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Using Nepal to understand the Nexus of Climate Change and Land-Use

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Abstract

The nexus between land use and climate change is a critical aspect of sustainable development, and few places show this inter-relationship better than Nepal. This paper uses Nepal as an example to explore the interconnections between land use and climate change, highlighting the key challenges and opportunities.

Nepal, with its diverse topography and ecosystems, is highly vulnerable to the impacts of climate change. The country's unique land use patterns, including agriculture, forest cover, and urbanization, play a significant role in shaping its climate resilience and carbon balance. This paper highlights the complex relationship between land use and climate change in such an environment. Balancing land use practices, conserving forests, and biodiversity, and promoting sustainable agriculture are essential for achieving climate resilience and sustainable development. The paper shows that only by addressing the nexus between land use and climate change, can Nepal move towards a more sustainable and climate-resilient future.

Keywords: Nepal, land use, climate change, sustainable development, topography, ecosystems, urbanization, environmental degradation, greenhouse gas emissions, deforestation.

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Introduction

The term “nexus” refers to a connection, link, or interrelationship between different elements or factors. It implies that there is a mutual dependence or influence between these elements, and they are intricately connected in a complex system. The concept of a nexus emphasizes the interconnectivity and interdependence of various components, often with the understanding that changes in one element can have implications for others.

In the context of climate change and land use, nexus refers to the interrelationship between these two factors. It recognizes that climate change and land use are closely intertwined, and changes in one can significantly impact the other. For example, land use changes such as deforestation or urbanization can contribute to greenhouse gas emissions and alter local climate patterns. Conversely, climate change can influence land use through shifts in temperature, precipitation, and extreme weather events, impacting agricultural practices, water availability, and natural ecosystems.

The nexus approach recognizes that addressing climate change and land use challenges requires understanding and consideration of their mutual interactions and synergies. It underscores the need for integrated and holistic approaches that consider the interconnected nature of these factors. By recognizing and addressing the nexus between climate change and land use, it becomes possible to develop more effective and sustainable strategies and policies that simultaneously mitigate climate change impacts, conserve ecosystems, and promote sustainable land management practices.

Here are some key aspects of the nexus between climate change and land-use:

- **Land-use Practices and Greenhouse Gas Emissions:** Land-use practices, such as deforestation, agriculture, and urbanization, can contribute to greenhouse gas emissions. Land-use change also affects the capacity of ecosystems to sequester carbon, as forests and other natural habitats are converted to other land uses.
- **Land-use Change and Climate Change Impacts:** Climate change can also have significant impacts on land-use patterns. Changes in temperature, precipitation, and extreme weather events can affect agricultural productivity, water availability, and the suitability of land for different uses. Sea-level rise and increased coastal erosion can threaten low-lying areas and coastal ecosystems. These climate change impacts can necessitate changes in land-use practices and land management strategies to adapt to the changing conditions.

- **Land-use Planning and Climate Change Mitigation:** Effective land-use planning and management can play a crucial role in climate change mitigation. Preserving and restoring natural habitats, such as forests and wetlands, can also contribute to carbon sequestration and biodiversity conservation.
- **Climate Change Adaptation and Land-use Decisions:** Climate change impacts can influence land-use decisions and choices. Rising sea levels and increased flood risks can affect urban planning and infrastructure development in vulnerable coastal areas. Integrating climate change considerations into land-use planning and decision-making processes can help identify and implement adaptation strategies.
- **Synergies and Trade-offs:** The nexus of climate change and land-use involves synergies and trade-offs between climate change mitigation and adaptation goals, as well as other socio-economic and environmental objectives. For example, renewable energy projects, such as solar and wind farms, can contribute to climate change mitigation but may require land conversion and have implications for biodiversity and local communities. Balancing these trade-offs and maximizing synergies is essential for sustainable land-use management.

Addressing the nexus of climate change and land-use requires integrated and holistic approaches that consider the environmental, social, and economic dimensions.

Climate Change

Climate change refers to long-term changes in temperature, precipitation patterns, wind patterns, and other aspects of the Earth's climate system. It is primarily caused by human activities, specifically the emission of greenhouse gases (GHGs) into the atmosphere.

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer” (IPCC 2019, 2022). The IPCC further explains that climate change is primarily attributed to human activities, particularly the increase in greenhouse gas emissions from burning fossil fuels and deforestation.

The Earth's climate has naturally undergone changes throughout its history due to various factors, including volcanic eruptions, variations in

solar radiation, and changes in the Earth's orbit. However, the current climate change is primarily driven by human-induced activities, particularly the burning of fossil fuels (such as coal, oil, and natural gas), deforestation, industrial processes, and agricultural practices (Bhandari 2018, 2019, 2020, 2023; Bhandari and Shvindina 2019; IPCC 2019, 2022; Mbow et al. 2019).

Climate change has various impacts on the Earth's ecosystems, weather patterns, and human societies (IPCC 2019, 2022).

Questions about Climate Change

The overwhelming scientific consensus is that the Earth's climate is changing, primarily as a result of human activities. Numerous scientific studies, measurements, and models have provided extensive evidence supporting the reality of climate change (Bhandari 2018, 2019, 2020, 2023; Bhandari and Shvindina 2019; IPCC 2019, 2022; Mbow et al. 2019).

Except for some deniers, there is no question about climate change and its impact. Addressing climate change requires global efforts to reduce greenhouse gas emissions, adapt to the changing climate, and promote sustainable practices. This includes transitioning to renewable energy sources, improving energy efficiency, protecting, and restoring ecosystems, adopting climate-resilient infrastructure, and implementing policies to mitigate and adapt to climate change. International agreements, such as the Paris Agreement, aim to facilitate collective action and cooperation to combat climate change and limit global temperature rise.

Interrelationships Between Land Use Change and Climate Change

Land use change refers to the alteration of land cover and land use patterns over time. It involves the conversion of land from one land use type to another, such as the transformation of forests into agricultural fields, the expansion of urban areas, or the conversion of natural habitats into industrial or infrastructure developments. Land use change is closely related to climate change in several ways (Thapa 2022; Bhandari 2019, 2020):

Understanding and managing the relationship between land use change and climate change is crucial for sustainable development and climate mitigation efforts. Promoting sustainable land management practices, conserving natural ecosystems, reducing deforestation, and enhancing reforestation

and afforestation efforts are essential for mitigating climate change and maintaining ecosystem services that support human well-being.

The Nexus of Climate Change and Land-use in Nepal

Nepal

Nepal, officially known as the Federal Democratic Republic of Nepal, is a landlocked country located in South Asia. It is situated in the central part of the Himalayas, bordered by India to the south, east, and west, and by China (Tibet Autonomous Region) to the north. Nepal covers an area of approximately 147,516 square kilometers, making it the 93rd largest country in the world (Bhandari 2018, 2019, 2020; Ministry of Agriculture 2016).

Nepal is renowned for its stunning landscapes, including the world's highest mountain, Mount Everest, as well as numerous other peaks that attract climbers and adventurers from around the globe. The country's topography is diverse, ranging from the rugged Himalayan mountains in the north to the fertile Terai plains in the south. It is also home to several national parks and conservation areas that showcase Nepal's rich biodiversity (Department of National Parks and Wildlife 2023; Bhandari 2019, 2020). Nepal has established national parks and wildlife reserves as a means to protect biodiversity and wildlife within its borders. These protected areas play a crucial role in conserving Nepal's rich natural heritage and ensuring the survival of numerous plant and animal species (Bajracharya et al. 2020; Baral et al. 2023).

The establishment of national parks and wildlife reserves in Nepal demonstrates the country's commitment to biodiversity conservation and wildlife protection. These protected areas serve as crucial pillars in safeguarding Nepal's natural heritage and promoting sustainable development.

The capital city of Nepal is Kathmandu, which is not only the political and administrative center but also a vibrant cultural hub. Nepal has a population of over 30 million people, consisting of various ethnic groups, including the dominant Nepali ethnic group, as well as Sherpas, Gurungs, Newars, Tharus, and many others. The country has a rich cultural heritage, with a blend of Hinduism, Buddhism, and other indigenous beliefs shaping its traditions, festivals, art, and architecture.

Agriculture forms a significant part of Nepal's economy, employing a large portion of the population and contributing to the country's food security. Rice, wheat, maize, and millet are among the main crops grown, along with

cash crops such as tea, coffee, sugarcane, and fruits. Tourism is another vital sector, with visitors drawn to Nepal's natural beauty, trekking routes, and cultural attractions.

Nepal has faced various challenges, including political transitions, economic development, and natural disasters. The country's geography and vulnerability to seismic activities make it prone to earthquakes and landslides. Efforts are being made to overcome these challenges, promote sustainable development, and improve the well-being of its people.

The Nexus of Climate Change and Land-use

Climate change is a significant issue with far-reaching implications for the country's environment, economy, and people (Bhandari 2018, 2019, 2020, 2023; Bhandari and Shvindina 2019; IPCC 2019, 2022; Mbow et al. 2019). Nepal is highly vulnerable to the impacts of climate change due to its mountainous geography and dependency on climate-sensitive sectors such as agriculture, water resources, and tourism.

Agricultural productivity depends on soil fertility and climatic conditions including the tools and techniques used in the farming process.

Soil Condition and Types in Nepal

Nepal, with its diverse topography and climatic conditions, exhibits a wide range of soil types (FAO 2021, Ministry of Agriculture 2016; GFAR 2021). The country's soils can be broadly classified into six major categories:

- **Alluvial Soil:** Alluvial soils are formed by the deposition of sediment carried by rivers and streams. These soils are found in the low-lying plains and river valleys of Nepal, particularly in the Terai region. Alluvial soils are generally fertile and suitable for agriculture, making them important for the country's agricultural productivity.
- **Hill Soil:** Hill soils are prevalent in the mid-hill regions of Nepal, which encompass the slopes and foothills of the Himalayas. These soils are derived from the weathering of parent rock materials, such as sandstone, shale, and limestone. Hill soils vary in their fertility and composition, depending on the parent material and slope gradient. They are generally suitable for a variety of crops and vegetation.
- **Mountain Soil:** Mountain soils are found in the higher elevations of Nepal, including the mountainous regions of the Himalayas. This soil

is characterized by rocky terrain, steep slopes, and limited organic matter. They are generally shallow and have poor fertility due to the challenging climatic conditions and erosion processes. Mountain soils are predominantly used for pasture and agroforestry practices.

- **Forest Soil:** Forest soils are associated with dense forest areas across Nepal. The soil is rich in organic matter due to the accumulation of decomposed leaves, branches, and plant material over time. Forest soils are generally well-drained and retain moisture, making them suitable for a wide range of forest ecosystems and vegetation.
- **Marshy Soil:** Marshy soils are found in the low-lying wetland areas, including marshes, swamps, and paddy fields. These soils are characterized by high water content and organic matter accumulation. Marshy soils are well-suited for paddy cultivation and other water-loving crops.
- **Saline and Alkaline Soil:** Saline and alkaline soils are present in certain regions of Nepal, particularly in the Terai plains. These soils have a high salt or alkaline content, which can adversely affect plant growth and productivity. Proper soil management practices, such as leaching and irrigation techniques, are required to mitigate the challenges associated with saline and alkaline soils.

It is important to note that within each major category, there can be significant variations in soil properties, fertility, and suitability for different agricultural practices. Soil testing and analysis at a local level are crucial for understanding the specific characteristics and requirements of soils in different regions of Nepal. This information helps farmers and land managers make informed decisions regarding land use, crop selection, and soil management practices.

The relationship between climate change and land-use in Nepal is multifaceted and interconnected. Here are some key points to consider:

Agriculture

Agriculture is a crucial sector in Nepal, employing a significant portion of the population and contributing to the country's economy. Climate change poses challenges to agriculture through changes in temperature, precipitation patterns, and increased occurrence of extreme weather events like droughts and floods (Bajracharya et al. 2020; Thapa 2022; Baral et al. 2023; Saah et al. 2019). These changes affect crop yields, food security, and livelihoods.

Unsustainable land-use practices, such as deforestation and conversion of agricultural land for other purposes, further exacerbate the vulnerability of agriculture to climate change impacts. Figure 1 shows Land use including Agriculture in Nepal.

Figure 1 Nepal Land Cover and Land Use – Including Agriculture.

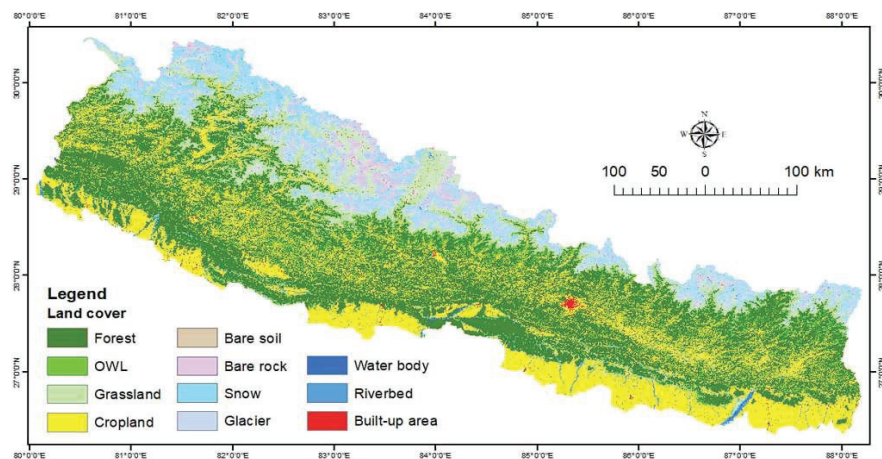


Figure 1 Map shows major land use and land cover of Nepal.

Source: FRTC. (2022). Land cover of Nepal [Data set]. FRTC.

<https://doi.org/10.26066/RDS.1972729>

<http://rds.icimod.org/Home/DataDetail?metadataId=1972729> (open access).

The agricultural conditions in Nepal vary across different regions of the country due to variations in climate, topography, soil fertility, and socio-economic factors. Here are some key factors that contribute to the variation in agricultural conditions in Nepal:

- **Climatic Variation:** Nepal experiences a wide range of climatic conditions, from subtropical in the lowlands to alpine in the high Himalayan regions.
- **Topography and Landforms:** Nepal's topography is characterized by diverse landforms, including plains, hills, and mountains.
- **Irrigation Availability:** Access to water for irrigation significantly impacts agricultural productivity.
- **Land Fragmentation:** Nepal has a high incidence of land fragmentation, where landholdings are subdivided into smaller and fragmented plots due to inheritance practices.

- **Infrastructure and Market Access:** The availability of infrastructure, including roads, transportation networks, and market access, affects the agricultural conditions in different regions.
- **Socio-economic Factors:** Socio-economic factors such as literacy rates, income levels, and access to resources and technologies also influence agricultural conditions.
- **Agro-Ecological Zones:** Nepal has been divided into different agro-ecological zones based on factors such as elevation, temperature, and rainfall.

Major Problems of Farmers in Nepal

Farmers in Nepal face several challenges that hinder their agricultural productivity and overall well-being (Bajracharya et al. 2020; Thapa 2022; Baral et al. 2023). These include:

- **Limited Access to Resources:** Many farmers in Nepal have limited access to essential resources such as land, water, credit, and technology. Fragmentation of land holdings, landlessness, and lack of secure land tenure make it difficult for farmers to expand their agricultural activities. Inadequate access to water for irrigation, especially in the context of changing rainfall patterns, also poses a significant challenge.
- **Climate Change and Vulnerability:** Nepal is highly vulnerable to the impacts of climate change, including erratic rainfall, increased frequency of droughts and floods, and changing temperature patterns. These climate-related challenges affect crop yields, water availability, and overall farm productivity, making farmers more susceptible to food insecurity and economic losses.
- **Outdated Farming Practices:** Many farmers in Nepal continue to rely on traditional and outdated farming practices, which often result in low productivity. Limited knowledge and access to modern agricultural technologies, such as improved seeds, fertilizers, and mechanization, hinder the adoption of more efficient and sustainable farming methods.
- **Lack of Market Access and Price Volatility:** Farmers in Nepal often face challenges in accessing markets and obtaining fair prices for their agricultural produce. Limited infrastructure for transportation, storage, and processing, coupled with the dominance of middlemen and intermediaries, can lead to low returns for farmers and inhibit their ability to invest in their farms.

- **Inadequate Agricultural Extension Services:** Farmers in Nepal often lack access to timely and relevant agricultural information, training, and extension services. The absence of extension officers, insufficient reach of extension programs, and a lack of appropriate technologies and practices tailored to local conditions hinder farmers' ability to adopt improved farming techniques and technologies.
- **Pest and Disease Management:** Pests, diseases, and crop losses pose significant challenges to farmers in Nepal. Inadequate knowledge and access to effective pest and disease management practices, including pesticides and integrated pest management techniques, can lead to reduced crop yields and financial losses.
- **Limited Financial Services:** Access to credit and financial services is a challenge for many farmers in Nepal. Formal banking services are often inaccessible in rural areas, and farmers rely on informal sources of credit with high interest rates. Limited access to credit hampers farmers' ability to invest in their farms, purchase inputs, and adopt modern technologies.
- **Gender Inequality:** Gender disparities exist in agriculture in Nepal, with women farmers facing additional challenges. Limited access to land, resources, credit, and decision-making power restricts women's participation in agricultural activities and limits their ability to improve their livelihoods.

Efforts are being made by the government, non-governmental organizations, and development agencies to address these challenges and support farmers in Nepal (Ministry of Agriculture 2016). These include initiatives to improve access to resources, promote climate-smart agriculture, enhance market linkages, strengthen agricultural extension services, and promote gender equality in agriculture. To address the variation in agricultural conditions, the government of Nepal has implemented various programs and policies. These include promoting irrigation facilities, providing subsidies for agriculture inputs, implementing soil conservation measures, supporting research and development in agriculture, and promoting market access for farmers. Efforts are also underway to promote commercial agriculture, value addition, and agro-processing to enhance agricultural productivity and rural incomes. Additionally, community-based initiatives, such as cooperatives and farmer groups, have been encouraged to improve resource management, enhance access to credit, and foster knowledge sharing among farmers.

Overall, understanding the variation in agricultural conditions and tailoring interventions to specific regions is crucial for sustainable agricultural

development in Nepal, ensuring food security, rural livelihoods, and economic growth.

Forests and Biodiversity

Forests and biodiversity in Nepal are of immense ecological, economic, and cultural significance. The country is known for its rich biodiversity, including diverse flora, fauna, and ecosystems. Forests cover a significant portion of Nepal's land area and provide numerous ecosystem services, support livelihoods of local communities, and contribute to climate change mitigation. Here are some key points about forests and biodiversity in Nepal:

- **Forests and Ecosystems:** Nepal's forests encompass a wide range of ecosystems, including tropical, subtropical, temperate, and alpine forests.
- **Biodiversity:** Nepal is recognized as a biodiversity hotspot, with a high concentration of species within a relatively small area.
- **Threats to Forests and Biodiversity:** Forests and biodiversity in Nepal face various threats, including deforestation, habitat degradation, illegal logging, encroachment, infrastructure development, and climate change.
- **Community Forestry:** Nepal is globally recognized for its community forestry initiatives, where local communities are involved in the management and conservation of forest resources.
- **Conservation Efforts:** The Government of Nepal, in collaboration with local communities and conservation organizations, has implemented various initiatives to protect and conserve forests and biodiversity.
- **Climate Change and Forests:** Climate change poses significant challenges to Nepal's forests and biodiversity. Rising temperatures, changing rainfall patterns, and increased frequency of extreme weather events can impact forest ecosystems, species distribution, and vegetation dynamics.

Forest and biodiversity conservation in Nepal face several threats due to various factors.

- **Deforestation and Forest Degradation:** Deforestation is a significant threat to forests in Nepal.
- **Land Encroachment and Fragmentation:** The encroachment of forest land for settlement, agriculture, and infrastructure development poses a threat to forest ecosystems.
- **Unsustainable Agriculture and Shifting Cultivation:** Unsustainable agricultural practices, such as slash-and-burn agriculture (shifting cultivation), contribute to forest degradation and loss of biodiversity.

- **Wildlife Poaching and Illegal Wildlife Trade:** Nepal is home to diverse wildlife, including endangered species like tigers, rhinos, and elephants. Illegal hunting, poaching, and the illegal trade of wildlife and their parts pose significant threats to biodiversity conservation.
- **Climate Change Impacts:** Climate change poses a threat to forest ecosystems and biodiversity in Nepal. Rising temperatures, changing rainfall patterns, and increased frequency of extreme weather events can disrupt forest ecosystems, alter species distributions, and impact the timing of ecological processes.
- **Invasive Species:** Invasive species, both plant and animal, pose a threat to native biodiversity in Nepal.
- **Lack of Awareness and Education:** Limited awareness and understanding of the importance of forest and biodiversity conservation among local communities, as well as policymakers, can hinder conservation efforts.

Addressing these threats requires a combination of policy measures, community participation, and effective enforcement of laws. Some of the key strategies to mitigate these threats include:

- Strengthening law enforcement to combat illegal logging, wildlife poaching, and illegal wildlife trade.
- Implementing sustainable forest management practices to ensure the long-term viability of forests.
- Promoting community-based conservation initiatives and involving local communities in forest management and biodiversity conservation efforts.
- Developing and implementing land-use plans that prioritize conservation and sustainable land management practices.
- Raising awareness and providing education on the importance of biodiversity conservation and sustainable resource use.
- Enhancing international collaboration to combat illegal wildlife trade and promote transboundary conservation efforts.

The government of Nepal, along with non-governmental organizations and international partners, is actively working to address these threats and promote sustainable forest and biodiversity conservation practices. Continued efforts and collaboration are crucial to safeguarding Nepal's unique and diverse ecosystems for future generations.

Water Resources

Water resources play a vital role in Nepal's socio-economic development, providing water for various sectors such as agriculture, hydropower generation, drinking water supply, and ecosystem services. Nepal is known as the "Water Tower of Asia" due to its abundant water resources, including rivers, lakes, glaciers, and groundwater. However, managing and utilizing these resources effectively is crucial due to the country's geographical complexity and diverse climatic conditions. Here are some key points about water resources in Nepal:

- **Rivers and Hydrology:** Nepal is crisscrossed by numerous rivers originating from the Himalayas. Major rivers like the Koshi, Gandaki, and Karnali have significant hydrological potential. These rivers are fed by glacier melt, snowmelt, and monsoon rainfall, making their flow highly seasonal. The snow and glacier melt from the high mountains contribute to the perennial flow of water, ensuring a stable water supply during the dry season.
- **Water Availability and Access:** Despite the abundance of water resources, water availability and access remain challenges in Nepal. Water scarcity can occur in certain regions during the dry season, particularly in areas with limited water infrastructure and poor water management practices. Additionally, access to safe drinking water and sanitation services is a concern, especially in rural and remote areas.
- **Agriculture:** Agriculture is the backbone of Nepal's economy, employing a significant portion of the population. Irrigation plays a crucial role in agricultural productivity, and the majority of irrigation water is sourced from rivers and groundwater. Climate change, with its impacts on rainfall patterns and melting glaciers, affects water availability for agriculture. Improved water management practices, such as efficient irrigation techniques and water storage systems, are important for sustainable agriculture.
- **Hydropower:** Nepal has immense hydropower potential, estimated to be one of the highest in the world. Rivers cascading down from the mountains offer significant opportunities for hydropower generation. Developing hydropower projects can not only meet Nepal's domestic energy demands but also enable the export of electricity to neighboring countries, contributing to the country's economic growth.

- **Climate Change and Water Resources.** Climate change affects the timing and intensity of rainfall, causes changes in glacier and snowmelt patterns, and alters river flows.

The Government of Nepal, in collaboration with development partners, has been working on various initiatives to address water resource challenges. The National Water Plan, National Adaptation Programme of Action (NAPA), and Integrated Water Resources Management (IWRM) policy provide frameworks for water resource management, climate change adaptation, and disaster risk reduction (Ministry of Agriculture 2016). Efforts are also being made to improve water infrastructure, promote community-based water management, and enhance water governance at the local level.

Natural Disasters

Nepal is a country highly prone to natural disasters due to its geographical location, rugged terrain, and diverse climatic conditions. The occurrence of natural disasters in Nepal is influenced by various factors, including its tectonic setting, monsoonal climate, and fragile ecosystems.

To address the challenges posed by natural disasters, Nepal has made efforts to enhance disaster preparedness, response, and risk reduction measures. The country has established the National Disaster Risk Reduction and Management Authority (NDRRMA) to coordinate disaster management activities. Local and international organizations are involved in community-level awareness, capacity-building, and infrastructure development for disaster resilience.

Improving early warning systems, strengthening building codes, promoting sustainable land-use practices, and enhancing disaster risk reduction strategies are essential steps taken by the government and various stakeholders to mitigate the impact of natural disasters. International cooperation and support are crucial in assisting Nepal's efforts to build resilience and effectively respond to natural disasters, given the country's vulnerability to such events.

Adaptation and Mitigation

Addressing the nexus of climate change and land-use in Nepal requires both adaptation and mitigation strategies. Adaptation measures include promoting climate-resilient agriculture practices, such as terracing, agroforestry, and

crop diversification, as well as improving water management and disaster preparedness. Mitigation efforts focus on reducing greenhouse gas emissions through sustainable land-use practices, such as community-based forest management, afforestation, and promotion of renewable energy sources (Bhandari 2018, 2019, 2020, 2023; Bhandari and Shvindina 2019; IPCC 2019, 2022; Mbow et al. 2019; United Nations 2015, 2016, 2017, 2023; Van Den Hoek et al. 2021; World Bank 2018, 2020; Wei et al. 2021).. Here are some key initiatives undertaken by Nepal in these areas:

Climate Change Adaptation

Climate change adaptation is the process of adjusting and preparing for the impacts of climate change in order to reduce vulnerability and increase resilience. It involves taking proactive measures to anticipate and respond to the changing climate conditions and their associated risks.

For climate change adoption- Nepal has prepared- National Adaptation Programme of Action (NAPA) to identify priority adaptation measures and strategies to address climate change impacts (Thapa 2022; Bluffstone 2018; Chhetri et al. 2021; Devkota et al. 2023; DFRS 2018 FAO 2017; Fox et al. 2019; FRTC 2022; MoAD – Ministry of Agricultural Development 2016). The NAPA focuses on sectors such as agriculture, water resources, health, and infrastructure and aims to enhance the resilience of vulnerable communities.

- **Community-based Adaptation:** Nepal has embraced community-based adaptation approaches, recognizing the importance of local knowledge and participation.
- **Climate-resilient Infrastructure:** The government is incorporating climate resilience into infrastructure planning and development.
- **Early Warning Systems:** Nepal has strengthened its early warning systems for natural disasters, particularly for floods and landslides.
- **Research and Capacity Building:** Nepal has been investing in research and capacity-building initiatives to enhance understanding and response to climate change impacts.

Climate Change Mitigation

Climate change mitigation refers to efforts and actions taken to reduce or prevent the emissions of greenhouse gases (GHGs) into the atmosphere

and thereby mitigate the impacts of climate change. It involves strategies and practices aimed at curbing the causes of climate change and transitioning towards a more sustainable and low-carbon future (IPCC 2019, 2022).

- **Renewable Energy Promotion:** Nepal has emphasized the development and promotion of renewable energy sources, particularly hydropower, to reduce reliance on fossil fuels and mitigate greenhouse gas emissions. The country aims to increase the share of renewable energy in its energy mix, promoting clean and sustainable energy production.
- **Forest Conservation and Carbon Sequestration:** Nepal's community forestry programs, supported by international initiatives such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation), focus on forest conservation and carbon sequestration.
- **Clean Cooking Solutions:** The government is promoting clean cooking solutions, such as improved cookstoves and biogas, to reduce the use of traditional biomass fuels.
- **Sustainable Transport:** Nepal is promoting sustainable transport options to reduce carbon emissions from the transportation sector. This includes encouraging the use of electric vehicles, promoting public transport systems, and improving infrastructure for non-motorized transport modes like cycling and walking.
- **International Cooperation:** Nepal actively participates in international climate change negotiations and seeks support and collaboration from the international community. The country engages in global climate change initiatives like the Paris Agreement and seeks financial and technical assistance for implementing climate change mitigation projects.

It is important to note that Nepal's efforts in climate change adaptation and mitigation are ongoing, and the government continues to prioritize these issues. The Government of Nepal has recognized the importance of addressing climate change and land-use issues and has taken steps to integrate climate change adaptation and mitigation into national policies and plans.

Engaging local communities, empowering marginalized groups, and strengthening institutional capacities are essential for effective implementation of climate change adaptation and mitigation measures in Nepal. International collaborations, financial support, and knowledge-sharing also play crucial roles in addressing the nexus of climate change and land-use in the country.

Conclusion

There are many books and papers on climate change and land use nexus, however, there is still a need for more conceptual and scientific knowledge to address climate change, food security, land use pattern change, water resources and actual impact of climate change on the ground. The purpose of this paper is to showcase Nepal as an example of a Country that has started to address these issues.

The impacts of climate change have significant implications for land use practices and vice versa. Understanding and addressing this nexus is crucial for sustainable development, biodiversity conservation, and the well-being of communities, including those in Nepal.

Adapting to climate change is equally important, especially in a country like Nepal that is highly vulnerable to its effects. Implementing climate-resilient agricultural practices, water management strategies, and disaster risk reduction measures can help farmers and communities cope with changing conditions. Enhancing the capacity of farmers through education, access to technology, and financial support is crucial in addressing the major problems they face, such as low productivity, limited market access, and vulnerability to climate-related risks.

Forests and biodiversity play a vital role in climate change mitigation and adaptation. Protecting and restoring forests in Nepal can contribute to carbon sequestration, conservation of biodiversity, and provision of ecosystem services. Implementing sustainable forest management practices, community-based forestry, and initiatives like REDD+ can support both climate change mitigation and livelihood improvement for local communities.

Water resources management is critical in the context of climate change and land use. Nepal's water resources, including rivers, lakes, and glaciers, are affected by climate change impacts, such as changing precipitation patterns and glacier melt. Implementing integrated water resource management, promoting water conservation, and strengthening climate-resilient infrastructure are essential for ensuring water availability, particularly for agriculture and human needs.

Natural disasters, such as earthquakes, floods, and landslides, pose significant challenges for Nepal. Climate change exacerbates these risks, making adaptation and mitigation measures crucial. Enhancing early warning systems, improving disaster preparedness, and implementing nature-based solutions can help reduce the vulnerability of communities and infrastructure to natural disasters.

To conclude, the interrelationships between climate change and land use have profound implications for Nepal's sustainable development, agriculture, forests, water resources, and adaptation to natural disasters. Efforts are required to reduce greenhouse gas emissions, promote sustainable land use practices, protect biodiversity, manage water resources effectively, and enhance community resilience. Collaboration among stakeholders, investment in research and innovation, and integration of climate change considerations into policies and planning processes are key to addressing the challenges posed by the nexus of climate change and land use in Nepal. By adopting a holistic and multidisciplinary approach, Nepal can pave the way towards a sustainable and climate-resilient future for its people and the environment.

References

- Bajracharya, S.R., Maharjan, S.B., Shrestha, F., Sherpa, T.C., Wagle, N., Shrestha, A.B. (2020), Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali river basins of Nepal, the Tibet Autonomous region of China, and India. Kathmandu, Nepal: International Centre for Integrated Mountain Development (ICIMOD).
- Baral, S., Nepal S., Pandey V.P., Khadka M., Gyawali D. (2023). Position paper on enhancing water security in Nepal. Prepared for the UN 2023 Water Conference, March 22–24, 2023, New York.
- Bhandari Medani P. (2019). “Bashudaiva Kutumbakkam” – The entire world is our home and all living beings are our relatives. Why do we need to worry about climate change, with reference to pollution problems in the major cities of India, Nepal, Bangladesh, and Pakistan? *Adv Agr Environ Sci.* (2019);2(1): 8–35. DOI: 10.30881/aaeo.00019 (second part) http://ologyjournals.com/aaeo/aaeo_00019.pdf.
- Bhandari Medani P. and Shvindina Hanna (2019), The Problems and consequences of Sustainable Development Goals, in Bhandari, Medani P. and Shvindina Hanna (eds) *Reducing Inequalities Towards Sustainable Development Goals: Multilevel Approach*, River Publishers, Denmark/the Netherlands – ISBN: Print: 978-87-7022-126-9 E-book: 978-87-7022-125-2.
- Bhandari, Medani P, (2019), Live and let others live – the harmony with nature/living beings-in reference to sustainable development (SD) – is contemporary world's economic and social phenomena is favorable for the sustainability of the planet in reference to India, Nepal, Bangladesh,

- and Pakistan? *Adv Agr Environ Sci.* (2019);2(1): 37–57. DOI: 10.30881/aaeoa.00020 http://ologyjournals.com/aaeoa/aaeoa_00020.pdf.
- Bhandari, Medani P. (2018), *Green Web-II: Standards and Perspectives from the IUCN*, River Publishers, Denmark/the Netherlands ISBN: 978-87-70220-12-5 (Hardback) 978-87-70220-11-8 (eBook).
- Bhandari, Medani P. (2019), *Sustainable Development: Is This Paradigm the Remedy of All Challenges? Do Its Goals Capture the Essence of Real Development and Sustainability? With Reference to Discourses, Creativeness, Boundaries, and Institutional Architecture, Socioeconomic Challenges*, Volume 3, Issue 4, 97–128 ISSN (print) – 2520-6621, ISSN (online) – 2520-6214 [https://doi.org/10.21272/sec.3\(4\).97-128.2019](https://doi.org/10.21272/sec.3(4).97-128.2019), <http://armgpublishing.sumdu.edu.ua/wp-content/uploads/2020/01/9.pdf>.
- Bhandari, Medani P. (2019), *The Debates between Quantitative and Qualitative Method: An Ontology and Epistemology of Qualitative Method- the Pedagogical Development*, in Douglass Capogrossi (Ed.) *Educational Transformation: The University as Catalyst for Human Advancement*, Xlibris Corporation, USA ISBN-10: 179604895X; ISBN-13: 978-1796048957.
- Bhandari, Medani P. (2020), *Getting the Climate Science Facts Right: The Role of the IPCC (Forthcoming)*, River Publishers, Denmark/the Netherlands – ISBN: 9788770221863 e-ISBN: 9788770221856.
- Bhandari, Medani P. (2023), *Perspectives on Sociological Theories, Methodological Debates and Organizational Sociology 1st Edition*, ISBN 10-8770227802 ISBN-13, 978-8770227803, Rivers Publishers.
- Bluffstone, R. (2018), *Collective action yields positive outcomes for Nepal's forests*. World Bank blogs. Accessed February 3, 2023.
- Chhetri, R., et al. (2021), *Forest, agriculture, and migration: contemplating the future of forestry and agriculture in the middle-hills of Nepal*. *The Journal of Peasant Studies*, 1–23.
- Devkota, P., Dhakal, S., Shrestha, S., and Shrestha, U. B. (2023), *Land use land cover changes in the major cities of Nepal from 1990 to 2020*. *Environmental and Sustainability Indicators*, 17, 100227. <https://doi.org/10.1016/j.indic.2023.100227>.
- Department of National Parks and Wildlife (2023) https://dnppwc.gov.np/media/others/PAs_Nepal_New2023_1.jpg.
- DFRS (2018), *Forest Cover Maps of Local Levels (753) of Nepal*. Department of Forest Research and Survey (DFRS), Kathmandu, Nepal.

- Food and Agriculture – FAO (2017), *The Future of Food and Agriculture – Trends and Challenges*; Food and Agriculture Organization of the United Nations: Rome, Italy, pp. 46–55. ISBN 978-92-5-109551-5.
- Fox, J., et al. (2019), Mapping and understanding changes in tree cover in Nepal: 1992 to 2016. *J. Forest Livelihood*, 18(1).
- FRTC. (2022), Land cover of Nepal [Data set]. FRTC. <https://doi.org/10.26066/RDS.1972729> <http://rds.icimod.org/Home/DataDetail?metadataId=1972729>.
- 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* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
- IPCC (2022), *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: 10.1017/9781009325844.
- IPCC (2022), *Summary for Policymakers* [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi: 10.1017/9781009325844.001.
- Mbow, C., Rosenzweig, C., Barioni, L.G., Benton, T.G., Herrero, M., Krishnapillai, M., Liwenga, E., Pradhan, P., Rivera-Ferre, M.G., Sapkota, T., et al. (2019), Food security. In *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, Shukla, P.R., Skea, J., Calvo Buendia, E., Masson-Delmotte, V., Pörtner, H.-O., Roberts, D.C., Zhai, P., Slade, R., Connors, S., van Diemen, R., et al., Eds., Intergovernmental Panel on Climate Change: Paris, France
- MoAD – Ministry of Agricultural Development (2016), Statistical information on Nepalese agriculture (2015/16). Kathmandu, Nepal: Ministry of Agricultural Development, Agribusiness Promotion and Statistics Division, Singha Durbar, Kathmandu. Government of Nepal.
- NASA (2022), Land-Cover and Land-Use Change Program Twenty-Five Years of Community Forestry: Mapping Forest Dynamics in the Middle Hills of Nepal.
- Saah, D., Tenneson, K., Matin, M., Uddin, K., Cutter, P., Poortinga, A., Nguyen, Q. H., Patterson, M., Johnson, G., Markert, K., Flores, A., Anderson, E., Weigel, A., Ellenberg, W. L., Bhargava, R., Aekakkararungroj, A., Bhandari, B., Khanal, N., Housman, I. W., ... Chishtie, F. (2019), Land Cover Mapping in Data Scarce Environments: Challenges and Opportunities. *Frontiers in Environmental Science*, 7. <https://doi.org/10.3389/fenvs.2019.00150>.
- Smith, A. C., et al. (2023), Community Forest management led to rapid local forest gain in Nepal: A 29-year mixed methods retrospective case study. *Land Use Policy*, 126, 106526.
- Subedi, Roshan, Madhav Karki, and Dinesh Panday. (2020), “Food System and Water–Energy–Biodiversity Nexus in Nepal: A Review” *Agronomy* 10, no. 8: 1129. <https://doi.org/10.3390/agronomy10081129>.
- Thapa, P. (2022), The Relationship between Land Use and Climate Change: A Case Study of Nepal. *IntechOpen*. doi: 10.5772/intechopen.98282 <https://www.intechopen.com/chapters/76898>.
- The United Nations. (2015), Transforming our world: the 2030 Agenda for Sustainable Development. <https://sdg.guide/sources-by-chapter-bibliography-e6d077ea03c8>.
- United Nations (2017), Resolution adopted by the General Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313).
- FAO – United Nations Food and Agriculture Organization (2016) Global Forest Resources Assessment 2015: How are the World’s Forests Changing? Rome: FAO. Accessed February 3, 2023.
- United Nations (2023), The United Nations World Water Development Report 2023: Partnerships and Cooperation for Water. UNESCO, Paris. ISBN 978-92-3-100576-3. Mar 15, 2023.

- Van Den Hoek, J., et al. (2021), Shedding new light on mountainous forest growth: a cross-scale evaluation of the effects of topographic illumination correction on 25 years of forest cover change across Nepal. *Remote Sensing*, 13(11), 2131.
- Wei, F., Wang, S., Brandt, M., Fu, B., Meadows, M. E., Wang, L., et al. (2021), Responses and feedbacks of African dryland ecosystems to environmental changes. *Curr. Opin. Environ. Sustain.* 48, 29–35. doi: 10.1016/j.cosust.2020.09.004.
- World Bank (2020), Data Bank: World Development Indicators. <https://data.banque.mondiale.org/reports.aspx?source=2&Topic=21>.
- World Bank (2018), World development report 2019. World Bank Publications.

Biography



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