasibility: Medium		NPC, MOF, sectoral ministries

Action	Impact and feasibility	Challenges/synergies/ trade-offs/co-benefits	Responsible agencies
banks, and annual budget by developing mechanisms to • Identify, screen, appraise, and prioritize programs/projects based on their contribution to the climate targets and • Incorporate programs/projects/ activities included in national climate action plans (NDC, NAP, LTS) into national development plan, sectoral plans, MTEF, and annual budget.			
Develop a standard list of typologies (activities) for climate action for all relevant sectors to enable climate tagging at the activity level for the three tiers of government for (a) budget proposal/allocation and (b) budget execution.	Impact: High Feasibility: Medium		Sectoral ministries, MOF, Financial Comptroller General Office
Incorporate required procurement methodology in Public Procurement Regulations for climate-responsive procurement.	Impact: High Feasibility: Medium		OPMCM, Public Procurement Monitoring Office
Establish a national integrated database system for monitoring, verification, and reporting, which includes the establishment of a monitoring, verification, and reporting system in each of the subnational governments (provincial and local) that feeds information to the integrated database.	Impact: High Feasibility: Medium		NPC, MoFE, provincial and local governments, MOFAGA, Central Bureau of Statistics
Institutionalize climate-specific oversight (for example, citizen climate budget, parliamentary oversight, and public audit system).	Impact: High Feasibility: High		MOF, NPC, Office of the Auditor General, relevant parliamentary committees (finance committee, public accounts committee, relevant sectoral committees)
Improve public disclosure and dissemination of climate-related information in a user-friendly and integrated manner, including through web-based portal, on • Climate trends and scenarios, vulnerabilities, and risks based on sectoral needs, and • Climate budget and execution (spending) in disaggregated manner.	Impact: High Feasibility: Medium		MoFE, MoEWRI/DHM, MOHA/NDRRMA, MOF, FCG
Scale up the technical, analytical, and implementation capacities at all levels of government through a National Capacity Development Program on Climate Change and DRM and the provision of adequate human resources for climate and disaster-resilient planning and implementation.			
Conduct a capacity needs assessment for • Each relevant sector and SOE, including through an organization and management survey as required; • Each provincial government; and • Local level.	Impact: High Feasibility: Medium	Challenges: Capacity constraints, especially at subnational governments	Sectoral ministries, SOEs; provincial and local governments in coordination with MoFE, MOHA/NDRRMA; MOFAGA in coordination with provincial and local governments, MoFE, MOHA/NDRRMA
Develop and implement a capacity building plan for • Each relevant sector and SOE, • Each provincial government, and • Local level.	Impact: High Feasibility: Medium		Sectoral ministries, SOEs; provincial and local governments in coordination with MoFE, MOHA/NDRRMA; MOFAGA in coordination with provincial *and* local governments, MoFE, MOHA/NDRRMA
Based on the Federal Capacity Needs Assessment, incorporate the provision of climate experts through an amendment of the Civil Service Act if/as required	Impact: High Feasibility: Medium		Public Service Commission