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Ministry of Forests and Environment

National Framework on Climate Change Induced Loss and Damage (L&D)

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ACRONYMS

AoSIS	Alliance of Small Island Developing States
AR	Assessment Report
BEK	British Embassy Kathmandu
CCIAV	Climate Change Impacts, Assessment and Vulnerability Approaches
CCMD	Climate Change Management Division
COP	Conference of Parties
CRM	Climate Risk Management Framework
DDT	Dichlorodiphenyltrichloroethane
DOFE	Department of Foreign Employment
DoFS	Department of Forests and Soil Conservation
DoMG	Department of Mines and Geology
DoWRI	Department of Water Resources and Irrigation
DHM	Department of Hydrology and Metrology
DRR	Disaster Risk Reduction
ELD	Economic loss and damage
EWS	Early Warning System
FAR	Fraction of attributable risk
GDP	Gross Domestic Product
GDI	Gender Development Index
GHG	Greenhouse gases
GLOF	Glacial Lake Outburst Flood
GNI	Gross National Income
GoN	Government of Nepal
HKH	Hindu Kush Himalayas
HDI	Human Development Index
IRM	Incident reporting mechanisms
IPCC	Intergovernmental Panel on Climate Change
JTA	Junior technical assistant
L&D	Loss and damage
LDCs	Least Developed Countries
LOESS	Locally estimated point cloud smoothing
MoFE	Ministry of Forests and Environment
MoHA	Ministry of Home Affairs
MoFAGA	Ministry of Federal Affairs and General Administration
MCDA	Multi-criteria Decision Analysis
NoAA	National Oceanic and Atmospheric Administration (NoAA)

NAP	National Adaptation Plan
NDCs	Nationally Determined Contributions
NDRRMA	National Disaster Risk Reduction and Management Authority
NELD	Non-economic loss and damage
NEOC	National Emergency Operating Centre
NIDIM	Nepal Integrated Drought Information Mechanism (NIDIM)
NPC	National Planning Commission
NPR	Nepalese rupees
NTFP	Non-timber forest products
OPM	Oxford Policy Management
PDGLs	Potentially Dangerous Glacial Lakes
PIF	Policy and Institutions Facility
REDD-IC	Reducing Emissions from Deforestation and Forest Degradation-Implementation Center
SIDS	Small Island Developing States
SRCCL	Special Reports on Climate Change and Land
SROCC	Special Report on Ocean and Cryosphere in a Changing Climate
TAR	Tibet Autonomous Region of China
UNDRR	United Nations Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change
UNWFP	United Nations World Food Programme
VRA	Vulnerability and risk assessment
WIM	Warsaw International Mechanism for Loss and Damage

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Foreword

Loss and damage (L&D) is gaining an increasing interest in climate change negotiations, research, policy, and implementation of climate change actions connecting the fields of climate change adaptation and disaster risk reduction. However, research on "L&D" remains uncharted territory with no official definition of “L&D” in documents. This has implications for both policy and practices in addressing L&D at the country level.

It is necessary to understand the country context of L&D. Definition of L&D will provide clarity on what L&D means in the Nepali context. Besides, the methodological framework used is an important milestone in terms of contextualizing L&D in Nepal’s context. Methods of assessing L&D provide a means to ascertain the severity of a disaster for a natural environment or an affected population. For this, L&D assessments should aim to go beyond simple stocktaking of impacts and bring out a more differentiated, comprehensive, and people-centered result. Hence, L&D assessments reflect a post-disaster situation, which recognizes the plight of an affected population and provides a strong basis for policies to avert, minimize and address L&D in the future.

I would like to thank all the sectoral ministries, the Chief of the Climate Change Management Division (CCMD), Dr Radha Wagle, Raju Sapkota, Dr Arun Prakash Bhatta, Srijana Shrestha, Milan Dhungana, and other officials in the Ministry of Forests and Environment (MoFE) who initiated this process, coordinated among different agencies, and contributed to finalizing the document. Also, I am grateful to NDRRRMA, NPC, MOHA, MOFAGA, all the relevant ministries, stakeholders, and experts who provided their valuable input in improving this document.

On behalf of MoFE, I would like to take this opportunity to express our sincere appreciation for the technical and financial support of the British Embassy Kathmandu (BEK), and Policy and Institutions Facility (PIF)/Oxford Policy Management (OPM).

Dr Pem N. Kandel

Secretary

Ministry of Forests and Environment

Acknowledgments

Nepal is one of the highly vulnerable countries to anthropogenic climate change and its impacts are felt in all sectors. L&D from climate change impact is visible in Nepal. Both slow onset events (drought, glacier melting), rapid onset events (flood, fire, landslide) are increasing in frequency, intensity, and magnitude.

In terms of disaster losses and damages, between 1971 and 2019, a significant number of people died in Nepal each year because of climate-induced disasters. The average annual economic loss is Nepalese Rupees (NPR) 2,778 million, or about 0.08 per cent of the total Gross Domestic Product (GDP) of the Fiscal Year 2018/19 (at the current price). The most devastating climate-induced disasters in Nepal are floods, landslides, epidemics, and fires. Extreme climatic events, particularly those related to temperature, are likely to become more frequent and severe. Intense precipitation events are expected to become more common, with extremely wet days increasing at a faster rate than very wet days. Climate-induced hazards, when combined with degrading ecosystems, biophysical processes, and other challenges, such as COVID-19, have the potential to cause chronic stress and catastrophic shocks.

This national framework on L&D is of relevance to both understand as well as contextualize L&D in the Nepali context. It provides further understanding of the relevant approaches, methodology, and tools to assess the unavoidable, avoidable, and avoided risks of climate change impacts. Besides, this framework will provide us a unique opportunity to devise country-driven, participatory, and inclusive approaches to tackle climate change risk and vulnerability.

On behalf of CCMD, I would like to acknowledge the contributions of Ajaya Dixit, Dr Bimal Raj Regmi, Dinesh Acharya, Sanchita Neupane, Apar Paudyal, Dr Ram Lamsal, Dinanath Bhandari, Bamshi Acharya, Pratik Ghimire, Regan Sapkota, Rojy Joshi, and Dr Keshab Gautam in drafting the report. Also, I am thankful to Raju Sapkota, Dr Arun Prakash Bhatta, Srijana Shrestha, Milan Dhungana, and all the officials of CCMD and MoFE for providing input in the document. Besides, let me take this opportunity to appreciate the suggestions provided by the National Disaster Risk Reduction and Management Authority (NDRRMA), Department of Hydrology and Meteorology (DHM), Ministry of Home Affairs (MoHA), National Planning Commission (NPC), Ministry of Federal Affairs and General Administration (MoFAGA), and other relevant stakeholders. I also appreciate the technical and financial support provided by BEK and PIF/ OPM.

Dr Radha Wagle

Joint Secretary

Ministry of Forests and Environment

Executive Summary

The rising concentration of greenhouse gases (GHG) in the atmosphere has led to a rise in average global temperature causing local weather systems to be more erratic than in the past and more devastating in terms of impacts. These changes are increasing L&D in developing and Least Developed Countries (LDCs) like Nepal.

In Nepal, climate-induced disasters cause around 65 per cent of all disaster-related annual deaths. The average annual economic loss from climate-induced disasters is about 0.08 per cent of the GDP (2018/19 figures at the current price). In extreme years, like 2017 when Tarai floods occurred, the economic loss and damage from the single disaster event was around 2.08 per cent of the GDP (2017/18 figures at the current price). Multiple studies have predicted an increase in L&D caused by climate-induced disasters in the future.

L&D is still a debated agenda in the United Nations Framework on Climate Change Convention (UNFCCC) process. While the LDCs claim that the agenda of L&D should be a separate item, the third pillar of climate negotiations (adaptation and mitigation being the other two), the developed countries often argue L&D is part of adaptation. While the claims of the LDCs is driven by ground realities and the increasing risk of L&D, the argument by the developed countries is fueled by concern for new resource commitments and a legal requirement for compensation. And the developed countries have been reluctant to accept L&D as a part of the global negotiations.

L&D has acquired importance with the establishment of the Warsaw International Mechanism for L&D in 2013. For the LDCs and developing countries to effectively take advantage of this process and transit to addressing climate risks comprehensively, they need to be able to first assess climate risks as they relate to L&D. This report is an effort towards that objective.

Definition of L&D in the national context: L&D for Nepal is defined based on a global discourse, emphasizing Nepal's ecological and social diversity. The proposed definition of L&D in Nepal is as follows:

"represents the actual and/or potential negative manifestations of climate change on sudden-onset extreme events, such as heatwave and extreme rainfall and slow-onset events such as snow loss, droughts, glacial retreat to which people in Nepal's mountains, hills, and Tarai are not able to cope with or adapt to as the country's natural ecosystem, infrastructure and institutions are overwhelmed, leading to the losses of life, livelihoods, including losses of cultural heritage."

L&D is conceived as economic and non-economic. Economic type includes resources, goods, and services lost that have economic value and can be quantified in monetary terms. Non-economic type involves goods and material services that cannot be bought or sold on the market and can be understood as losses of, inter alia, life, health, displacement and human mobility, territory, cultural heritage, indigenous/local knowledge, biodiversity, and ecosystem services.

Framing and operationalizing L&D: Developing a conceptual framework for L&D to serve as a tool will be critical to advancing L&D action in developing countries and LDCs. This is because increasing vulnerability and higher levels of risks due to climate change will take society beyond thresholds that can limit adaptation. Such a framework will need to play two key roles: i) help operationalize a method for assessing L&D within a country context and ii) engage with the UNFCCC process. The parties to the UNFCCC acknowledge that L&D should include, and, in some cases, involve impacts that can be reduced by adaptation and those that cannot be. It is also argued that the focus of L&D should be on those climate-related risks where physical and socio-economic limits to adaptation are breached and to be able to do that many challenges and questions need to be addressed if L&D is to be operationalized.

Methodological framework for assessing L&D: Climate-induced L&D manifests itself as a cascading effect across interconnected natural and human systems and infrastructure, resulting in the cessation of services. In addition, the events also directly hit those who face death, injuries, and diseases, and trauma in rapid-onset events, and displacement in slow-onset events. The core components of the proposed framework include slow-onset and rapid weather extremes; exposure and vulnerability; risks of climate change impacts; the assessment of L&D from the perspectives of unavoidable impacts, avoided impacts, and not avoided impacts. The framework looks into adaptation limits and the constraints of adaptation. To develop a mechanism for assessing L&D, there are key steps to follow. It starts from identifying indicators for assessment, collection of data, analysis of data, and interpretation. This leads to offer a pathway to assess climate-induced L&D which includes i) Assessment of climate-induced events: Trend and scenario assessment; ii) Assessment of exposure, vulnerability, and risks; iii) Assessment of the success, and limits of adaptation and disaster risk reduction; iv) Assessment of direct losses; and v) Assessment of economic and non-economic L&D.

Climate-induced migration and displacement: Migration and displacement due to climate-induced disasters are increasing every year. Climate-induced migration and displacement were first mentioned in the UNFCCC documents in 2008. It broadly refers to the movement of people driven by sudden or progressive changes in weather or climate. Such movement can include temporary and permanent, seasonal, and singular as well as voluntary and forced movement of people.

Transformation approach to avoiding impacts and risks of climate-induced disasters: This includes risk assessment, risk reduction, risk transfer, and risk retention. Such approaches aim at building long-term resilience of countries, vulnerable populations, and communities to loss and damage, including in relation to extreme and slow onset events, including through emergency preparedness; measures to enhance recovery, rehabilitation and build back/forward better; social protection instruments, including social safety nets; and transformational approaches. Dealing with risk is also shifting the burden of impact to another party through insurance. Nepal has already put an integrated disaster risk financing and support model to the test. One of the more innovative projects has been the pooling of assets insurance, which began in urban areas and is now being expanded to other areas. Another initiative is to relocate high-risk settlements to a more secure location. To assist in the development of an integrated settlement in safe locations, the government is providing financial grants to purchase land in a safer location. There is an ongoing program to reconstruct 4937 households damaged by the 2020 landslides and floods. Similarly, there are requests to reconstruct more than 2000 households that have been damaged by the 2021 floods, landslides, fires including forest fires.

Besides, the government has started a process to prepare a prioritized National Action Plan for various insurance products to save assets and livelihood (such as agriculture). A farmer, for example, may contact a local microfinance institution, self-help group, or insurance company to cover some of his/her risk of crop failure. Presently, agricultural insurance covers almost all major crops and livestock products with subsidies and compensation in case of complete or partial loss or damage. Agricultural insurance covers products under categories like goats, fish, poultry, and other livestock. Crop insurance includes rice, ginger, orange, turmeric, mushrooms, other crops, and medicinal plants.

Nepal and global climate negotiations: In UNFCCC negotiations, Nepal's position is aligned with the approach to adaptation and risk management in avoiding existential threats. Nepal's quest for support to deal with the challenge by attributing all L&D to human-induced climate change will remain hard and it will be appropriate to pursue a comprehensive approach to the assessment including climate risk management considering all abnormal weather events that lead to disasters. To that end, policymakers and practitioners in Nepal are working towards systematically developing an approach that allows them to assess L&D caused by anthropogenic climate change, estimate the cost, and design and implement policies to minimize them.

Recommendations: The following recommendations are made to the relevant agencies for operationalizing L&D in Nepal:

Ministry of Forests and Environment (MoFE)*:* The development of a multi-stakeholder initiative of action research and pilots is required to institutionalize L&D assessment. The piloting should also help to answer questions about the institutional architecture, which will be used to assess climate change-related L&D in Nepal. The Ministry of Forests and Environment, and the National Disaster Risk Reduction and Management Authority (NDRRMA) are working together to develop a national coordination approach and platform for assessing, reducing, and monitoring L&D.

National Disaster Risk Reduction and Management Authority (NDRRMA**):** As per the 'Disaster Risk Reduction and Management Act, 2017 (amended in 2019),' the NDRRMA is mandated to coordinate with ministries, departments, academic institutions, international agencies, and other stakeholders on activities related to multi-hazard risk assessment, risk communication, and disaster risk reduction. It also compiles and manages the BIPAD portal (https://bipadportal.gov.np/), a national common platform. Risk data, information, and data on hazards, exposure, and vulnerability are compiled and shared in open-source formats to help key development sectors, provincial, and local governments make risk management decisions.

In collaboration with DHM, NDRRMA has begun to generate flood and landslide impact forecasting. The proposed landslide and flood rainfall thresholds are a good start, but they must be combined with other triggers and ambient land conditions to create a combined general landslide and flood threshold that can be used to make more accurate impact-based forecasting.

Department of Hydrology and Meteorology (DHM)**:** DHM must make climate science research a priority. It must combine weather data such as temperature, rainfall, and wind to feed into the L&D assessment. It must also focus on climate modeling and examine the impact of climate change on various sectors in collaboration with other agencies. Data from DHM's radars, high altitude monitoring stations, and automatic weather stations must be used regularly to refine and align regional and global scenarios for use in hazard assessment and Climate Change Trend and Scenario analysis.

In the past, the government has made substantial investments in flood warning systems, which helped to reduce the number of people who died. Assessing the benefits of such systems in preventing L&D will be beneficial.

Department of Mines and Geology (DoMG)**:** All landslide hazard assessments in Nepal, including landslide susceptibility, are conducted, and coordinated by the DoMG. To determine landslides L&D, DoMG should take the lead in utilizing landslide hazard data.

Department of Water Resources and Irrigation (DoWRI)**:** The DoWRI is responsible for conducting and coordinating all flood risk assessments in Nepal. To establish flood-related L&D, flood hazard information should be collected by DoWRI.

Department of Forests and Soil Conservation (DoFSC)*:* The department uses satellite imagery to manage forest fire observations. It also provides technical and financial assistance to communities to help them manage forest fire risks. Given the context of climate change and the recent increase in fire hazards, the DoFSC needs to improve its monitoring system.

Provincial government: Provincial government can specifically play the role of consolidating data and creating a database on L&D, coordinating with the local governments.

Rural and Urban Municipalities (Palikas)**:** Local governments play a critical role in gathering data on losses and damage, as well as responding to disasters. At the local level, a baseline profile with information on infrastructure and natural ecosystems is required to be used as a guide for calculating economic L&D, and then non-economic costs are gradually added to assess total L&D.

Other agencies: Other government agencies, such as civil society, development agencies, I/NGOs, and the private sector, need to assist the MoFE/NDRRMA/DHM in developing a database and data collection mechanisms. Furthermore, these organizations can assist the government in developing country positions based on solid evidence, as well as accessing and mobilizing climate finance to address L&D.

1. INTRODUCTION

The 2015 Paris Agreement called upon all nations together to adopt ambitious efforts to mitigate climate change-causing greenhouse gases (GHG). The agreement also calls for enhancing support for developing countries so that they can adapt to the impacts of climate change. Countries agreed to do so putting forward their best efforts through Nationally Determined Contributions (NDCs) and vowing to strengthen them in the future in five-year cycles. Countries with an NDC timeframe ending in 2025 are required to communicate a new set of commitments by 2020 (UNFCCC 2019). Similarly, countries with NDCs ending in 2030 are asked to communicate or update their NDCs by 2025. The Government of Nepal (GoN) has already submitted its second NDC in 2020.

GoN envisions achieving socio-economic prosperity building a climate-resilient society. To this end, the country submitted Nepal’s second NDC in 2020 to meet the stipulation of the Paris Agreement. The major objective of the second NDC is to raise Nepal’s national ambition for mitigation and adaptation, set clear, time-bound targets for each, consider associated costs, and draft investment plans as well as an implementation roadmap. According to the GoN’s preliminary outline, the second NDC will run to 2030 (10-year targets), where activities can be made more concrete and achievable, both 2025 and 2030 targets are included. Besides, following Article 4, paragraph 19 of the Paris Agreement, Nepal is formulating a long-term low GHG emissions development strategy by 2021. The strategy will present a vision towards net-zero GHG emissions and a resilient economy.

A critical area of interest to GoN as part of the NDC revision is assessing climate-induced loss and damage (L&D). Nepal's Climate Change Policy 2019 also emphasizes the need to conduct research on L&D associated with climate change impacts and implement measures to reduce climate change-related vulnerabilities. Another step in this process is the preparation of a National Adaptation Plan (NAP) that aims to reduce the country’s vulnerability to climate change and facilitate the integration of climate change adaptation in policies, programs, and activities across all sectors and levels. The NAP process considers the country’s climatic and geographic characteristics as well as opportunities and challenges associated with climate adaptation and development.

L&D assessment is important for Nepal's NDC on multiple levels. First, methods of assessing L&D provide the means to ascertain the severity of a climate change spawned disaster in a natural environment and on affected people. L&D assessments should be people-centered and include comprehensive and differentiated information, not a simple stocktaking of impacts. An L&D assessment can only adequately reflect a post-disaster situation if it recognizes the plight of the affected population and provides a strong basis for policies to avert, minimize and address L&D in the future. In doing so, it can also provide significant input for efforts to adapt to climate change. Second, L&D research needs to ascertain the degree to which climate-related events can be attributed to anthropogenic climate change. This knowledge plays a key role in policymaking, as it can be argued that climate events that can be identified as having anthropogenic causes may require appropriate remedies. Third, L&D research is relevant for compensation, relief, and reconstruction following a disaster, including climate induced. As the methods employed by L&D research aim to evaluate the ‘true’ effects that a climate-induced disaster has had on an affected population, they can be a valuable tool to measure the amount of compensation an affected household may claim from a climate insurance plan or the amount and type of relief required during the post-disaster period and facilitate recovery.

1.1 OBJECTIVES AND RATIONALE

L&D is a local manifestation of the global phenomenon which in turn has its geneses in the historical emission of GHG by the developed countries. The rising concentration of GHG in the atmosphere which leads to a rise in average global temperature has also caused local weather systems to be more erratic than in the past and, in the longer term, climate is changing. This change has consequences on temperature and precipitation: occurrence, for example, of extreme precipitation and frequent droughts. The changes have consequences on hazards like landslides, floods, snowmelt, glacier retreat, and forest fires. The impacts cascade through the local and regional hydrological cycle with consequences on the dependent social and economic contexts. The assessment of L&D thus has to aim to balance local context with the global processes related to climate change, particularly under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC).

It is important to assess how these local realities juxtapose with the global discourse on L&D and its assessment. Answering the question can help identify existing systemic barriers in countries like Nepal to develop a practical approach to deal with climate change-related L&D. By presenting local complexity in assessing L&D due to climate change, a case can be made for considering L&D as a part of a comprehensive disaster risk reduction effort.

This study has attempted in assessing potential L&D due to climate change in Nepal. The method could help in the costing of adaptation and risk reduction efforts at national, provincial, and local levels. It will be useful for mapping the financial investments required to implement disaster risk reduction and climate adaptation actions. It also aims to strengthen policies aimed at reducing climate-induced L&D in the country and support Nepal's second NDC and NAP. It intended to support policymakers in appreciating the challenges involved in the assessment process, the need for taking measures to develop a system that will help deal with the residual impacts of climate-related stressors that cannot be or have not been avoided. The specific objectives are:

- Develop a commonly agreed-upon standard methodological framework for L&D assessment, building on successful and replicable national and international concepts and practices as well as limitations.
- Use nation-wide available L&D data on both economic and non-economic losses from climate-related events to suggest an assessment process by analyzing the current trend and future scenarios of L&D.
- Propose an approach to use the proposed process for engaging both domestic and global climate negotiations and dialogue.

It is important to look into climate change challenges on top of the already existing development challenges in Nepal. For example, exploring the linkage between climate change and road development, climate change, and urbanization, and climate change and overall development is key. We need to understand that Nepal already faces major challenges in balancing development needs with environmental conservation (ADB, 2020) and that climate change will make it more serious.

This assessment aimed to provide an answer to the additional scale of the support required to address severity and vulnerability. By doing so, we can find an answer to what Nepal needs to do to build resilience and minimize climate change-induced L&D. We look at the challenge of attribution— historical versus current impacts to generate evidence to demonstrate that this approach can be publicly acceptable with the backing of additionality data. Establishing a standardized data system is a prerequisite for assessing L&D and using it as a basis to secure additional climate finance support.

1.2 METHODOLOGY

The study used a review of literature and consultation with relevant stakeholders as major methods for collecting information and data. Specifically, it used the following methodological processes.

- Reviewed national and international legal and policy documents related to L&D and the policy directions in understanding L&D
- Reviewed the existing literature with regards to the commonly practiced methodology for assessing climate-induced loss and damage
- Discussed with relevant stakeholders and captured their views and suggestions on the concept and methodology.
- Due to the COVID-19 lockdown, virtual consultations were held with officials of the GoN and other stakeholders. Some of the local level consultations could not be held and were managed through virtual means. The methodology also involved regular consultations with the MoFE- CCMD, and PIF team whose support has been key.
- Developed drafts of a scoping paper for defining climate-induced L&D in the context of Nepal and a methodological framework for assessing climate-induced L&D (loss and assessment indicators; methodology and set of procedures for climate-induced L&D data collection, assessment, and analysis). The methodology was designed to provide a clear definition of what type of information needs to be collected and how it should be analyzed.
- Proposed a mechanism for assessing L&D, reviewed, and suggested indicators that will form the basis for the assessment.
- Organized a national workshop to share the draft and receive feedback.

1.3. Limitations

This study focused more on defining L&D in the country context and providing a framework for the assessment. Although a few examples are cited in this document, it was difficult to assess climate-induced L&D for three reasons. First, the ability to attribute impacts to specific weather events has not been established except for glacier melting and its impact. Second, there is no globally accepted approach to assessing climate change-induced L&D. Third, lack of systematic data on economic and non-economic loss and damage. All three reasons create wrangling in global negotiations, where legal and political imperatives are likely to make L&D a means to support developing countries face a major hurdle.

One of the important aspects of the future L&D assessment is to establish a robust database system that captures both economic and non-economic L&D and covers every aspect of it. It is also important to come up with scenarios for climate-induced hazards in terms of quantifying how it will change in the future and the likelihood of their impacts in terms of L&D.

2. LOSS AND DAMAGE: GLOBAL PROSPECT

2.1. Evolution of Loss and Damage

As the pace of anthropogenic climate change continues to rise, the impacts are starting to manifest themselves through higher intensity and more frequent rapid onset extreme weather events, and greater impacts from slower onset weather events. These impacts are already being felt and hitting marginalized and vulnerable people the most. The fact that the climate is becoming more extreme and causing more L&D in the present points to the fact that climate justice needs to be a principal component of humanity's response to climate change and that addressing L&D is a critical element of addressing climate justice.

Interest in L&D is increasing in global climate change negotiations, research, and policy, and the implementation of climate change actions. It is also being discussed in the context of formulating NAP and revising the NDC report as mentioned above. However, research on L&D remains largely uncharted territory, though it is framed as the actual and/or potential manifestation of impacts associated with climate change in developing countries that negatively affect human and natural systems. This fact has implications for both the policy and practice of addressing L&D at the country level.

L&D is not a recent phenomenon in global climate negotiations. During the establishment of the UNFCCC in the early 1990s, the Alliance of Small Island Developing States (AoSIS) submitted a proposal that included the concepts of insurance for losses from sea-level rise and compensation for climate impacts. Over the years, however, L&D has been a politically sensitive topic where consensus-building has been difficult in the global dialogue on climate change.

Discussions about L&D have been polarized between developed and developing countries, especially around notions of compensation and liability for L&D from climate change. Fueled by the concern of new resource commitments and a legal requirement for compensation, developed countries have been reluctant to accept this agenda as part of the global negotiations. Developed countries have often argued that L&D is a part of adaptation, while AoSIS and Least Developed Countries (LDCs) have claimed that the agenda of L&D should be a separate item, the third pillar of climate negotiations (adaptation and mitigation being the other two).

While the concept of L&D has been used implicitly since the beginning of climate change negotiations, it has acquired particular importance with the establishment of the Warsaw International Mechanism (WIM) for Loss and Damage in 2013 (see Table 1 on the history of L&D in the UNFCCC process) (UNFCCC, 2019; Doktycz and Abkowitz, 2019). This was primarily due to calls from Small Island Developing States (SIDS) and LDCs, which stressed that while they were the most impacted by climate change their responsibility was limited. In this context, L&D has been implicitly defined as "the actual and/or potential manifestation of impacts associated with climate change in developing countries that negatively affect human and natural systems". This includes, in particular, the impacts of extreme events (e.g., heatwaves and floods) and slow-dynamic changes (e.g., sea-level rise, glacier, and ice retreat).

As discussions around climate crises and climate emergency gain credence, L&D, due to the adverse impacts of climate change, have become increasingly relevant for international climate policy and advocacy. For LDCs and developing countries to effectively take advantage of this process and transit to addressing climate risks comprehensively, they need to be able to first assess climate risks as they relate to L&D.

Several reports highlight the increasing risk of climate-induced L&D. These are: i) the Intergovernmental Panel on Climate Change's (IPCC) Special Report on 1.5˚C (IPCC 2018), ii) the 2019 Special Reports on Climate Change and Land (SRCCL), iii) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) (IPCC 2019 a,b), and iv) the 2018 Hindu Kush Himalaya Assessment Report that summarizes evidence on the risks and impacts from climate change in the Hindu Kush Himalaya (HKH) regions (Wester et al., 2019). All reports point to a potential existential and irreversible trend and provided further traction to this policy agenda of L&D.

Table 1: The history of L&D under the UNFCCC process

1991	Vanuatu, on behalf of AoSIS tabled a proposal for an insurance facility for SIDS to compensate for sea-level rise.
2007	Parties to the convention during COP13 agreed in the Bali Action Plan to explore 'means to address loss and damage associated with climate change impacts in developing countries particularly vulnerable to the adverse effects of climate change'.
2008	During COP 14 in Poznan, AoSIS submitted a proposal for a multi-window mechanism for an international L&D mechanism.
2010	During COP 16 in Cancun, parties agreed to establish a 'work program to consider approaches to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change'. This program was housed within the 'Cancun Adaptation Framework'.
2011	Relevant knowledge on L&D is shared and synthesized in COP 17.
2012	The role of the COP in addressing L&D is agreed upon in COP 18.
2013	During COP 19 in Warsaw, parties agreed to establish WIM for L&D and its executive committee. WIM was meant to be the main mechanism under the UNFCCC for addressing L&D in a 'comprehensive, integrated and coherent manner'.
2014	The work plan and the organization of the executive committee are approved in COP 20.
2015	In Paris, WIM was anchored in the Paris Agreement through Article 8. Parties agreed to 'averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.' Gave mandates for establishing a clearing house for risk transfer and to establish a task force on displacement.
2016	The first review of WIM was conducted during COP 22.
2017	The Fiji Clearing House for Risk Transfer and the Task Force on Displacement was launched during COP 23.
2018	Task Force recommends integrated approaches to avert, minimize and address displacement in COP 24.
2019	The second review of WIM was conducted during COP 25 in Madrid, Spain, where parties sought to strengthen WIM helping to improve collaboration and coordination inside and outside the convention and to scale up resources, action, and support to developing countries. The Santiago Network to catalyze support to developing countries for L&D was also established.

Source: www.unfccc.int

2.2. Differing Perspectives on Loss and Damage

Scholars on L&D have also grown in the last decade, with a focus on understanding the economic losses of climate change, looking beyond adaptation, and further explaining what L&D could mean (McNamara and Jackson, 2018). The IPCC has included a three-page text box on 'Residual Risks, Limits to Adaptation and Loss and Damage' in its SR 1.5˚C report (Mechler, Singh and Ebi, 2020), the first time the IPCC reviewed scientific literature on L&D (Shinko et al., 2019).

Developing countries in the UNFCCC negotiations consider L&D as distinct from adaptation, treat climate change negotiations as an appropriate forum to discuss L&D, hold developed countries liable for L&D; and call for compensation (Huq et al., 2013). Developed countries, on the other hand, as mentioned earlier, do not recognize L&D as distinct from adaptation and avoid references to compensation and liability.

A political settlement was reached at the COP 21 in Paris in 2015 and L&D was institutionalized within the UNFCCC architecture. However, its formulation is still ambiguous and vague. It is not clear what L&D means for it to be applicable in practice. A UNFCCC literature review defined L&D as "the actual and/or potential manifestation of impacts associated with climate change in developing countries that negatively affect human and natural systems" (UNFCCC, 2014). The WIM text is ambiguous as it is all-encompassing, but it does include language on specific L&D measures, comprehensive risk management, non-economic losses, and particularly mentions vulnerability.

In the Paris Agreement, L&D is more 'tightly constrained.' For the first time, L&D is separated from adaptation in its article (Article 8), which conflicts with some core aspects of adaptation. Conversely, the Paris decision text explicitly states (in paragraph 51) that Article 8 does not involve liability and compensation…though permanent and irreversible losses are mentioned…' (Boyd et al., 2017). Some have suggested that the relative ambiguity has helped different actors ascribe their understanding to the concept (Calliari, 2016). Table 2 lists the distinct typologies of perspective on L&D based on expert interviews of UNFCCC supported actors (Boyd et al., 2017).

Table 2: Typologies of perspectives on L&D

Perspective	Implications for practice	Implications for research: How to improve our understanding of L&D?	Implications for finance: How to finance L&D?
Adaptation and Mitigation	Mitigation and adaptation.	All climate change impacts are potential L&D; therefore, we must continue research efforts to understand climate change impacts (e.g., climate change risk assessments for adaptation, climate services).	L&D does not require additional funding beyond existing climate finance.

Risk Management	Comprehensive risk management. Suggestions from interviewees include insurance, insurance pools, catastrophe bonds, life insurance, disaster risk reduction (DRR), sovereign disaster risk rating, climate services and early warning, engineering, and capacity-building.	Integration of disaster risk assessment with climate change risk assessment. Analysis of risk management tools to identify gaps.	Emphasis on insurance schemes and private sector finance.
Limits to Adaptation	Focus on options or contingency plans for vulnerable people. Interviewees emphasized risk transfer, social safety nets, micro-insurance, innovations in livelihoods (early warning), and participation.	Analysis of what is beyond adaptation. Research is done with vulnerable people to identify limits, monitoring, and evaluation for adaptation, climate change risk assessment with estimates of adaptation pathways, and limits.	Emphasis is not generally on finance.
Existential	Focus on mitigation to avoid L&D and ex-post measures to address loss, including compensation, migration facilities, homeland resettlement, acknowledgment, official apologies, memorials, historical preservation, and international litigation.	Analysis of the probability of and vulnerability to, permanent, irreversible, long-term, unavoidable changes. Assessment of L&D, which has already occurred. The research was done with vulnerable people to understand and anticipate loss, particularly non-economic loss (e.g., post-traumatic stresses induced by events, loss of identity, or sense of place).	Associated with calls for compensation, but the emphasis that this is not the only or even the most important aspect of addressing L&D.

2.3. Relevant Terminologies

Terms such as risks, hazards, exposure, capacity, vulnerability, adaptation, and mitigation are commonly used in all efforts to deal with climate change-induced L&D though they have varying meanings within different epistemic communities. While hazard, exposure, and capacity can be treated straightforwardly, risk and vulnerability present analytical challenges. From a scientific perspective, the risk is considered as a probability of events in a geographical area. Risks are also socially constructed, and risk perceptions vary depending upon one's worldview (Rayner and Malone, 1998). The terms adaptation in climate change and mitigation in disaster risks imply a similar connotation. In the reduction of GHGs, mitigation is commonly used.

The key terminologies related to L&D are explained below: (Source: Doktycz, C., & Abkowitz, M., 2019)

Adaptation constraints: Factors that make it harder to plan and implement adaptation actions or that restrict options.

Adaptation limit: The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions. *Hard adaptation limit:* No adaptive actions are possible to avoid intolerable risks. *Soft adaptation limit:* Options are currently not available to avoid intolerable risks through adaptive action.

Adaptation deficits: The lack of timely action and support.
Extreme events refer to landslides, floods, debris flow, GLOFs, hailstones, wildfire along with droughts, and heatwaves in the context of Nepal.

Loss is considered as the negative impact that prohibits restoration or reparation. Damage is the negative impact that permits restoration or reparation.

***Tangible cost*:** Tangible cost is the quantifiable cost that is associated with distinguishable assets. Damage to infrastructures and property such as cars, livestock, crops, business interruptions, costs for relocation, are some examples of tangible costs.

Direct tangible cost: Direct tangible costs are considered those that occur as a direct result of the physical impact of the event on assets and property (e.g., cost per square foot of residential housing).

Indirect tangible cost: Business interruption, relief efforts, lost tourism, relocation costs, disruption to transportation, and diminished living conditions are indirect intangible costs.

Intangible cost: Intangible costs cannot be quantified or easily estimated because of the subjective nature of the variables involved. Putting a dollar value on environmental degradation can include several considerations and is complex. Physical injuries, social disruption, and challenges in post-disaster recovery are intangible.

Direct intangible cost: Direct intangible costs occur as a result of the physical impact of the event on the subjective variables that are difficult to value monetarily. Examples: loss of life, productivity loss, the decline in employee morale, loss of brand value, or damage to brand equity.

***Indirect intangible cost*:** Indirect intangible costs are triggered by placing subjective value on a circumstance or event in an attempt to quantify the direct impacts. Social disruption, challenges in post-disaster recovery, and cultural impacts are some examples of indirect intangible costs.

***Risk mitigation costs*:** Risk mitigation costs signify the expenditure incurred to achieve a reduction in L&D when an extreme event is experienced. Common risk mitigation costs comprise funding for (1) administrative practices, (2) land-use preparation, (3) hazard reforms,

(4) infrastructure, (5) prior communication of events, (6) emergency response and evacuation, (7) financial incentives, and (8) risk transfer (e.g., insurance).

Slow-onset events refer to the events that take place over longer time frames (typically years to decades). Examples are sea-level rise, salinization, ocean acidification, coastal erosion, desertification, loss of biodiversity, and glacial retreat, etc.

The above definitions are useful but, in a situation, where the basics need to be established, they can make the task of assessing L&D complicated. In this report, L&D can be understood in two forms: Economic Loss and Damage and Non-Economic Loss and Damage. The differences are presented in Table 3 and the text below.

Table 3: Difference between economic and non-economic L&D

Non-Economic Loss and damage	**Economic loss and damage**
Individuals: life, health, human mobility	Income: Business operations; agricultural production (crops yields, livestock fisheries); Tourism
Society: territory, cultural heritage, indigenous knowledge, societal Cultural identity	Physical assets: infrastructure (buildings, bridges, roads, railways, irrigation canals, reservoirs, trails, power generation stations, dams, dykes, etc.), property (house, land, etc.)
Environment: biodiversity, ecosystem services	

Source: UNFCCC, 2013/Frankhauser, and Dietz, 2014; Andreni et al., 2015; Morrissey and Oliver-Smith, 2013

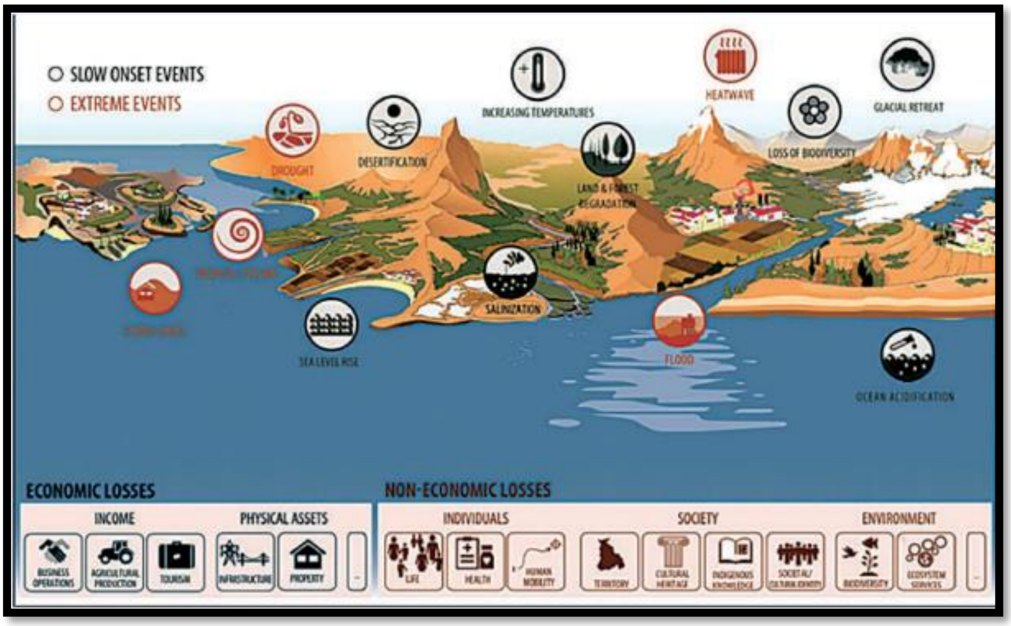


Figure 1: Concept of Climate-induced Loss and Damage

Source: UNFCCC, 2018[1]

Economic Loss and Damage (ELD): Economic losses are defined by the UNFCCC as "losses of resources, goods, and services that are commonly traded in markets." (UNFCCC, 2013b: 3). It categorizes economic loss and damage into five types: business operations, agriculture production, tourism, infrastructure, and property (See Figure 1). It can be further classified as direct loss and indirect loss. Direct loss is caused due to contact with

[1] https://unfccc.int/sites/default/files/resource/Online_guide_on_loss_and_damage-May_2018.pdf

disasters. Examples of direct loss include buildings, cars, livestock, crops, infrastructure, etc. The indirect loss has no contact and causes as a consequence of the disaster.

Non-Economic Loss and Damage (NELD): By contrast, non-economic losses are understood as losses that involve goods and material services that cannot be bought or sold on the market (Morrissey & Oliver-Smith, 2013). According to the UNFCCC, "Non-economic losses are additional to the loss of property, assets, infrastructure, agricultural production and/or revenue that can result from the adverse effects of climate change. It covers loss and damage that are not easily quantifiable in economic terms, such as loss of life, degraded health, losses induced by human mobility, as well as loss or degradation of territory, cultural heritage, indigenous knowledge, societal/cultural identity biodiversity, and ecosystem services (UNFCCC, 2013). NELD is dynamic, contains multiple values, and is hard to account for and monetize. Their assessment presents conceptual, ethical, and empirical challenges. Broadly, NELD has not been used in the assessment of diverse impacts of climate change, and in designing compensation mechanisms, and in insurance.

There have been attempts to develop working definitions of L&D. One such definition is that 'L&D is the adverse effects of climate-related stressors that cannot be or have not been avoided through mitigation or managed through adaptation efforts' (Zommers et al., 2016). L&D is defined as adverse effects of climatic stressors resulting from inadequate efforts to reduce greenhouse gas emissions and insufficient capacity to reduce the risks associated with climatic stressors, to cope with impacts of climatic events, and to adapt to climatic changes (Van der Geest and Schindler, 2017). Other analysts define L&D from the disaster risk management perspective, covering responses from individual hazard events to system risks. Such responses could include measures such as watershed conservation, improvement of community access to information on extreme weather events, and capacity to use that information in a local level forewarning.

This perspective, discussed above, on L&D could help in developing a framework that is useful to local governments and sector-specific, sub-national, and national-level actors. Though concerns over uncertainties and data gaps remain, climate change will result in both economic and non-economic L&D. It will be necessary to develop a conceptual framework of L&D that includes these impacts on humans as well as to other natural systems to guide assessment practice.

2.4. Global Framing of Loss and Damage

The different frames presented between 2003 and 2013 give an overall picture of how the L&D issue has been discussed over time. Before 2009, the issue tended to be discussed either in terms of an "insurance and risk transfer" frame or a "compensation and liability" frame. This changed dramatically after 2008, when a broader, more ambiguous "loss-and-damage" frame emerged, in part because of the Bali Action Plan language negotiated in 2007 (Vanhala and Hestbaek, 2016). Debates around "L&D" from anthropogenic climate change have expanded rapidly since the adoption of WIM for Loss and Damage in 2013.

In recent years, there have been important contributions to the L&D debate, especially by (i) framing it through a disaster and climate risk management perspective (Birkmann and Welle, 2015; Mechler and Schinko, 2016); (ii) looking at the connection between L&D and the limits to adaptation (Warner and van der Geest, 2013, 2015); (iii) and outlining how attribution studies could support the assessment of L&D (Huggel et al., 2013).

Despite the urgent need for scientific best practices to inform policies to avoid, minimize and address L&D, the international framing faces internal disagreements and lacks a coherent conceptual framing, which hinders scientific progress and practical implementation (Boda et al., 2020). Developing a conceptual framework for L&D to serve as a heuristic tool will be critical to advancing L&D action in developing countries. Such a framework will need to play two key roles: i) help operationalize a method for assessing L&D within a country and ii) engage with the UNFCCC process. Some work has been done globally to develop such a framework. A few relevant frameworks are explained below:

Framework one: This concept refers to the negative effects of climate variability and climate change that people are not able to cope with or adapt to (Warner and Van der Geest, 2013) (Figure 2). The authors argue that data is necessary on i) climate stressors (variability and change), ii) societal impacts, iii) responses (adaptation), and IV) residual L&D (limits to adaptation). They identify four L&D pathways:

- Adaptation is not enough to avoid L&D.
- Measures have costs that are not regained.
- Measures are erosive and maladaptive creating further vulnerability.
- No measures are adopted (due to limits to or constraints on adaptation).

Framework two: A second framework (Figure 3) identifies four distinct typologies of perspectives on L&D as listed in Table 1.2 (Boyd et al., 2017). These perspectives create a useful method to understand the different ways that different actors conceptualize L&D. However, the framework offers little practical way forward.

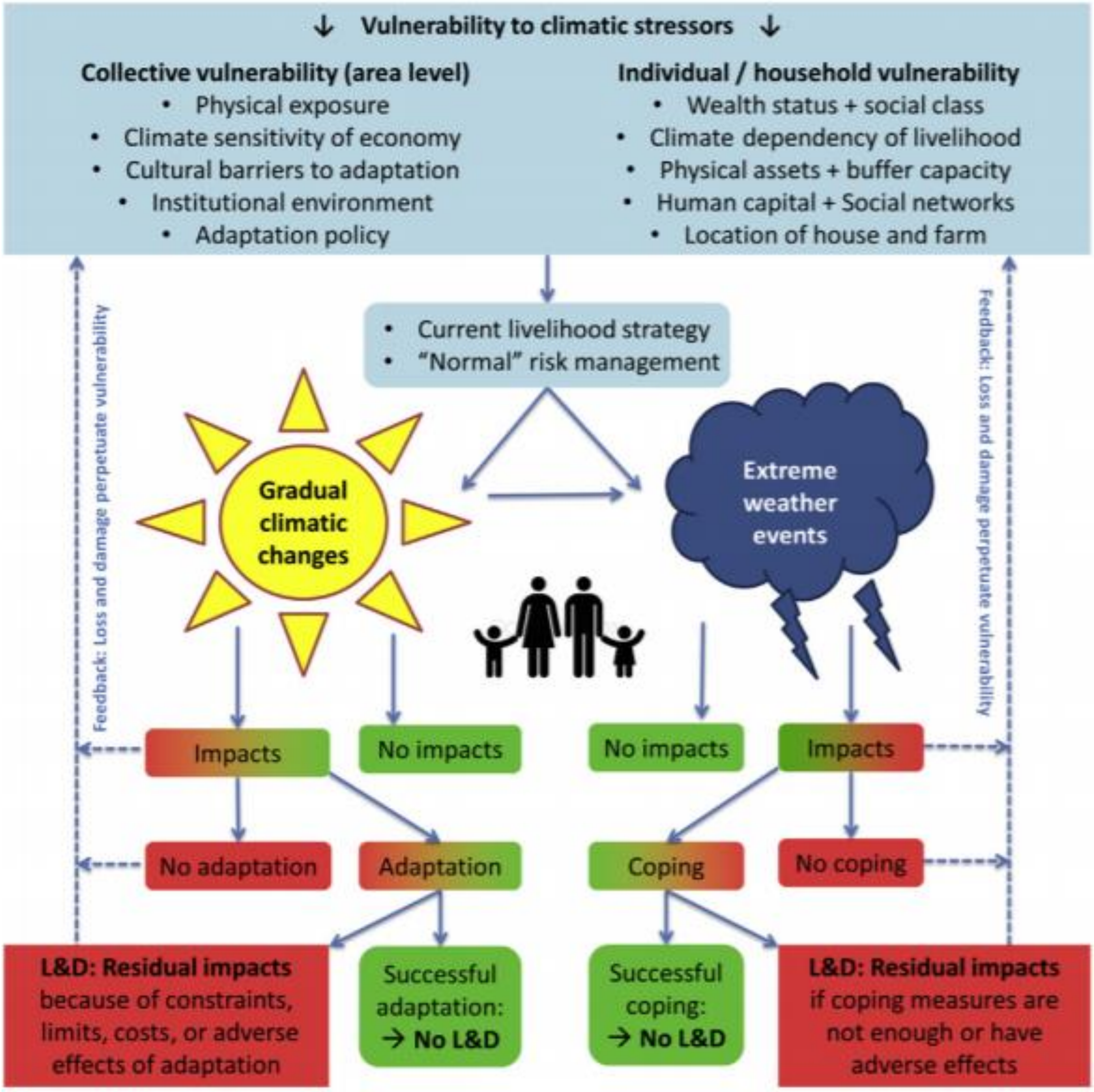


Figure 2: Conceptual framework: Linking loss and damage to vulnerability, risk management, and adaptation

Source: Van der Geest and Schindler, 2017

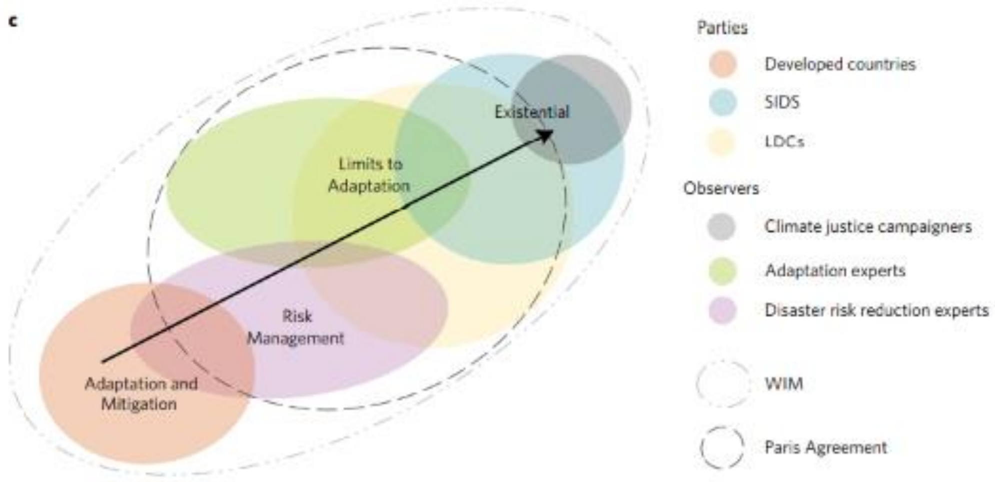


Figure 3: Distinct typologies of L&D

Source: Boyd et al. (2017)

Framework three: Several challenges to the operationalization of L&D arise. One is the current limitation in attributing L&D to a specific climate event and the other is a stalemate in global climate negotiations. Though there is scientific consensus that human actions lead to greater emission of GHGs and exacerbate climate-related risks, overcoming these twin limitations is not easy. The Climate Risk Management Framework (CRM) (Figure 4) suggests that by addressing existing climate variability and extreme weather events in the short term, the process of assessing L&D could be initiated (Schinko and Mechler, 2017). The CRM would help mainstream climate change impacts into the process of assessing L&D as new scientific evidence continues to emerge. The CRM Framework can address the root causes of vulnerability and thus help build the resilience of communities, livelihoods, and ecosystems. It can develop and implement policies to minimize L&D despite difficulties in attributing specific weather events to climate change (Roberts and Pelling, 2018). At the same time, the identification of options for practical adaptation actions and limits to adaptation remain key challenges to overcome in dealing with climate change-induced L&D.

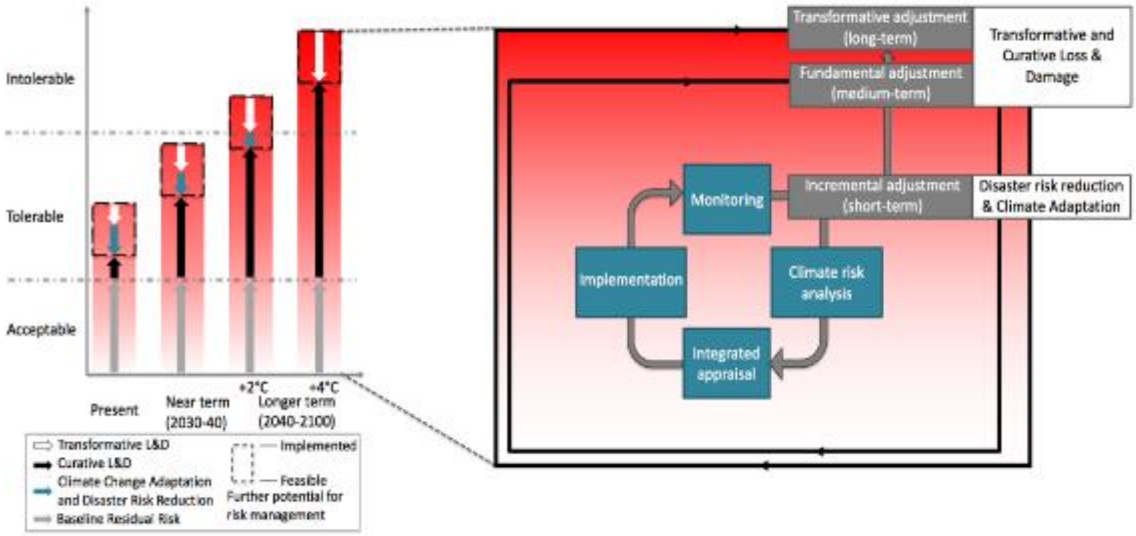


Figure 4: Dynamic framework for assessing and managing climate-related risks

Source: Mechler, R., Bouwer, L.M., Schinko, Th., Surminski, S., Linnerooth-Bayer, J. (Eds.)

Framework four: Figure 5 illustrates how past risk from extreme weather has increased, and how this risk can be reduced or avoided through disaster risk reduction (protection and prevention). There will always remain a residual risk (see also a chapter by Schinko et al., 2018), which cannot be reduced in a cost-efficient way, i.e., the costs of eliminating the risk are considered higher than incurring the costs. However, current risk has increased by increasing exposure, and possibly by anthropogenic climate change. Part or all of this risk is related to the L&D debate, depending on whether or not residual impacts are considered to be included. Future risk will increase further due to anthropogenic climate change, leading to an increasing number of losses and damages, not addressed by disaster risk reduction and adaptation. However, as vulnerability is likely to be further reduced, the share avoided by disaster risk reduction and adaptation will also increase. The losses and damages after adaptation include unavoidable losses and damages, potentially including the residual risks that will remain.

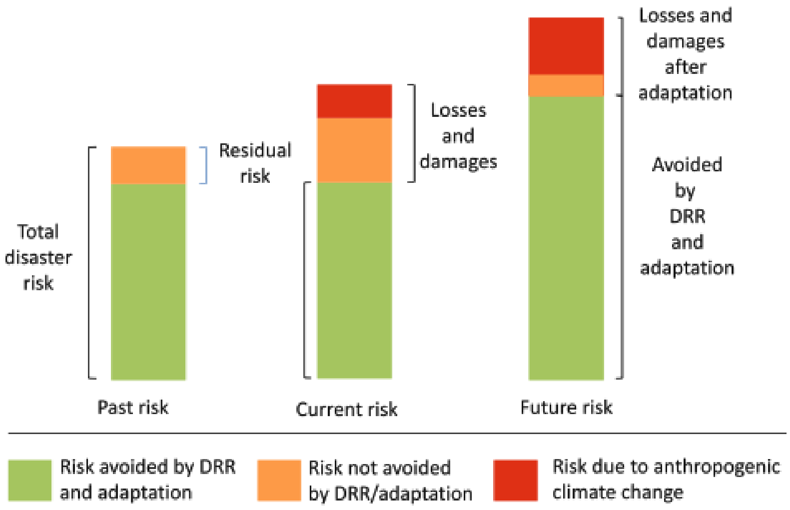


Figure 5: Current and future risk from extreme weather events, and the relation to Loss and Damage

Source: Bouwer, L. M., 2019

Framework 5: Figure 6 depicts the framework developed by GIZ as part of their global risk assessment and management program for climate change adaptation (Loss and Damage). The framework and process are designed to promote a risk-based approach to L&D management. This approach assists public and private sector decision-makers in better prioritizing, funding, and implementing options by analyzing risks and identifying appropriate solutions. Continuous learning is enabled by monitoring and evaluating the implemented measures, which feeds into the CRM cycle and informs future decisions.

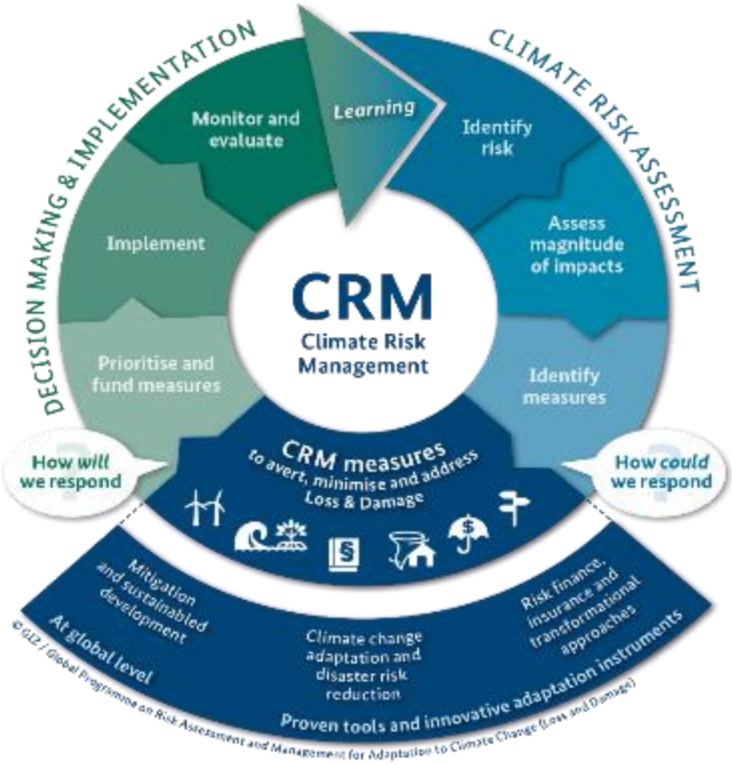


Figure 6: CRM Framework to deal with climate-related Loss and Damage

Source: Siebert, 2019 (giz2020-en-comprehensive-climate-risk-management.pdf)

3. OPERATIONALIZING LOSS AND DAMAGE

3.1. Operationalizing Loss and Damage

The parties to the UNFCCC acknowledge that L&D should include, and, in some cases, involve, impacts that can and cannot be reduced by adaptation. It is also argued that the focus of L&D should be on those climate-related risks where physical and socio-economic limits to adaptation are breached. When do these happen and at what threshold? The answers are not clear. Adaptation encompasses the capacity to recover from a hazard impact, build back better, and remain in a position to minimize L&D. Yet L&D from hazards are inevitable because both the character of hazards and societal exposure to them are changing. At the same time, increasing vulnerability and higher levels of risks due to climate change will take society beyond thresholds that can limit adaptation. As a result, numerous challenges and questions need answers if L&D is to be operationalized. Some of them include the following:

1. **Uncertainty about the future climate and its impacts**
    a. What are the patterns of local changes in weather and climate variability?

2. **The unequal impact of climate change across time and space**
    a. How do different climate stressors impact societies?
    b. Who is most vulnerable to these impacts, and why? Given the primacy of justice framing, why are women and other vulnerable groups often at the receiving end of L&D?
    c. How does the impact of a climate variable on society lead to L&D among individuals and households in a geographic area?
    d. How can impacts on ecosystems, health, security, biodiversity, and loss of cultural identity best be measured and addressed?

3. **Adaptation measures, adaptation limits, and residual losses**
    a. How can the hard and soft thresholds at which impacts exceed adaptive capacity be identified?
    b. How is residual L&D related to adaptive capacity? How can it best be linked to disaster mitigation as well as to the suitability of proposed adaptation options?
    c. What specific adaptation measures address the needs of the most vulnerable section of the population?

4. **Attribution to climate change**
    a. How can L&D from specific weather events be attributed to anthropogenic climate change?
    b. How can L&D from climate change-induced hazards be separated from L&D triggered by other non-climatic hazards?

The above questions are equally important for Nepal in operationalizing the assessment of L&D. There are no clear answers.

3.2. Definition of Loss and Damage in National context

As mentioned above, many global-level studies rank Nepal as one of the high-risk countries due to climate change and vulnerability to climate-induced disasters. While lessons of the studies may be fragmented to provide a substantive articulation of cause and effect as well as the role of other factors such as human intervention, governance, and institutional capacity to respond to the impact and build back better, the increasing influence of uncertain climate is clear (Gautam, 2020).

The social context brings to the fore the limitation of adaptive action to climate change. Crop diversification is an example. Diversification is suggested as an adaptation strategy to changing climate but also reflects the challenge of such a singular strategy. It is problematic in Nepal's diverse and differential social context. Nepal has thousands of small landholders and landless households. The landless have no option to crop diversification and small landholders when faced with stress many times borrow food from a wealthier neighbor, money lender, or even sell off their assets such as livestock to deal with the stress (Man, 2019).

The diversification practice is not adaptation (if adaptation is conceived as doing well when faced with stress) but coping (defined as barely surviving). Such farmers also face unequal power relations and socioeconomic marginalization. Many smallholding farming families face indebtedness that lowers their well-being. To this, climate change impacts add a new layer and push them further into vulnerability. While climate change will affect most Nepali people, the extent of its impact will vary among households living in the country's diverse ecological regions (Mountain, Hills, and the Tarai). It will affect more those in the lower social and economic bracket.

In this backdrop, L&D for Nepal is defined based on global discourse by emphasizing Nepal's ecological and social diversity. The proposed definition of L&D in Nepal is as follows:

"represents the actual and/or potential negative manifestations of climate change on sudden-onset extreme events, such as heatwave and extreme rainfall and slow-onset events such as snow loss, droughts, glacial retreat to which people in Nepal's mountains, hills, and Tarai are not able to cope with or adapt to as the country's natural ecosystem, infrastructure and institutions are overwhelmed leading to the losses of life, livelihoods, and cultural heritage."

3.3. National Framework for Loss and Damage

There are various frameworks and conceptualizations on how to assess risk and vulnerability, including quantitative and qualitative assessment methodologies (see, e.g., Wisner et al., 2004; Birkmann, 2013; International Federation of the Red Cross and Red Crescent Societies 2008; IPCC, 2012). While risk is seen as the product of the interaction between an extreme event or hazard and the vulnerability of a society or community, the term vulnerability is understood as a predisposition to be affected (see, e.g., IPCC, 2012) or as an internal risk factor (Birkmann, 2013). In this regard, the hazard or the physical event linked to climate change is seen as an external factor to the society or system exposed. In the early 1990s, Burton et al. (1993) stressed that disaster L&D is caused by the interrelation between hazardous events and the characteristics of the exposed elements that are susceptible to damage.

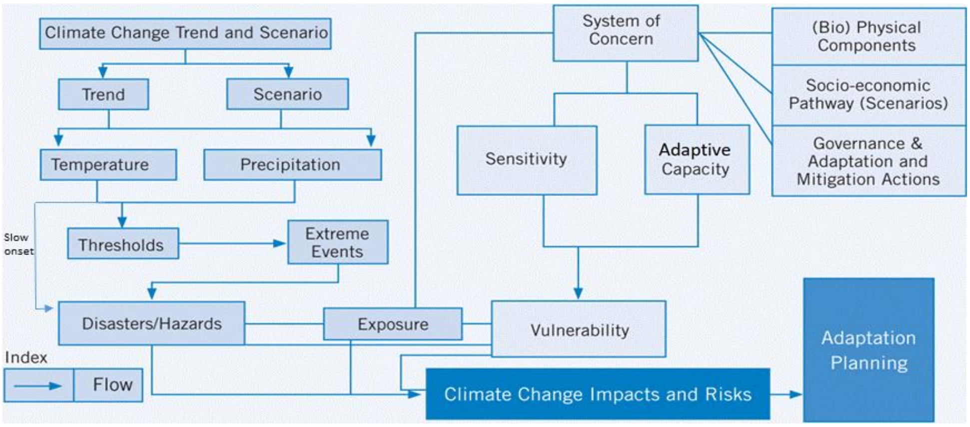


Figure 7: Climate change vulnerability and risk assessment framework

Source: Ministry of Population and Environment (MoPE), 2017

The framework presented in the Vulnerability and Risk Assessment Report (MoFE, 2021) of Nepal underscores that (disaster) risk is determined by the interaction between extreme weather events which are influenced by anthropogenic climate change and climate variability on the one hand, and the vulnerability and exposure of societies influenced by socio-economic development processes on the other (Figure 6). The MoFE report also emphasizes that a risk perspective is essential to be able to effectively address the potential negative consequences of extreme events due to climate change (MoPE, 2017).

In the context of Nepal, addressing the risk of climate change-induced L&D requires an improved understanding of the social construction of vulnerability and exposure as well as the potential changes and magnitude of climate-related hazards. The integration of climate change adaptation and DRR is necessary to practically address the challenges. However, IPCC assessment reports that a range of biophysical, institutional, financial, social, and cultural factors constrain the planning and implementation of adaptation options and potentially reduce their effectiveness (Klein et al., 2014).

L&D occurs where adaptation actions are unavoidable, not physically or technically possible, socially difficult, or simply not sufficient to prevent some harm to humans, the environment, and assets (Morrison and Pickering, 2013). The more global temperatures continue to rise, the more likely it is that adaptation limits will be reached. The impacts of climate change that cannot or will not be avoided through mitigation or adaptation efforts are particularly challenging for those poor countries that are already exposed to harsh climate conditions. They include the losses and damages both from changes in the frequency, intensity, and geographical distribution of extreme weather events such as storms and floods and from slow-onset phenomena such as glacier melting, loss of biodiversity, and desertification. Climate adaptation policies and programmes typically involve ex-ante actions aimed at building resilience before the occurrence of extreme weather or slow-onset event. Actions to address losses and damages build on these efforts by also establishing mechanisms to help those who have already experienced losses and damages through financial or other forms of support such as social safety nets or social protection programmes (ex post relief).

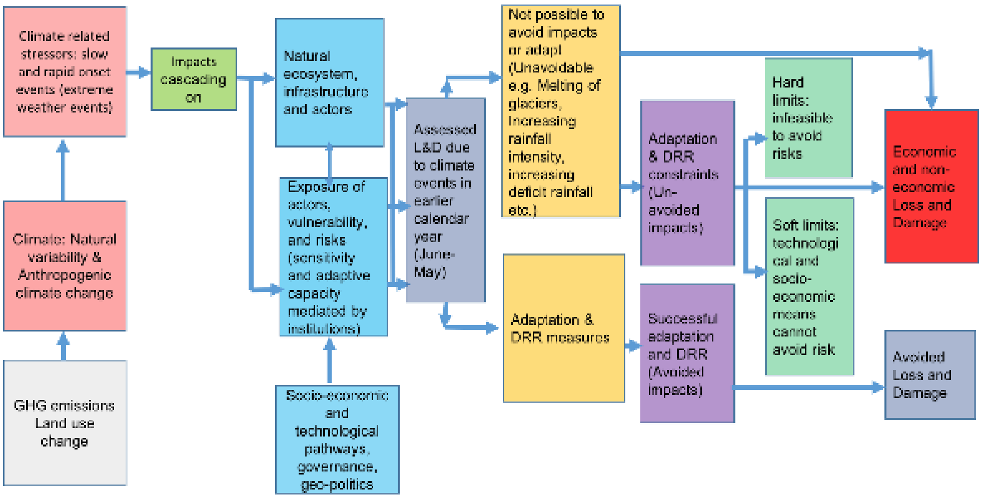


Figure 8: Framework for assessing climate change-induced L&D

The proposed framework (Figure 7) for Nepal is based on global and national discourses which recognized that there are limits and constraints to adaptation and DRR measures. There are particular types of approaches to address L&D from climate change risk which includes: i) Avoided: Avoidable losses and damages can be or will be avoided by climate change mitigation and adaptation measures; ii) Unavoidable: adaptation and disaster risk reduction is not enough to avoid L&D, even though avoidance is possible, which is because financial, technical, and political constraints, as well as case-specific risk narrow down the adaptation and DRR space; iii) Unavoidable: L&D that cannot be avoided and adapted to through further mitigation/and or adaptation and DRR measures, for example, impacts from slow onset events, such as melting glaciers, that have happened already. Besides this, adaptation and DRR measures can be erosive and maladaptive creating further vulnerability; and due to the nature of the risk and vulnerability, no measures are adopted due to limits to or constraints on adaptation and DRR.

The IPCC's 5th Assessment Report (AR5) recognizes important biophysical, institutional, financial, social, and cultural barriers to adaptation, which, particularly when compounded, can lead to soft and hard adaptation limits. Hard limits occur when adaptive actions become infeasible to avoid risks, and hence impacts and risks become unavoidable. Soft limits arise when technological and socioeconomic options are not immediately available to avoid risks through adaptive action, meaning that impacts and risks remain un-avoided for the moment (Dow et al., 2013; Klein et al., 2014).

4. ASSESSMENT METHODOLOGY

4.1. Approaches and methods

Different methods and tools exist in assessing L&D in developing countries such as the Philippines (Gabriel et al., 2019) and Bangladesh (Bhowmik et al., 2021). One of the key challenges in most of the available methodologies and tools is their pre- or post-disaster assessment focus. Post-disaster assessments provide relevant information on disaster L&D which is often crucial for validating and calibrating pre-disaster assessment (e.g., damage curves, potential impact estimation, etc.). However, it is also evident that much of climate change-related (future) impacts are not captured in these databases, such as the impacts and losses due to process-related or slow onset events, such as glacier melting. Hence, these databases also face severe constraints in the assessment of climate-related L&D. In this regard, the assessment of losses, damage, and risks due to creeping processes and accumulated shocks from non-extreme events is still a challenge (Birkmann et al., 2011, p. 24).

Figure 8 below provides an overview of approaches linked to the two schools of thought described above. While the largest databases for L&D (EM-DAT, DesInventar) have a clear post-disaster focus, most of the models focus on pre-disaster contexts.

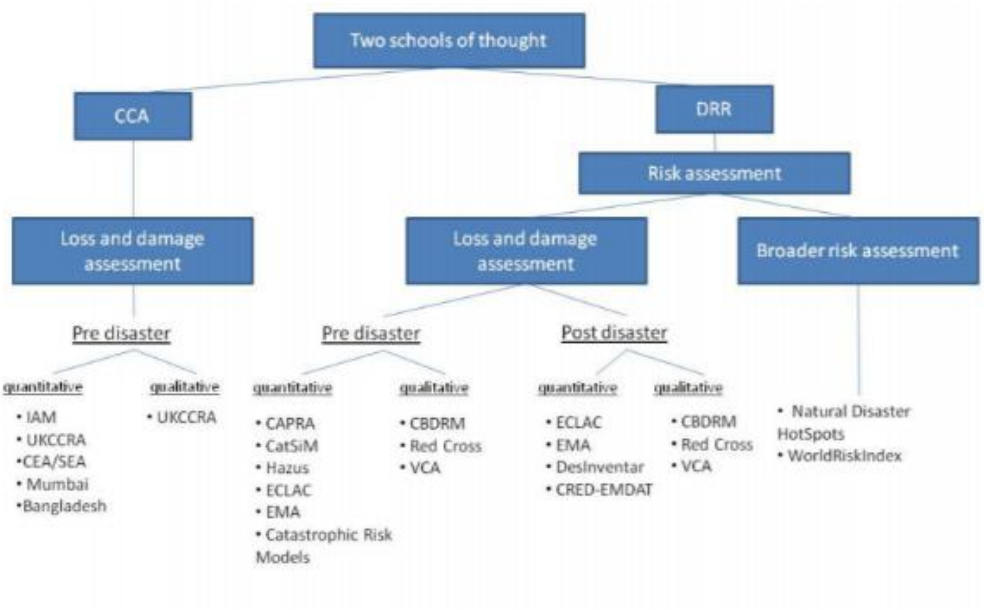


Figure 9: Overview of different approaches, methodologies, and tools for loss and damage assessment

Source: UNFCCC, 2012

The World Risk Index (Birkmann et al., 2011; Welle et al., 2012, 2013) encompasses a new approach and methodology to assess the risk of people facing major damages and losses in the context of natural hazards and extreme events. The concept is based on the understanding that the risk of L&D due to climate-related hazards is not caused solely by external forces and natural phenomena such as floods or droughts. Exposure and vulnerability are also considered as important drivers of future risks. Many, but not all of these studies, also integrate projections of increasing population and wealth or capital at risk in the quantitative estimates of future risk.

In the context of Nepal, one applicable methodology is to use the Vulnerability and Risk Assessment (VRA) methods that look into the hazard, exposure, vulnerability, and risk of climate change impacts which can help in identifying vulnerability and risks and respective adaptation and disaster risk reduction measures to avoid the L&D from the climate-induced extreme events. It will be equally important to identify adaptation and DRR options adopted by the communities, local government, and other stakeholders at various scales and assess their effectiveness. Besides, it will be important to identify the successful adaptation and DRR actions that have been effective to address L&D. On the contrary, it is necessary to assess the limitation and constraints of adaptation and DRR options and identify any residual impacts. Besides, there are instances where the risks and impacts are unavoidable. It is important to assess these unavoidable risks and impacts. The key elements of the method in understanding L&D (economic and non-economic) are:

- Information on climate-induced events: climate change stressors (slow and rapid onset weather events) and trends.
- Information on exposure, vulnerability, and baseline risk and scenarios.
- Information on observed impacts based on analysis of loss trend and interpretation of drivers of losses.
- Information on existing adaptation and DRR measures.
- Assess L&D:
    - Assess the adaptation and DRR responses
    - Assess unavoidable risks (cannot be avoided):
    - Assess the L&D post-intervention (economic and non-economic) un-avoided risks

In assessing L&D, exposure of natural ecosystem, people, and infrastructure to climate risk in the specified area are important to recognize. According to National Oceanic and Atmospheric Administration (NoAA), “Risk areas identify geographically (typically on maps) those areas most likely to be affected by a given hazard. People and resources located within the risk areas are at risk from hazards [exposed] and may or may not be vulnerable to hazard impacts. The vulnerability of the people and resources within the risk areas is a function of their susceptibility to the hazard impacts and their capacity to cope or adapt.”

4.2. Methodological steps for assessment

There are no universally agreed methodological steps for assessment of L&D. There are several ways through which risk and vulnerability are assessed, including the assessment of the effectiveness of adaptation and DRR responses and identifying limits to adaptation. However, the proposed steps are an example of assessing L&D using the VRA framework.

Step 1: Identifying key indicators for climatic extreme events: In this step, the most relevant indicators need to be identified to assess the changes in climatic hazards. The indicators selected can be used for both quantifying and qualifying the extent, trends, and future scenarios of the climatic hazards. The indicators of changes in climatic hazards consisted of historical occurrence indicators such as frequency, magnitude, and areal extent and climate change-related indicators such as the changes in climate variables and climate extreme indices.

For example, 15 climate-related hazards mentioned in Tables 4 and 5 can be selected which are the most relevant hazards for Nepal in terms of average annual losses and deaths. The multi-hazard assessment is dependent on the chosen set of hazard indicators. Metrics used to represent the selected indicators are crucial for the resulting hazard scenarios. Historical hazard occurrences in the form of several events and/or hazard-prone areas can be taken as indicators to obtain hazard indices based on historical climate. Climate change-related indicators can be used to infer future descriptive scenarios of climatic hazards.

Table 4: Examples of Indicators for Climate Variables and Climate Extreme Indices

Climate Variables and Extreme Indices	Indicators
Temperature	Change in Temperature (^{0}C)
Precipitation	Change in Precipitation (%)
Very Wet Days (P95)	Change in Very Wet Days (%)
Extreme Wet Days (P99)	Change in Extreme Wet Days (%)
Consecutive Wet Days	Change in Consecutive Wet Days (%)
Number of Rainy Days	Change in Number of Rainy Days (%)
Consecutive Dry Days	Change in Consecutive Dry Days (%)
Warm Days	Change in Warm Days (%)
Warm Nights	Change in Warm Nights (%)
Warm Spell Duration	Change in Warm Spell Duration (%)
Cold Days	Change in Cold Days (%)
Cold Nights	Change in Cold Nights (%)
Cold Spell Duration	Change in Cold Spell Duration (%)

Source: MoFE, 2021

Table 5 below provides the list of indicators and their relative weights for the past scenario of climate-related hazards under historical climate.

Table 5: Example of Indicators and their Relative Weights for the Past scenario of Climate-related hazards

SN	Climatic Hazards	Indicators
1	Cold Wave	Number of Events (No.)
2	Heat Wave	Number of Events (No.)
3	Heavy Rainfall	Number of Events (No.)
4	Snowstorm	Number of Events (No.) Snow area (sq. km.)
5	Thunderbolts	Number of Events (No.)
6	Windstorms	Number of Events (No.)
7	Hailstorm	Number of Events (No.)
8	Floods	Number of Events (No.) Flood-prone area (sq. km.)
9	Landslides	Occurrence (No.) Landslide prone area (sq. km.)
10	GLOFs	Number of Events (No.) Potentially dangerous glacial lakes (No.) Distance from potentially dangerous glacial lakes (km)
11	Drought	Number of Events (No. of months) Drought-prone area (sq. km.)
12	Forest Fire	Number of Events (No.) Fire burnt area (sq. km.)
13	Structural Fire	Number of Events (No.)
14	Avalanche	Number of Events (No.)
15	Epidemics	Number of Events (No.)

Source: MoFE, 2021

Table 6 provides the list of indicators for future scenarios of climate-related hazards.

Table 6: Indicators for Future Scenarios of Climate-related Hazards

SN	Climatic Hazards	Indicators
1	Cold Wave	Change in Cold Spell Duration (%)
2	Heat Wave	Change in Warm Spell Duration (%)
3	Heavy Rainfall	Change in Extreme Wet Days (%)
4	Snowstorm	Change in Precipitation (%) Change in Temperature (^{0}C)
5	Thunderbolts	Change in Temperature (^{0}C) Change in Precipitation (%)
6	Windstorms	Change in Temperature (^{0}C)
7	Hailstorm	Change in Temperature (^{0}C) Change in Precipitation (%)
8	Floods	Change in Precipitation (%) Change in Extreme Wet Days (%)
9	Landslides	Change in Precipitation (%) Change in Extreme Wet Days (%)
10	GLOFs	Change in Temperature (^{0}C) Change in Warm Spell Duration (%) Change in Precipitation (%)
11	Drought	Change in Precipitation (%) Change in Consecutive Dry Days (%) Change in Number of Rainy Days (%) Change in Warm Spell Duration (%)
12	Forest Fire	Change in Consecutive Dry Days (%) Change in Warm Spell Duration (%)
13	Structural Fire	Change in Consecutive Dry Days (%) Change in Warm Spell Duration (%)
14	Avalanche	Change in Precipitation (%) Change in Temperature (^{0}C) Change in Warm Spell Duration (%)
15	Epidemics	Change in Temperature (^{0}C) Change in Cold Spell Duration (%) Change in Warm Spell Duration (%) Change in Precipitation (%) Change in Consecutive Dry Days (%) Change in Consecutive Wet Days (%)

Source: MoFE, 2021

Step 2: Identifying key indicators for exposure and vulnerability: The main purpose of this step is to outline the most relevant indicators to measure and assess trends in exposure elements, state of sensitivity, and adaptive capacity of people and systems. For example, the relevant indicators can be identified from desk reviews and in consultation with experts.

Table 7: Examples of Indicator of Exposure, Sensitivity, and Adaptive Capacity

Types	Indicators
Exposure	• Human population: Male, female, population size, density, number of households • Animal and wildlife population: Livestock population - dairy cattle, goat, sheep, pig, poultry, duck; wildlife population • Natural systems: Forest, non-timber forest products (NTFPs), protected areas, water bodies (groundwater, river, snow cover, glaciers), wetlands and watershed area, built-up and municipal area, the area under key cereal crops, land area under permanent meadows, and pasture • Services and infrastructures: Airport, road, bridges, buildings, hospitals, dams, hydropower, and transmission lines drinking water supply schemes, industries, vehicles, fish farms and ponds, trekking routes, hotels, surface irrigation schemes, cultural and archaeological sites
Sensitivity	• Demographic characteristics: Gender (male and female); urban and rural population, age group (children, elderly, youth, adult), population density, economic status (poor, rich) • Socio-economic characteristics: Population growth, population density, sex ratio, *Dalit* and *Janajati* population, differently abled, and people with health issues, poverty incidences, female household population, smallholder farmers, landless population, refugees, slum dwellers, orphans, the dependency ratio • Characteristics of infrastructures: types of infrastructures, age of infrastructures, location of infrastructures (proximity to hazards), build-up and types, repair and maintenance status, strength, and robustness, etc. • Biophysical factors: Slope, soil types, topography, the trend of change in land use and land cover, the trend of change in snow cover, water flow, forest types, species richness • Intrinsic characters- forest types, slope, landslide & flood intensity
Coping and adaptive capacity	• Socio-economic capability: Human Development Index (HDI), Gross National Income (GNI), Gender Development Index (GDI), Gross Domestic Product (GDP), economically active population, labour productivity, land ownership by female • Access to goods and services: Access to roads, infrastructures, communication, technology, education, health facilities, seeds, and planting materials and fertilizers, households with radio and television, market services, rescue and rehabilitation centres, fire management equipment, waste disposal, water purification and refinement,

	standardized roads, and alternative means of transportation • Access to technology: Climate-smart and climate-resilient technologies, risk reduction and risk management technologies, water-efficient technologies, soil and land management technologies, crop management technologies, early warning systems, bioengineering technologies, sustainable forest management, agro advisories • Access to finance: Investments and allocations, budget, insurance, credit, and grants facilities, blending and lending • Policy and institutions: Law, policy, plans, number of active agencies working, networks and groups, reinforcement of building codes • Awareness and knowledge: Indigenous knowledge, knowledge on climate change, and response measures

Step 3. Examples of Indicators for Loss and Damage Assessment

As discussed earlier, there are broadly two types of L&D. One is economic and another is non-economic. This step identifies the indicator for assessing the economic and non-economic sectors.

Table 8: Scope of the Economic and Non-economic Loss and Damage

Sectoral Category	Indicator	Subcategory
Social	Settlements	Housing plot
		Houses: • Concrete • Non-concrete
	School Buildings	
	Office Buildings	
	Temples	
	Households Migrated/Displaced	
Production	Area under Irrigation	Paddy
		Wheat
		Millet
		Potatoes
		Vegetables
	Unirrigated Land Area	Maize
		Fruit
		Others
		Paddy
		Wheat
		Millet
		Potatoes
		Vegetables

	Livestock	
	NTFPs	Lost Medicinal Plants
Infrastructure	Highways	National Highway
		Feeder Roads
		District Roads
		City Roads
	Bridges	
	Culverts	
	Trails	
	Suspension Bridges	Embankments
	Rivers	River Trained
	Energy	Hydropower Plants
		Transmission Pylons
		Transmission Lines
		Micro-hydro Plants
		Watermills (ghatta)
		Solar Plants
		Hybrid Plants
		Biogas Plants
		Windmills
		Headwork
	Irrigation System	Canals
		Gravity System: Intake, Pipeline Storage Tanks Tap Stand Point Source
	Drinking-Water Supply Scheme	Rainwater Harvesting Tanks
		Tube-wells
		Toilets
	Sanitation	Fiber Cable Line
	Communication Systems	Mobile Towers
		Temple, Monuments, historical locations
Natural and Cultural Heritage	Tourism locations under NELD	

Step 4: Data Collection and Analysis

The data sources determine the availability and quality of data. The data sources can be obtained from government agencies, regional and global centers, international and national organizations, and other stakeholders. Interviews, one-on-one meetings, exploratory surveys, and consultations with experts and related stakeholders and individuals can be valuable data collection methods. Survey software and Google Form can be used for the questionnaire survey. The filtering, cleaning, and normalization process should be conducted to ensure whether the collected or tabulated data were correct, complete, relevant, unique, properly formatted, and with a uniform unit. A min-max method can be adapted to normalize the quantitative dataset.

Step 5: Analysis of Climate-induced Hazards

The analysis consisted of the detection and attribution of changes in climatic hazards. 'Detection' is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. Changes in climatic hazards can be detected by assessing their trends. However, from a scientific point of view, assessing changes in climatic hazards rather than climate variables or climate extreme indices can be problematic for several reasons. First, the data that is available to study climatic hazards are biased towards recent years simply because of improved reporting, data keeping, communication technology, and early warning systems. Second, methods to compare reported events in an objective way considering biases are lacking. Third, even when corrected for improving communication technology, the number of reported climate-related disaster events may reflect factors representing not only the frequency of climatic hazards but the trends in vulnerability and exposure as well (WMO, 2009).

Disaster impacts highly depend on exposure and vulnerabilities. The occurrence (number of events) of climatic hazards is a natural phenomenon that is less likely affected by the exposure and vulnerabilities and hence the trend analysis on the occurrences of climatic hazards may reflect the influence of climate change.

The historical climate-induced disaster data should be analyzed to identify trends of climatic hazard occurrences and their impacts. The trend analysis should be conducted using graphical and statistical methods. The trends of climatic hazards then should be compared with the trends of climate variables and climate extreme indices to identify the attribution of climate change. Once the attribution of climate change is established, then the future scenarios of climatic hazards can be inferred using the future scenarios of climatic variables and climate extreme indices in a descriptive way.

The quantitative past scenarios of climatic hazards under historical climate can be generated using historical hazard indices. The historical hazard occurrences are used to compute historical hazard indices. Since the occurrence of a climatic hazard varies from place to place, historical hazard indicators could be based on the frequency of hazard, such as the number of times a specific event occurred in a specific place and/or areal extent of the hazard.

The future quantitative scenarios of climatic hazards can be obtained using the Fraction of Attributable Risk (FAR) method. FAR is the approach of separating causal factors of climatic hazards and calculating their relative contribution which is widely used to calculate how a particular climate driver has changed the probability of an event occurring (Allen, 2003, Stott et al., 2004). FAR is the fractional change in the likelihood of exceeding a hazard threshold as a result of anthropogenic influences. It is important to recognize that this is a relative rather than an absolute metric.

Figure 9 shows the likelihood of risk in the natural world without climate change and the actual world with climate change. In Figure 8, P_0: Probability of exceeding a threshold in "world that might have been" (no anthropogenic forcings), P_1: Probability of exceeding a threshold in "world that is". Then, the FAR is given by $FAR = 1 - P_0/P_1$ (IPCC, 2007, pp. 698). Computing the FAR requires physically based model simulations using only natural forcings and with anthropogenic climate changes separately.

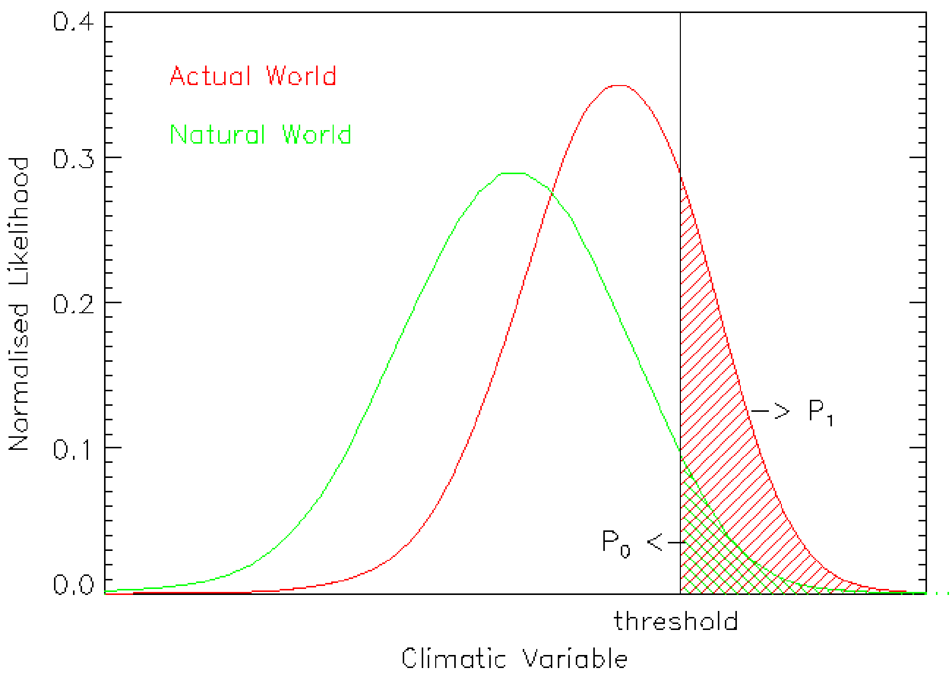


Figure 10: Likelihood of risk in the natural world, and actual world

Source: Stott, P. A., Stone, D. A., & Allen, M. R., 2004

Example of the assessment of hazard

One example of assessment of hazard scenarios can be drawn from the recent report of MoFE. **Table 9** below presents the results of the Mann-Kendall test and Sen's slope for 14 climatic hazard events. Among 14 climatic hazards, all-hazards except drought are in the increasing trend. The drought events are in decreasing trend. While trends of epidemic, avalanche, hailstorm, and drought are statistically insignificant, the trends of the other 10 hazards are statistically significant at a 5% level (MoFE, 2021).

Table 9: Mann-Kendall Test Statistics for Linear Trend of 14 Climatic Hazard Events

Hazard	Z-statistic	P-value	Sen's Slope	Significance (5%)
Fire	6.40	0.00	7.32	Yes
Thunderbolt	7.44	0.00	2.70	Yes
Windstorm	5.23	0.00	0.57	Yes
Epidemic	1.63	0.10	1.16	No
Heavy Rainfall	4.53	0.00	0.25	Yes
Landslide	6.62	0.00	2.70	Yes
Flood	5.43	0.00	2.64	Yes
Avalanche	1.61	0.11	0.03	No
Hailstorm	0.34	0.74	0.00	No
Heat Wave	2.18	0.03	0.00	Yes
Cold Wave	3.70	0.00	0.00	Yes
Snowstorm	2.60	0.01	0.04	Yes
Forest Fire	1.96	0.05	83.50	Yes
Drought	-1.73	0.08	-2.39	No

Source: MoFE (2021)

The descriptive scenarios of climate variables and extreme indices under future climate change can be expressed in **Table 10** (MoFE, 2021).

Table 10: Descriptive Scenarios of Climate Hazards Under Future Climate Change

Climate Variables and Extreme Indices	Medium Term Scenario	Long Term Scenario
Increase in Temperature	*Likely*	*Likely*
Increase in Precipitation	*Likely*	*Likely*
Increase in Very Wet Days	*Likely*	*Likely*
Increase in Extreme Wet Days	*Likely*	*Likely*
Decrease in Rainy Days	*Likely*	*Likely*
Increase in Consecutive Dry Days	*About as likely as not*	*About as likely as not*
Increase in Consecutive Wet Days	*About as likely as not*	*About as likely as not*
Increase in Warm Days and Nights	*Likely*	*Likely*
Decrease In Cold Days and Nights	*Likely*	*Likely*
Increase in Warm Spell Duration	*Likely*	*Likely*
Decrease in Cold Spell Duration	*Likely*	*Likely*

Source: MoFE (2021)

Step 6: Analysis of Climate informed Multi-Hazard Risk

Assessment: Combined Analysis of Exposure, Vulnerability and Hazard for various climate change

Exposure data can be analyzed by consolidating or disaggregating into components such as the human system, natural system, and infrastructure. The indicator-wise data will be given weightage, it will be normalized, and exposure index will be prepared.

The vulnerability of the identified sector can be analyzed with an aggregated value of sensitivity and adaptive capacity as shown in equation V. According to IPCC- AR5, vulnerability is a function of Sensitivity and Adaptive Capacity. The relationship illustrates a typical process and analysis of the chain of vulnerability and risk with the indicator-wise data of sensitivity, adaptive capacity, and exposure.

$$V = S - AC \qquad \text{(V)}$$

Were,
V is the composite vulnerability indicator,
S is the sensitivity component of vulnerability and
AC is the adaptive component of vulnerability

Similarly,
Sub-sector-wise and cumulative risk of the forests and biodiversity, and watershed management are estimated as a function of Hazard, Exposure, and Vulnerability as shown in (VI).

$$R = H \times V \times E \text{ ....} \qquad \text{(VI)}$$

Were,

R is the risk index, H is the hazard intensity considering future climate parameters, V is the vulnerability and E is exposure.

Climate Informed Risk Assessment evaluates the effects of different climate scenarios on exposed assets and people, as well as their vulnerability. The resulting risk indicates which regions and locations are most likely to be affected. The quantified monetary damages and risk estimates can also be used to help make decisions about risk-reduction measures and appropriate investment levels.

Taking the case of floods, the objective of the assessment is to identify the following impact types:

- Quantify the monetary damages.
- Quantify the number of people affected.
- Quantify the affected transport lines and number of critical infrastructures.
- Assess the impacts of historic flood events; and
- Simulate the impacts for selected historic flood events.

The data to analyze the exposed assets and the population is used to this end. Flood impacts can be assessed using a variety of open-source software that has been used in risk assessments all over the world. The assessment of monetary damages for buildings using a standard flood damage model that includes stage damage functions and maximum damages is one of the outcomes of such a flood risk assessment. Loss and damage estimates per flood return period, as well as Probable Average Annual Loss and Damage, are presented. In addition, by overlaying inundation maps for different return periods with the exposed infrastructure, estimates of people affected and critical infrastructure are made. The climate change vulnerabilities and risks can be ranked into five categories (very low, low, moderate, high, and very high) for their threats or impacts by using the Jenks natural breaks (Jenks, 1967) method. The Jenks natural break is widely used for categorizing data. The VRA created the classes in such a way that the best groups of similar values come together and maximize the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big differences in the data values. The natural break classes are characterized based on the variety of data an indicator possesses. Thus, the natural break value may differ with the dataset/indicators.

From the analysis of data, maps, and indices for existing climate trends and projected scenarios for climate hazards, vulnerabilities and risks can be generated.

Example of assessing exposure and vulnerability

Impacts of climate extremes are determined by the climate extremes themselves as well as by exposure and vulnerability. The severity of the impacts of climate extremes depends strongly on the level of exposure and vulnerability. Without exposure, there is no impact. Exposure is a necessary but not sufficient condition for impacts. For exposed areas to be subjected to significant impacts from a weather or climate event there must be a vulnerability.

Increasing exposure of people and economic assets is a major cause of long-term increases in economic losses from climate extremes. Besides, the impacts of climate extremes are differentiated by socio-economic factors such as gender, livelihood strategies, and cultural practices, and biophysical factors such as landscapes and ecosystems (MoPE, 2017). The districts having very high and high disaster impacts have also high socio-economic exposure and vulnerability as shown in Figures 10 and 11 respectively.

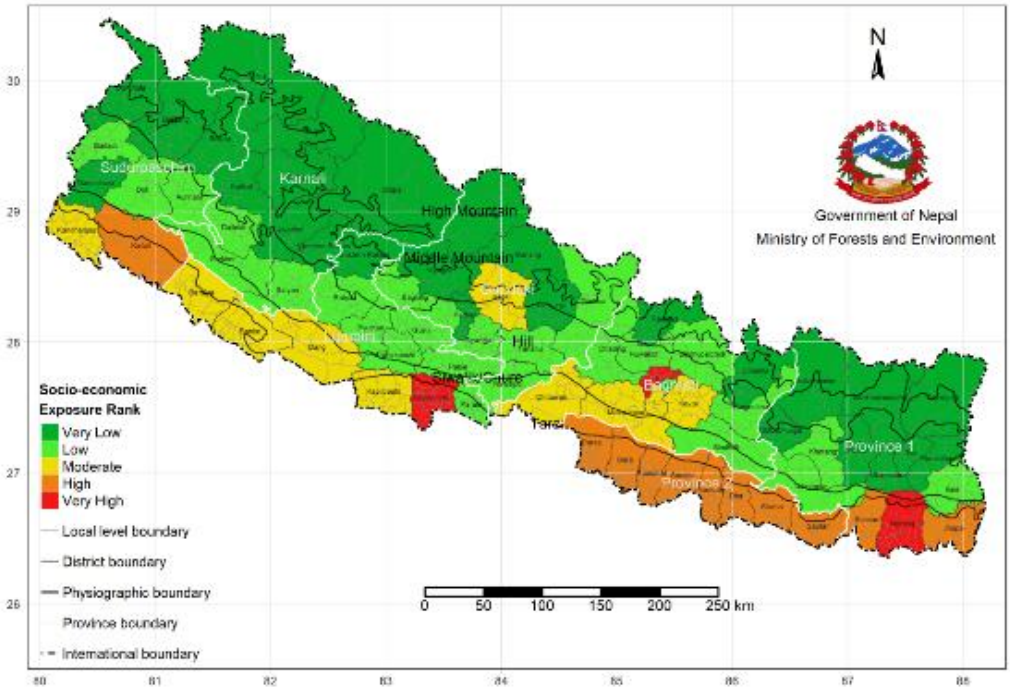


Figure 11: District-wise socio-economic vulnerability

Source: MoFE, 2021

According to MoFE (2021) transport, infrastructure, water, and tourism are among the key sectors sensitive to climate extremes. Besides, agriculture is also an economically exposed sector that is vulnerable to climate extremes. The economy of Nepal relies heavily on agriculture, dominated by small-scale and subsistence farming. Livelihoods in this sector are especially exposed to climate extremes. The most vulnerable populations include the urban poor in informal settlements, internally displaced people, and those living in marginal areas. Population growth is also a driver of changing exposure and vulnerability. Women, children, senior citizens, people with disabilities, and socially and economically marginalized groups are also highly vulnerable (MoFE, 2021).

In addition, the National Disaster Risk Reduction and Management Authority (NDRRMA) has been mapping exposure data and vulnerability at the household level in collaboration with selected hotspot municipalities. Municipal governments compile the data, which is then stored on the national portal:bipadportal.gov.np (Figure 11).

Figure 12: Snapshot from Bipad Portal showing a typical municipality's vulnerability and exposure information overlaid over hazard information

Source: Bipad Portal

Step 7. Assessing the Loss and Damage (Quantifying and Qualifying Loss and Damage)

The L&D from climate-influenced events is rising in Nepal. Given the current global climate change trend, the extent of L&D is likely to increase, making adaptation more challenging. Already the country is incapable of coping with the level of L&D even when adaptation measures are applied.

Although it is very difficult to attribute the disasters to climate change solely, the analysis shows that climate change is responsible for the changes in the frequency, magnitude, and impact of the disasters. Financial estimates for L&D are also difficult to make for several reasons. There are many uncertainties, from GDP and population growth to mitigation policy agreements and the effectiveness of mitigation and adaptation measures. Non-economic, non-market impacts such as loss of life or social disruption are difficult to estimate and the cost of loss in one place will be very different from the cost in another (ActionAid, 2010). The section below provides the process and output of assessing L&D from disasters.

Step 7.1. Assessing the Loss and Damage of Pre and Past Disasters in Nepal

There are mechanisms to look into the economic and non-economic impact of climate change, mostly the loss and damage of the past disasters in Nepal. The study carried out by the GoN, for example, shows that an indicative analysis of the impacts of climate change on water-induced disasters at the national level estimates that the additional average expected annual direct cost could be equivalent to 0.6-1.1%/year of current GDP by mid-century (over and above existing damages), with an upper estimate of almost 3% per year. The study identified that a major increase in investment is needed in the three areas assessed (hydropower, irrigation, and agriculture), estimated at US$ 2.4 billion by 2030 (present value) (IDS-Nepal, PAC, and GCAP, 2014). Besides, based on discussions and the analysis of the climate and hydrological modeling results, the total additional adaptation costs to build resilience into the planned future sector development is approximately US$ 500 million, (present value) above the baseline for the period of which the US$ 200 million falls on the public budget (IDS-Nepal, PAC and GCAP, 2014).

As mentioned at the beginning of this chapter, several attempts have been made to incorporate loss and damage estimation, using either pre-disaster or post-disaster methodologies. Here are a few of them, along with brief descriptions:

- Econometric approaches: These methods use historical data to estimate the effects of climate variability and change on a wide range of quantifiable outcomes, such as GDP, mortality, injuries, infrastructure and resource damage, and agricultural yields.

  - World Risk Index: The World Risk Index is a third assessment model that can be used to assess loss and damage caused by climate change. This index uses indicators to assess social, economic, and environmental vulnerability.

  - HAZUS-MH: It is a tool developed by the Federal Emergency Management Agency for assessing hurricane, flood, and earthquake loss and damage [21]. It employs geographic information systems to forecast the effects of hazards both before and after a disaster. The methodology divides loss and damage into four categories: (1) direct damage, (2) induced damage, (3) direct losses, and (4) indirect losses.

  - Damage and Loss Assessment (DaLA): DaLA is a damage and loss assessment approach developed by the United Nations Economic Commission for Latin America, in which the user is responsible for obtaining the necessary data for implementation.

- Post Disaster Needs Assessment (PDNA): The PDNA methodology is intended to aid in the management of emergency and recovery situations. It assesses loss and damage using the ECLAC method. Gathering pre-disaster baseline data to compare to post-disaster conditions to determine the overall impact as well as impacts by sector is part of the PDNA methodology. The assessment includes damage to infrastructure and physical assets, disruption of access to goods and services, governance, and decision-making processes, as well as increased risks and vulnerabilities.

The National Planning Commission's post-flood damage and recovery need assessment (2016) that computes the Damage and Loss. In the case of the 2017 floods, based on the assessment of nine sectors, the total damage and losses caused by the floods have been estimated at NPR 60,716.6 (USD 584.7 million). It does not include personal household losses. While most of the important assets in the public and private sector have been included, the damage to small-scale community infrastructure has not been costed.

a. Accounting Economic Loss and Damage from Past Disasters in Nepal

Due to anthropogenic climate change, the likelihood of extreme events has increased by a certain percentage (Otto et al., 2018). In Figure 12 below, the Y-axis shows the magnitude of flooding (depth), and the X-axis shows the return period of the event. The upper line shows the possible flood distribution with the impact of climate change. The lower line shows the possible flood distribution without climate change. The dotted horizontal line is an extreme past flood event. The same flood event would have a higher return period in a world with climate change, at a risk ratio of N2/N1. In simple terms, this means that the chance of occurrence of a higher magnitude event will increase and will become more frequent. In a hypothetical example, a flood of magnitude with say 35 years will occur with a 30-year return period in a world with climate change.

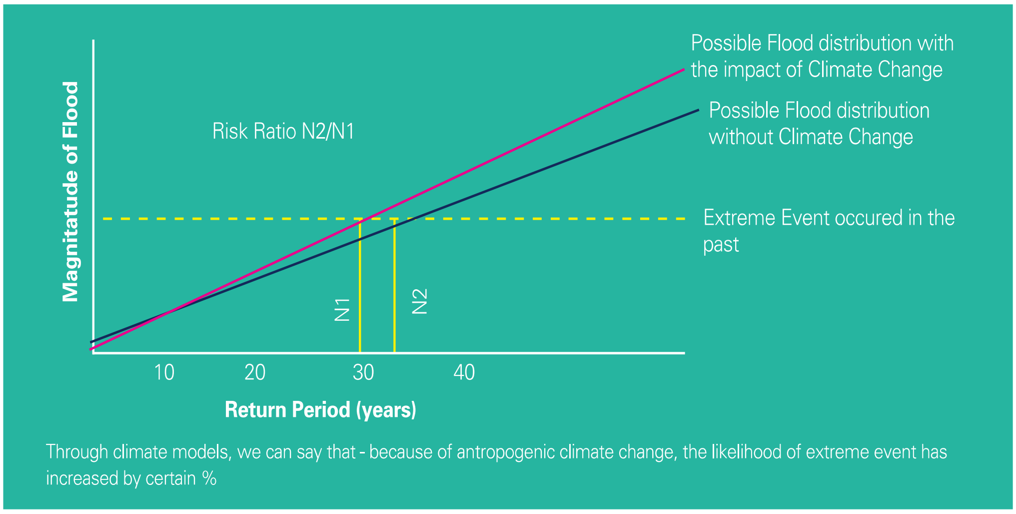
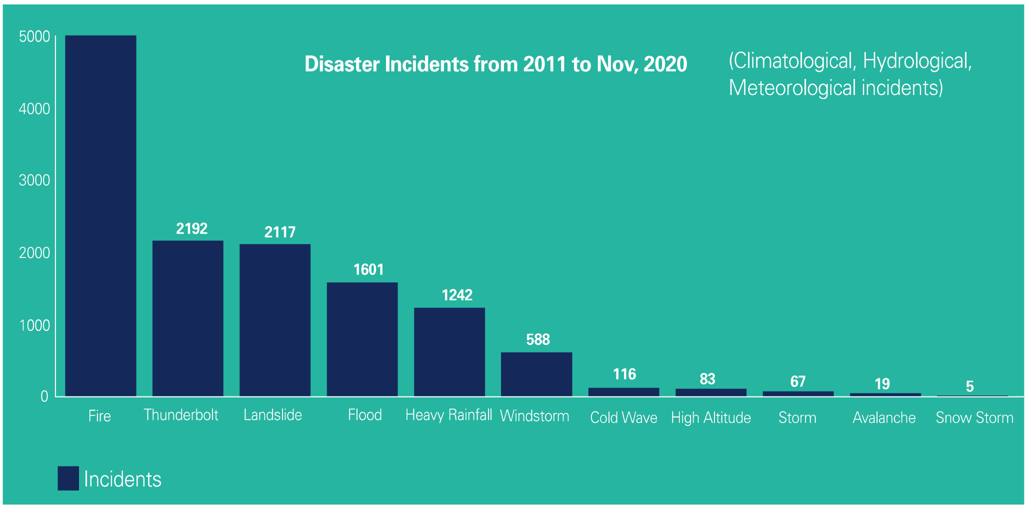


Figure 13: Impact of climate change on extreme events

Created based on Otto, et al., 2014 and presentation https://www.youtube.com/watch?v=ZP2yxYBn_Ow&t=245s

The impact of climate change can be seen across all hazard types (hydrological, climatological, meteorological, and biological) except geophysical (earthquake, rockfall, etc.) and human-induced disasters (road, industrial, and chemical accidents).



Source: DRR portal, bipadportal.gov.np

Figure 14: Key climatological, hydrological, and meteorological incidents in Nepal

In terms of losses, the trends of the number of deaths and economic losses from climate-induced disasters were analyzed from 1971 to 2019. Figure 13 shows deaths and economic losses from climate-induced disasters from 1971 to 2019 and Locally Estimated Point Cloud Smoothing (LOESS) lines indicating trends (MoFE, 2021). While climate-induced disaster-related deaths are decreasing in recent years mainly due to improved early warning systems and better mitigation structures, there is an increasing trend of economic losses due to increased exposure and vulnerabilities.

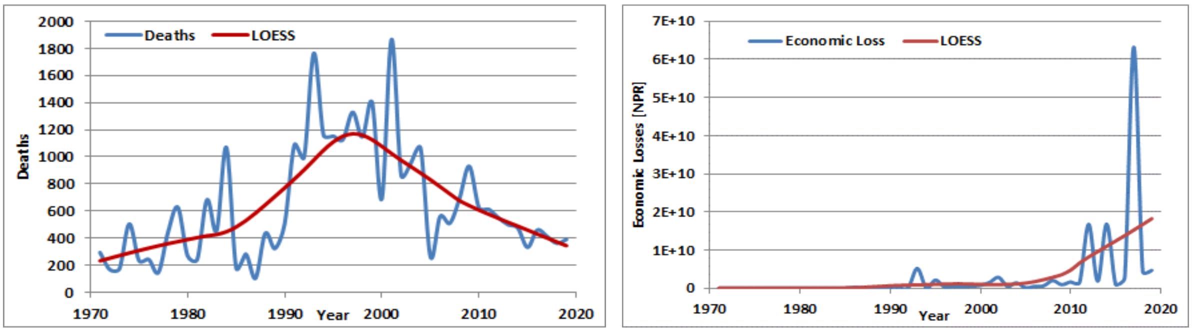


Figure 15. All Nepal trends of climate-induced disaster deaths

Table 11 below presents the results of the Mann-Kendall test and Sen's slope for deaths and economic losses. The Mann-Kendall test suggests that the economic losses are in a significantly increasing trend whereas the number of deaths is in an increasing trend but statistically insignificant.

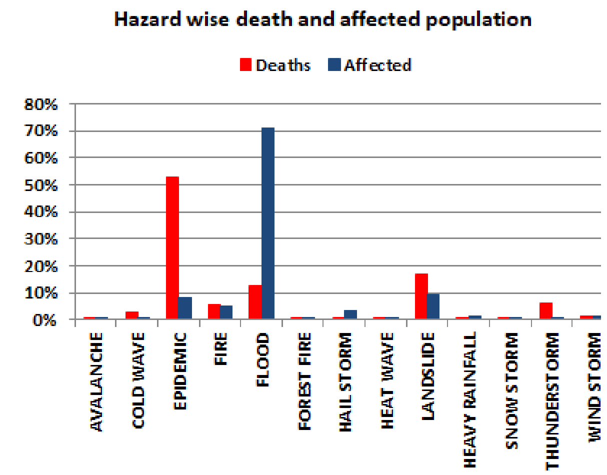
Table 11: Mann-Kendall Test Statistics for Linear Trend of Climate-induced Disaster Deaths and Economic Losses

Series	Z-statistic	P-value	Sen's Slope	Significance (5%)
Deaths	1.67	0.094	5.44	No
Economic Losses	7.53	0.000	41854210	Yes

Source: MoFE, 2021

On average in the last 10 years, 647 people died from climate-induced disasters in Nepal each year which is about 65% of the total deaths from all disaster events except road (and other) accidents (MoHA, 2018). The maximum number of climate-induced disaster deaths occurred in 2001 where 1,866 people lost their lives due to epidemics, landslides, thunderbolts, fire, floods, heavy rainfall, and windstorm. The maximum economic loss of NPR 63,186 million occurred in 2017 during the Tarai floods (NPC, 2017), which is about 2.08% of GDP (at current price) of FY 2017/18 (MoF, 2018).

Floods, landslides, epidemics, and fires are the most devastating climate-induced disasters in Nepal. Figure 15 shows the percentage of deaths, affected population, and economic losses due to 13 types of climate-induced disasters in Nepal from 1971 to 2019. Hazard-wise comparison of deaths affected population and economic losses revealed that epidemics cause the most deaths (52.8%) followed by landslides (16.7%) and floods (12.7%). However, statistics point out that floods affect about 71% of the total affected population followed by landslides (9.5%) and epidemics (8.2%). Fires cause the most economic losses (56.6%) followed by floods (31%) and landslides (3.7%).



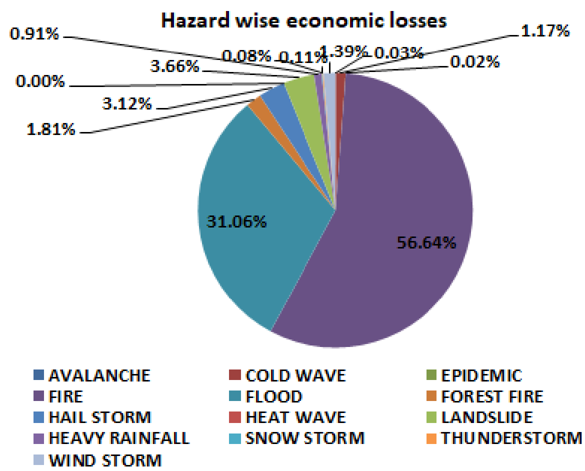


Figure 16: Hazard wise deaths, affected people, and economic losses due to climate-induced disasters

Source: MoFE, 2021

In addition, among the key hazards included in Figure 16, in the last 10 years (2011-2020), the greatest numbers of deaths (losses) have occurred from landslides and floods combined, and then from fires. The maximum economic loss is reported from fires, with flooding and landslides second and third respectively. Lightning caused the least economic damage. It is important to recognize that the economic damage is based on Nepal Police's post-disaster Incident Reporting Mechanisms (IRM). It does not fully consider direct losses, let alone measure indirect L&D.

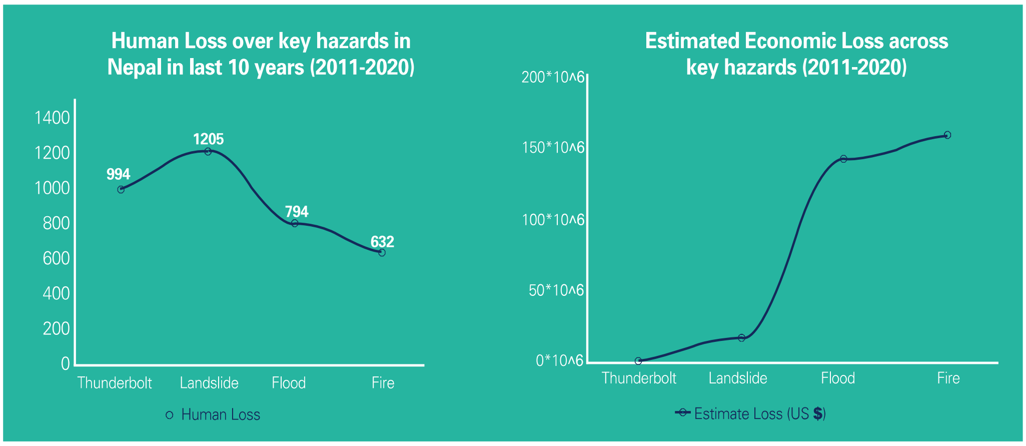


Figure 17: Human and economic losses due to key hazards

Source: NDRRP, 2019

In the discussion of L&D, the case of the droughts that affect many districts of Nepal causing crop damages is illustrative. Nepal faced drought in 1994, 2006, and 2009 (NDRRP, 2019) and among the drought years, the winters of 2006, 2008, and 2009 across central Nepal were the worst since 1981 (Dahal et al., 2016). According to the United Nations World Food Programme (UNWFP), in 2009 dry winter led to a reduction in crops by 40% (mountain), 25% (hill), and 10% (Tarai) compared to the previous year. The result was a decrease in national production of wheat and barley (the two major winter crops) respectively by 15% and 17%. In 2006, the drought resulted in 11% loss of rice yields and 7% loss in wheat and maize, whilst in 2009, there was 15% and 17% loss in wheat and barley yields, respectively. The economic costs based on international market prices of 2006 and 2009 amounted to 1.9% and 0.4% of the current GDP. These events also result in indirect costs on health, welfare, lost production, lower household incomes, and food insecurity. These impacts are likely to exert negative multiplier effects in an economy that would elevate the full economic L&D. It is argued that the full costs when these impacts are considered would be 25% to 100% larger than the direct costs (Devkota et al., 2017). The discussions suggest that climate change will increase drought-related L&D but the available data is highly fragmented making systematic assessment difficult.

Table 12: Accounting of Economic Loss and Damage Due to Climate-induced Disasters in Nepal

Date	Nature of hazard	Region	Loses and Damages	
			Loss	Damage
			NELD	ELD

Rainfall from 19th to the 21st of July 1993, Mid-Mountain cloudbursts, and flood	Weather	An unprecedented number of landslides and floods in South-Central Nepal	1,460: Dead/missing	73,606 families affected, 39,043 houses completely/partially destroyed, 43,330 hectares of cultivated land washed away/covered with debris. 367 kilometers of roads, 213 large and small bridges, 38 small and large irrigation schemes, 452 school buildings, hospitals, and government offices were destroyed.
August 24, 1998, Rohini River and other Tarai floods	Weather	Ramgram Municipality, Nawalparasi	No death	Affected 279 families in Nawalparasi. washed away about 24 hectares of land, and property damage of NPR 680,000.
August 18, 2008, embankment breach	Agency failure	Kushaha	Killed 3/12 missing	65,000 people were displaced.
19th and 21st September 2008, flooding in Mid-and Far-west, Nepal	Weather	Banke, Bardiya, Kailali, and Kanchanpur Dang, Dadeldhur, Doti and Salyan	11 males and 15 females died and 2 males and 6 females/ missing in Kailali District	2,152 houses were completely damaged, 12,962 houses partially damaged, 5,647 households lost stored grains, 12,552 households lost some stored grains, 18 VDCs and Dhangadi municipality affected, 30,733 people in 5,961 households of Dekhatbhuli and Shankarpur VDCs and Mahendranagar Municipality in Kanchanpur District worst hit
2009 Drought	Weather		No death	More than 330,000 ha of agricultural land in the Tarai and western Hills/ Mountains were affected, summer crop damaged, diseases increased.

2009 Forest Fires	Weather	.	43 deaths, 12 injured	516 families affected, 375 livestock killed, 74 houses and 22 cattle sheds destroyed, loss of NPR 140 million, 100,000 cattle burned to death.
2009 Diarrhoea Epidemic in the Mid-western Hills	Weather	Mid-Western Development Region	143 deaths in Jajarkot, more than 2,000 ills, 42 dead in Rukum	20,000 families affected
2014	Weather	Kailali, Badia, Surkhet, Dang	222 dead 84 injured	5,167 houses fully damaged, 14,913 partially- damaged households, 6,859 displaced households Affected population: 117,580,
2017	Weather	35 Tarai Districts	134 people dead, 22 injured	Affected a total of around 1.7 million people. more than 190,000 houses were destroyed or partially damaged; tens of thousands of people were displaced, and many rendered homeless. NPR 60,716.6 million lost
2020	Weather	58 Districts	297 dead 64 missing 223 injured.	NPR 51 million lost

Source: NCVST, 2009; NPC, 2017; BIPAD.portal, McKlune et al., 2014

The 2021 recent disasters in Nepal are examples of L&D. On 14 June 2021, a large flood struck the Melamchi area of Nepal following an early monsoon downpour. The flooding caused high levels of damage. Three people are confirmed to have died, whilst 17 more remain missing. Many houses were destroyed. It is now clear that this event resulted from the breach of a landslide dam upstream, releasing a torrent of debris and floods that struck settlements. The case study is provided in **Annex 1**.

As of July 25, a preliminary estimate of loss and damage due to the monsoon disaster shows damage worth NPR 9781 million (USD 81.5 Million). The estimated cost of recovery is NPR 5415 million (USD 45 Million). This assessment is based on preliminary figures prepared by respective ministries and departments, data from the Bipad Portal, and information on housing damage received from District Administration Offices, including municipalities. Loss values were calculated using the NDRRMA thumb rule for a typical type of infrastructure. Total incidents, casualties, injured, missing, and affected families are listed in the table below for the period 14 April to 25 July 2021 (NDRRMA, 2021).

b. Accounting Non-Economic Loss and Damage from Past Disasters in Nepal

The assessment and valuation of non-economic loss and damage is a key requirement for dealing with NELD in line with the Paris Agreement and as demanded by those affected. The accounting of non-economic loss and damage from past disasters in Nepal is difficult due to the lack of a database. All the data recorded in the national system are economic losses and limited to a few areas.

Another conceptual framework is proposed, placing the assessment categories into a matrix with four different domains of NELD, namely the material-intrinsic domain, the material-instrumental domain, the non-material-intrinsic, and the non-material-instrumental domain (Serdeczny/Waters/Chan, 2016, p. 12.). Refer to **Table 13** for an example.

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Table 13: NELD Framework of Assessment

	Intrinsic	**Instrumental**
Material	Biodiversity: Biodiversity/species, biodiversity loss Place: Loss of culturally important landscape, habitat destruction Human life: Loss of life Artifacts: Destruction of cultural sites/cultural heritage	Production site: Loss of productive land Communal site: habitat destruction (markets, religious sites) Ecosystem services:
Non-material	Intrinsic value: Dignity (human mobility), the intrinsic value of biodiversity, physical and mental well-being	Agency Social cohesion, peacefully functioning society Security Adverse health impact Physical and mental well being Ability to solve problems collectively Ecosystem services Sovereignty Health Education Identity (knowing/belonging) Traditions/religion/customs Loss of knowledge/ways of thinking The decline of indigenous and local knowledge Loss of identity (social bonds/relations, sense of place)

The four main categories of possible valuation techniques are:

- Economic valuation: Valuates a change in the provision of a service or the value of an asset; in other words, it compares the relative merits of actions. The method has severe limitations in the case of incommensurable NELD.

- Multi-criteria decision analysis (MCDA): Valuates complex situations based on a set of criteria against which various alternative options are to be evaluated; scores but doesn't use monetary terms. This method may be appropriate for highly intangible NELD.

- Composite risk indices: Relatively similar to MCDA, valuates vulnerability based on multiple criteria.

- Qualitative & semi-quantitative approaches: Valuates and provides information in a more disaggregated form. Scoring is semi-quantitative or qualitative, and simple. A good example is the United Kingdom's Climate Change Risks Assessment (CCIAV).

Although there is no database in terms of NELD assessment in Nepal, Practical Action has come up with case studies of L&D in Nepal. The study examined the impacts of the 2014 floods in the Karnali River as a typical case of climate-induced L&D. The study focused on flood impacts on four key sectors — agriculture and food security, shelter, education, and protection, given their importance in people's lives. These losses and damages have been captured based on discussion with the affected communities and interviews with key actors with first-hand experience working in flood response and recovery.

Table 14. Assessing NELD of 2014 Floods in the Karnali River

Individual	
Life	• Loss of childhood, disruption in education, and children get affected mentally, physically, and socially • Stress and anxiety • A deep sense of dependency • Loss of life • Fear and pain • Increased vulnerability
Health	• Illness due to water-borne diseases • Increased morbidity • Effects on infants' normal growth
Human Mobility	• Migration • Loss of sense of belonging • Increased male migration to India • Homesickness for people working in India - constantly worried about the well-being of their family • Women returning feel helpless and haunted by the unpredictability of the situation
Society	
Territory	• Not considered in the study as it related to political borders
Cultural Heritage	• Rituals, practices lost with having to cope in a unique environment, location
Indigenous Knowledge	• Traditional weather and flood prediction practices
Societal/Cultural Identify	• Loss of dignity, identity, and security • Exposure to different vulnerabilities and uncertainties

	• Loss of networks • Possibility of an increase in child labor and child marriage
Biodiversity	• The gradual extinction of bird species, frogs, and useful insects such as bees, and an increase in unheard-of diseases, agricultural pests, and invasive alien plant species
Ecosystem services	• Loss of commodity, leasehold, and agriculture and forests badly impacting soil fertility, floods mitigation, and recharging of water leading to multiple losses • Loss of agriculture biodiversity • Soil loss

Source: Singh et al., 2021

Gender and marginalized groups should also be considered separately when assessing non-economic loss and damage. Differentiated risk and vulnerability of different groups based on age, sex, economic status, and other factors must be considered, as well as intersectionality issues within gender.

Step 7.2. The Climate-Induced Loss and Damage of Recent Disasters in Nepal

A solid case of climate-induced loss and damage can be cited from recent rainfall patterns and floods in the mountain districts of Nepal. The pre-monsoon and the first month of the monsoon (June) of 2021 had broken all scientific precipitation records in Manang and Mustang districts. The two weather stations of Manang (Humde) and Mustang (Jomsom) showed extreme rainfall events. The Humde weather station of Manang recorded 232 mm of pre-monsoon rain this year while the average pre-monsoon rainfall in the past six years was 135 mm. Similarly, the Jomsom weather station of Mustang recorded 142 mm of rain compared to the normal 70 mm during March-May. The Humde station had received 172% greater precipitation than the normal.

During June 2021, 12- 16 (5 days period), the Humde station received 175.8 mm and the Jomsom station received 86.5 mm precipitation (**Table 15**). On 15 June, the Humde station recorded 54 mm rainfall and 82.23 mm on 16 June which was the highest rainfall recorded since 2015. Similarly, from 1958 to 2020, the highest recorded precipitation at Jomsom in June was 75.8 mm. It also illustrated that the trend of extreme precipitation in June was observed to be increasing at a rate of 0.09 mm per year.

Table 15: Rainfall Data of Humde and Jomsom Weather Station Recorded in 2021

Weather Station	Average pre-monsoon 2015-2020 (mm)	Pre-monsoon 2021 (mm)	12-16 June 2021 (mm)	Loss and Damage ($)
Humde (Manang)	135	232	175.8	approx. 9.5 million USD
Jomsom (Mustang)	70	142	86.5	NA

Incessant heavy rainfall in the pre-monsoon and monsoon season of 2021 had flooded many small rivers and rivulets in Manang with floodwaters entering villages and causing damage. Floods in the Marshyangdi River and the landslides triggered by continuous rainfall had displaced more than 350 people. Due to floods and landslides, 24 households from Sirantal area and 11 households from Thoche area of Nasong Rural Municipality were displaced and rescued by Nepal Army. Manang faced one of the worst situations 65 km long road connecting the district with others was damaged along with 5 suspension bridges and 1

Bailey bridge due to the floods. According to the local authorities, the loss and damage of one day rainfall that triggered the disasters is equivalent to 9.5 million USD.

The recent rainfall pattern has shocked and surprised the local communities and stakeholders. According to them, the rain is very heavy and intense, with more rainfall in a shorter period. 'The local houses and other infrastructure are not built to cope and adapt with the current changes in the rainfall pattern,' a Thoche resident observed. Similarly, a resident of Sirantal expressed his belief that the disasters he had witnessed were both devastating and unusual.

7.3. Attributing Loss and Damage Triggered by Climate-Induced Disaster: A Case of Snow Melting and Glacier Lake Formation in Nepal

In all three basins, 47 glacial lakes, both draining down from Tibet and upstream from the Nepal Himalaya, were identified as Critical Lakes in a recent report by UNDP and ICIMOD (2020). One unique example of climate-induced L&D is glacier melting and the formation of glacial lakes. According to the information available, Nepal has experienced at least 24 Glacial Lake Outburst Flood (GLOF) events in the past. Of these, 14 are believed to have occurred in Nepal itself, and 10 were the result of flood surge overspills across the China-Nepal border (Tibet Autonomous Region). Based on the GLOF hazard, the mapping shows (**Figure 17**) that the eastern Himalayas are the hotspots of GLOF hazards. Mostly GLOF is concentrated in Province 1, Bagmati Province, Gandaki Province, Karnali Province, and Sudurpashchim Province (MoFE, 2021).

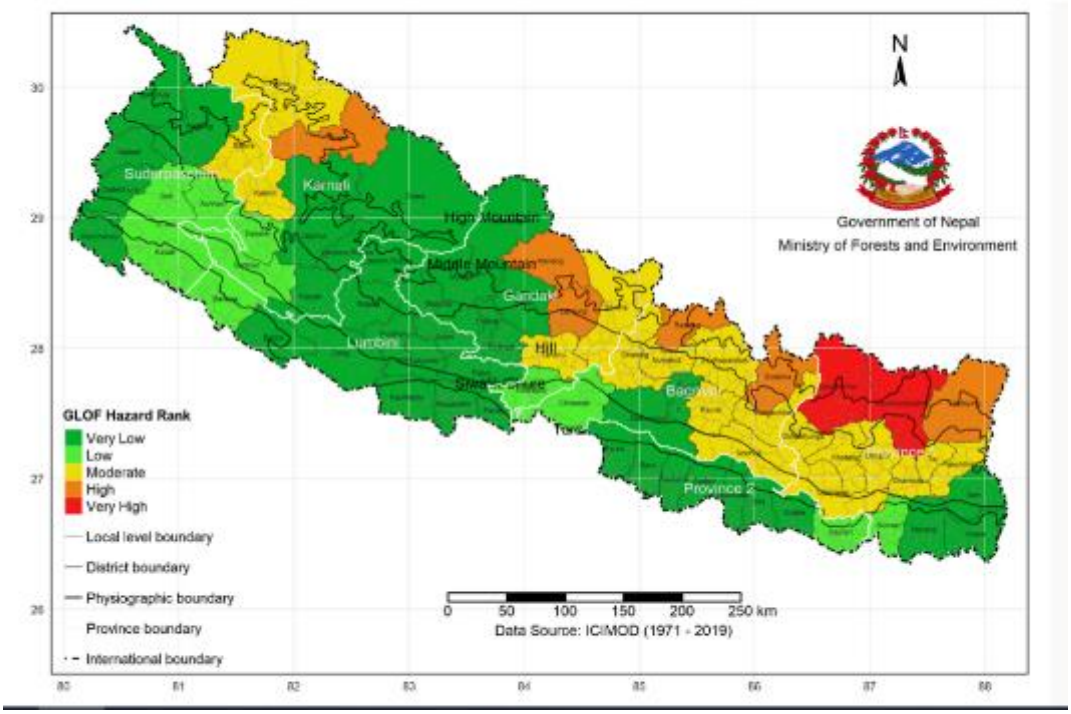


Figure 18: Map showing the GLOF hazard ranking in Nepal.

Source: MoFE, 2021

The past GLOFs have caused considerable damage and loss of life. The Bhote Koshi and Sun Koshi GLOFs of 1964 and 1981 and the Dig Tsho GLOF of 1985 are some examples. The 1981 event damaged the only road link to China and disrupted transportation for several months (ICIMOD, 2011), while the Dig Tsho GLOF destroyed the nearly completed Namche Small Hydroelectric Project, in addition to causing other damage farther downstream. The floods destroyed bridges, homes, agricultural land, and the nearly completed Namche Small Hydropower Plant, two weeks before its inauguration, which resulted in an estimated loss of US$ 1.5 million. Remarkably, only 4-5 people lost their lives in the floods because a Sherpa festival was in progress and few people were walking the trails at the time (ICIMOD/UNEP, 2002; Kattelmann, 2003). The source of the event was inside the Tibet Autonomous Region of China, indicating the necessity for international regional cooperation to address the problem. For run-of-river hydropower plants, the main risk is related to the reduction in river flow during drier periods (and associated reduction in output) and increased flows in wet periods (which means facilities need to be planned with greater capacity).

Table 16: Major GLOF Events and Loss and Damage

	Date	River basin	Lake	Cause	Losses
Entirely within Nepal					
1N	450 years ago,	Seti Khela	Machhapuchchhre	Moraine collapse	Pokhara valley is covered by 50-60 m deep debris.
2N	3 Sep 1977	Dudh Koshi	Nare	Moraine collapse	Human lives, bridges, and others
3N	23 Jun 1980	Tamor	Nagma Pakhari	Moraine collapse	Villages destroyed 71 km from the source
4N	4 Aug 1985	Dudh Koshi	Dig Tsho	Ice avalanc he	Human lives, hydropower station, 14 bridges, etc.
5N	12 Jul 1991	Tama Koshi	Chubung	Moraine collapse	Houses, farmland, etc.
6N	3 Sep 1998	Dudh Koshi	Tam Pakhari	Ice avalanc he	Human lives and more than NPR 156 million
7N	15 Aug 2003	Madi River	Kabache Lake	Moraine collapse	Not known
8N	8 Aug 2004	Madi River	Kabache Lake	Moraine collapse	Not known
9N	Unknown	Arun	Barun Khola	Moraine collapse	Not known
10N	Unknown	Arun	Barun Khola	Moraine collapse	Not known
11N	Unknown	Dudh Koshi	Chokarma Cho	Moraine collapse	Not known
12N	Unknown	Kali Gandaki	Unnamed (Mustang)	Moraine collapse	Not known
13N	Unknown	Kali Gandaki	Unnamed (Mustang)	Moraine collapse	Not known
14N	Unknown	Mugu Karnali	Unnamed (Mugu Karnali)	Moraine collapse	Not known
Originated in TAR/China and caused damage in Nepal					
1C	Aug 1935	Sun Koshi	Tara-Cho	Piping	66,700 square meter of wheat fields, livestock, etc.
2C	25 Aug 1964	Trishuli	Longda	Not known	Not known
3C	21 Aug 1964	Arun	Gelhaipuco	Glacier surge	Highway and 12 trucks
4C	1964	Sun Koshi	Zhangzangbo	Piping	No remarkable damage

5C	1968	Arun	Ayaco	Not known	Road, bridges, etc.
6C	1969	Arun	Ayaco	Not known	Not known
7C	1970	Arun	Ayaco	Not known	Not known
8C	11 Jul 1981	Sun Koshi	Zhangzangbo	Ice Avalanc he	Hydropower station
9C	27 Aug 1982	Arun	Jinco	Glacier surge	Livestock, farmland
10C	6 Jun 1995	Trishuli	Zanaco	Not known	Not known
11C	Jully 2016	Bhotekoshi	Gongbatongsha	Glacier surge	Bhotekoshi Hydropower

Source: Bajracharya et al., 2020

A unit-loss approach can be used to estimate the potential loss of GLOF (Khanal et al, 2015). First, the value of individual properties was calculated; these were then added together to derive a total potential loss figure. The estimated losses were grouped into four categories: direct damage to real estate (land and houses); indirect damage to agriculture (crops and livestock); direct damage to public infrastructure (roads, trails, bridges, schools, office buildings, temples, water mills, transmission lines, hydropower, and others); and indirect secondary damage (such as loss of revenue from trade and hydropower, resulting from damage to roads, bridges, and hydropower dams or powerhouses). Intangible losses were also discussed. The local prevailing purchase values of household assets, including land, crops, livestock, and others, and replacement cost of infrastructure, were used in estimating the monetary value of the elements exposed to a potential GLOF risk. Information on the per-unit local prevailing purchase values was collected during the group discussions for each section/block. The national average cost per unit was used to estimate the replacement cost of larger infrastructure such as roads and hydroelectric infrastructure (Khanal et al., 2015). All values were based on the prices reported at the time of the fieldwork (**Table 17**).

Table 17: Monetary Value of Elements Potentially Exposed to Glacial Lake Outburst Flood Risk (US$ thousands)

Sectors	**Imja (Dudhkoshi)**		**Tsho Rolpa (Tamakoshi)**		**Thulagi (Marsyangdi)**		**Lumuchimi (Bhotekoshi/ Sunkoshi)**	
	Model	Max	Model	Max	Model	Max	Model	Max
Real Estate	8,917	31,729	1,411	6,524	2,036	6,685	15,889	40,606
Agriculture	932	1,680	117	330	234	519	246	996

Public Infrastructure	2,037	2,084	319	1,928	335,784	339,469	98,845	109,446
Revenue	7	7	0	0	68,678	68,678	37,762	37,762
Total	11,894	35,501	1,847	8,781	406,731	415,351	152,741	188,810
Model = modelled GLOF scenario. Max = maximum affected level.								

Source: Khanal et al., 2015

The future risk of GLOF could be devastating. Recent study by UNDP (2021) estimates the potential outburst of Thulagi lake alone could incur a loss of thousands of lives and at least $ 400 million of economy. If this price is considered as uniform for all the 21 potential glacier lakes loss and damage, it will be 8.4 billion USD. However, the loss and damage are contextual and depend on resources and infrastructure downstream, other resources, the season or time when it will occur, etc.

Step 8. Assessment of Avoided Risks through Adaptation and DRR Options

Once the risk and vulnerability and estimation of post-disaster L&D and future economic implications are identified, it is important to assess which risk and vulnerability can be avoided through adaptation and DRR actions, as described above, and those that are not possible to avoid or have some limitations in terms of making responses.

Step 8.1. Assess the Avoided Risk through Adaptation and DRR Options: It is important to assess L&D that can and will be avoided by climate change mitigation and/or adaptation measures. It is important to list the successful adaptation and DRR actions that have helped in avoiding the risk and vulnerabilities which ultimately avoid L&D. When mountain glaciers melt, the adaptive response may be building or strengthening dikes to contain the glacial lake, and by increasing the ability to surround landscapes to hold the water recharge, such as through reforestation.

The assessment could look into the following aspects:

- Can the existing and future risks of climate change impacts be avoided? If yes,
    - What are the available and existing and potential adaptation and DRR options?
    - How effective were/are these options in addressing the risk and impact? Are these options sufficient?

There are different methods and tools in identifying adaptation options. It is mostly done through a participatory process of engaging experts, planners, communities, and practitioners. With regards to the assessment of the adaptation options at all scales, the assessment should include elements of:

- Effectiveness - Achieving objectives: to reduce vulnerability or risk, increase adaptive capacity, or achieve an enhanced level of protection.
- Flexibility - How far can we adapt: Successful adaptation has to be flexible, not least because of the potential range of climate changes projected under different emission scenarios.
- Equality - Inequality dimensions to adaptation: Address inequalities between sectors, between regions, and society.

- Effectiveness - Cost-effectiveness. Successful adaptation will involve deciding on acceptable levels of risk (defined to some extent by communities, policymakers, and funders in a collaborative way) as a trade-off with the resource investments needed to reduce this risk, and whether this should involve maintaining or improving the current levels of risk and resilience accordingly.

- Sustainability - The wider implications of adaptation: Sustainable adaptation is likely to include strong elements of partnership-building, community engagement, education, and awareness-raising, as well as focusing on interventions that are 'mainstreamed' into existing development processes and mechanisms, and cutting across key sectors (water management, agriculture, health, and education).

Examples of Risk Reduction measures

If glacier melting is identified as one of the current and future risks from climate change, it is preferable to investigate the feasibility of avoiding the risk through successful adaptation and mitigation measures, such as draining the lake to avoid Glacier Lake Outburst Flood (GLOF) or establishing GLOF monitoring systems, early warning stations, and so on. The Imja and Tsho-Rolpa glacial lakes in Nepal have already been lowered by the Nepalese government. Following the devastating GLOF event of 1981, both national and local governments recognized the need to work on GLOF risk management. National Disaster Risk Management Strategies (2009), National DRR Policy (2018), National DRR Strategic Action Plan (2018-2030), National Adaptation Program of Action (2010), and National Climate Change Policy (2019) in Nepal, and National Adaptation Strategies for Climate Change and National Disaster Reduction Plan (2006–2010) in China, both emphasize the need to respond to the GLOF issue. The Sendai Framework for Disaster Risk Reduction, for example, has set a goal of lowering seven glacial lakes by 2030 and establishing a multi-hazards Early Warning System (EWS) by that year.

Step 8.2. Un-avoided Risks (constraints and limits of response measures) Both Soft and Hard measures: L&D

Once the potential climate risks are identified, it is imperative to analyze the risk that is acceptable, tolerable, and intolerable. This will help understand the limits of adaptation interventions and the resulting loss and damage. Literature shows different models can be used to identify risk categories. Mostly expert judgment is used.

Limits to adaptation can be breached when catastrophic extreme events resulting from climate change become increasingly severe or frequent, such as severe droughts. It can also prove impossible to adapt to slow-onset impacts that continue to develop and leave behind territories uninhabitable and unproductive. Increasing temperatures, glacial retreat and related impacts, land and forest degradation, loss of biodiversity, and desertification are all major challenges to adaptation efforts (ActionAid, Care, WWF, 2015).

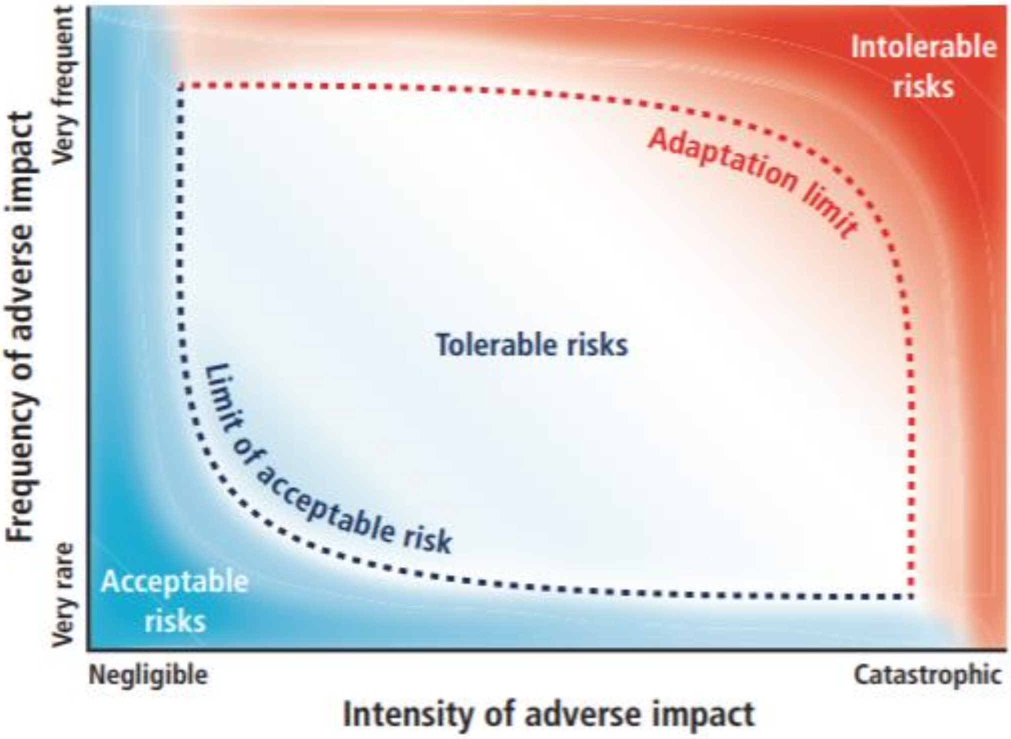


Figure 19: Understand Intolerable Risks and Adaptation Limits

Source: Klien et al., 2014

One of the reasons why some adaptation measures are not taken, or losses and damages remain unavoided is actors may be subject to socio-economic constraints, especially international financing, and/or implementation constraints, although, at least in theory, these measures could have been taken. Further constraints to adaptation planning and implementation comprise a lack of technological or knowledge resources and institutional characteristics that impede action.

The assessment of this adaptation limit and constraints can be done by looking at the effectiveness of adaptation options as described under section 8.1. The key questions relevant to explore are:

- What are the limits and constraints of adaptation and DRR options, including adaptation and DRR deficits? This framework can be used to see if there are any adaptation limits, i.e., when standard adaptation isn't enough and transformational actions are needed (relocation, resettlement of households, switching livelihoods, etc.). What implications does it have in addressing the risks and impacts of climate change?

- What are the residual risks and impacts due to this limit and constraints?

GLOF issue can be taken as an example for assessment. Of the forty-seven dangerous lakes in three river basins, forty-two lakes are in the Koshi, 3 in the Gandaki, and 2 in the Karnali basins. Of these, twenty-five potentially dangerous glacial lakes (PDGLs) are in the Tibetan Autonomous Region, China, and flow across the border into Nepal, 21 PDGLs are situated in Nepal, and one is located in India (Bajracharya et al., 2020).

However, when glacial lakes burst (for example, through a sudden breaking up of large glacial pieces), even with an effective early warning system, the resulting floods can cause L&D destroying homes and harvests. It can also result in loss of life.

The L&D which goes beyond adaptation is, therefore, a critical issue for Nepal. The Himalayan ecosystem of Nepal has more than thirty million people living downstream of the glaciers (Action Aid, CARE, WWF, 2015). Major climate hazards such as GLOFs pose a serious risk to substantial investments, the country's social capital, and communities who live near the glaciers. Over the years, there have been significant investments made in the region's economy, and more investments will likely be made in the future.

Low-income countries are more heavily affected by extreme weather events and future climate change than rich countries. This discrepancy is known as an "adaptation deficit" (Frankhauser and McDermott, 2014) is another constraint. This largely occurs due to inaction or lack of timely response. Due to the limitation of funding, the draining of the water from the potential GLOF sites has not been conducted. Tsho Rolpa and Imja glacial lakes are being drained. These are the residual risk and limits and constraints to adaptation and risk mitigation measures.

Many other examples can also be cited. The inability to recover and reclaim flooded land and infrastructure, the inability to continue to grow particular agricultural produce in the flooded area. Another example could be the rising temperatures causing drought and erratic rainfall may lead to major crop losses proving disastrous for communities whose livelihoods are largely dependent on agriculture. Some farmers and farming systems may find innovative ways to adapt, for example, through adopting water submergence varieties, increasing their locally adapted crop diversity, using early warning systems to timely planting and harvesting, or through building dykes/bioengineering measures to protect the crops from floods. However, above certain temperatures, crops fail to pollinate or set seed, the rain fails to arrive, and the land may even turn to desert, resulting in permanent loss of livelihoods. These residual impacts are important to account for and address adding to L&D (Van der Geest and Schindler, 2017).

There are also limits to adaptation and DRR technology and practices. For example, the Early Warning System (EWS) has been effective to save the lives of thousands of people in Nepal due to improved flood hazard monitoring and communicating the information beforehand. However, there will still be some losses and damages with regards to properties like land, houses, local infrastructure, and livestock (big). This limits the ability of communities to fully cope, let alone adapt to the impacts of flooding in Nepal.

Another major constraint of adaptation is the lack of financial resources. Although the adaptation and DRR options are identified, it has been almost impossible to address all the risks and vulnerabilities of communities. External support has been limited to few areas. In many cases, communities themselves adopt autonomous adaptation actions. The severity of climate change impacts constrains the effectiveness of action and reduces L&D. These deficits or limited resources and limited timely interventions lead to the accumulation of risks and more impacts.

Step 8.3. Assessing: Unavoidable Risks (cannot be avoided)

An unavoidable impact of L&D that cannot be addressed either by mitigation or adaptation is extreme event risks which no adaptation efforts can help in preventing the physical damage (Verheyen and Roderick, 2008). One of the reasons is that some adaptation measures cannot be pursued, and consequential L&D remain. Key questions to understand this are:

- Are there risks and impacts beyond adaptation and DRR responses? How and why?

- What are the implications of these unavoidable risks to human and natural systems?
- How can these unavoidable risks be addressed?

One example of the avoidable risk is glaciers melting in Nepal. Likewise, sea-level rise is another example for coastal countries. Glacier melting is happening, which is also highlighted in IPCC six assessment report. The Glacier will retreat faster in the future which will have major implications to the millions of people downstream in terms of L&D caused due to GLOF events, lack of access to drinking water, limited access to irrigation, negative impact on hydropower, and changes in river flow dynamics that affect the riverine ecosystem. Changes in the volume of glacial lakes mirror changes in their source glaciers. In the 33 years between 1977 and 2010, glaciers in Nepal have decreased by almost a quarter of their initial area (Bajracharya et al., 2014) and over this period, the number of glacial lakes in the Koshi basin has increased from 1,160 in 1977 to 2,168 in 2010; their total area has increased from 94.4 km^2 to 127.6 km^2 (Shrestha et al., 2017). The number of lakes has increased by 86.9%, and the total lake area by 35.1%.

Glacier melting has major impacts on water availability, the nature of disasters, and other socio-economic activities (hydropower, irrigation, drinking water, and industrial use of water), including mountain culture and tradition. These impacts will lead to both economic and non-economic costs.

Step 9. Identifying Other Drivers of Loss and Damage

Step 9.1. Assessment of Climate-induced Displacement

Climate change-induced weather events (too much and too little rainfall), gradual changes in average temperatures, and sea-level rise can trigger displacement and migration. Changes such as rising heat due to spikes in temperature and humidity could directly affect people and trigger them to move to areas where the heat index is lower. Droughts that may lead to the drying up of springs can drive people to migrate. In Nepal, lack of drinking water is already leading households' move from where they live in the hills to new places where drinking water supply is more reliable. River flooding, on the other hand, does result in immediate displacement but it may not trigger permanent movement. Permanent inundation, waterlogging, and bank cutting, on the other hand, often do result in permanent movement. Though migration is a major phenomenon in Nepal, the movement of people impacted by climate-related threats is not systematically documented. Extreme weather events contribute to the rising migration increasing food insecurity and destroying arable and usable land (IOM, 2016). This limitation needs to be addressed because migration patterns influence the ability of the country to achieve its adaptation goals. Even in normal times, population displacement is a major social and development challenge for any country as migrants face a sense of insecurity in their new places of resettlement. Generally, the migrant population tends to be excluded from basic services, disaster preparedness, and mitigation support and thus faces greater threats (Ramirez et al., 2021).

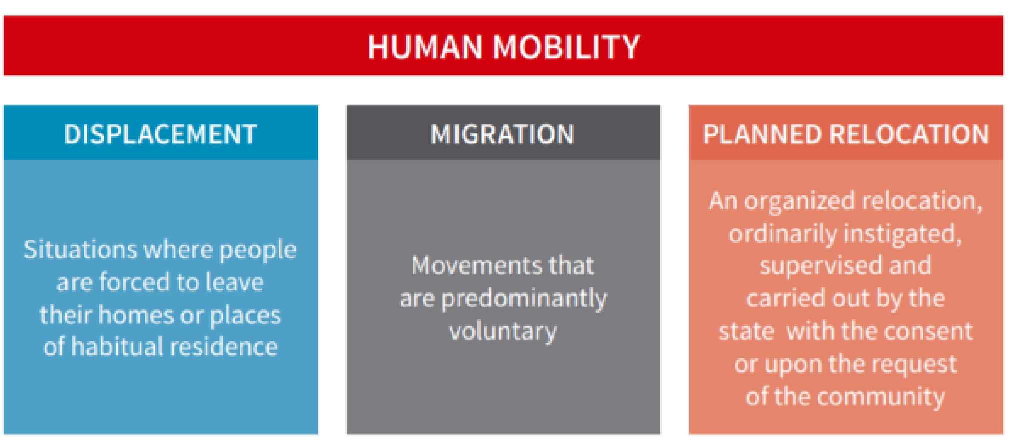
In global climate change negotiations, formal recognition of climate-induced migration and displacement is lacking even though displacement and migration are often major climate change-induced L&D. There is no universally agreed definition of climate-induced human mobility (Warner, 2010). Climate-induced migration and displacement were first mentioned in the UNFCCC documents in 2008 and then brought up again at the 14th COP in Poznán and included in Paris Agreement as migration and human mobility. It broadly refers to the movement of people driven by sudden or progressive changes in weather or climate. Such movement can include temporary and permanent, seasonal, and singular, as well as the voluntary and forced movement of people. "Climate change is projected to increase the displacement of people throughout this century. The risk of displacement increases when populations that lack the resources to migrate experience higher exposure to extreme weather events, in both rural and urban areas, particularly in low-income developing countries. Changes in migration patterns can be responses to both extreme weather events and longer-term climate variability and change, and migration can also be an effective adaptation strategy (IPCC, 2014). The distinction between displacement and migration is as follows in **Tables 18 and 19**.

Table 18: Displacement and Migration

Displacement	Migration
Displacement is a situation in which people are forced to leave their homes or place of residence. Displacement is associated with intensive risk, where the occurrence of a disaster event is the primary driver of movement. It can take place within or across borders.	Migration is usually associated with extreme risk and can take place within or across borders. The decision to move is complex and often linked to multiple drivers, including, but not limited, to climate change. To some degree the decision to move is voluntary.

Source: Advisory Group on Climate Change and Human Mobility, 2014

Table 19: Displacement, Migration, and Relocation



Source: IOM, 2014

The issue of climate change and mobility, an important aspect for Nepal reflects multiple relationships between the two processes. Likely, the numbers of people moving internally to cities and across borders will rise over the coming decades (Milan et al., 2015). Some displaced people will remain within their own country or region, and most are likely to head to urban centers (DST, 2008). Some will migrate to other countries. The impacts of climate change intertwine with other drivers of change to exacerbate the vulnerability of people across the country and affect the migration patterns of many. For example, some inhabitants from hill settlements that face water scarcity will move to newer locations with easier access to water. Many others may decide to move to urban areas seeking new employment opportunities. At the same time, as the temperature rises, people may move to the hills, seeking the comfort of its cooler environment. In this way, climate change may alter the pattern of migration, both in the short and the long terms. Climate change spawned impacts thus would work on pre-existing conditions and add to L&D.

Step 9.2. Nepal Migration: Historical Context

Migration from Nepal's rural areas has not only increased significantly but also changed in many ways. New labor markets in Southeast Asia and the Middle East, many of which pay better wage rates and requiring greater levels of skill than does India, have opened up for Nepali migrants (Adhikari & Hobley, 2011). This shift in destination from low-paying to high-paying countries has increased the earnings of migrants and the remittance they send home.

Since the early 2000s, there has been an increase in the volume of Nepali workers headed to the Gulf countries and Malaysia for temporary employment. In 1993/94, the Department of Foreign Employment (DOFE) issued 3,605 labour approvals. A decade later, in 2003/2004, the number increased to 106,660, and in 2013/14 to 519,638. Since 2013/14, however, the volume of annual outmigration has been decreasing. It was 354,098 and 236,208 in 2017/18 and 2018/19 respectively. The financial remittance they send has significantly increased from US$ 2.54 billion in 2010/11 to US$ 8.79 billion in 2018/19 (Nepal Labour Migration Report, 2020). In addition, opportunities in urban areas within the country itself have served as a "pull factor" for in-country migration, increasing the rate of urbanization. People's mobility has increased, but as explained above, it is hard to attribute migration and displacement directly to climate change and label it as part of L&D.

The COVID-19 pandemic has introduced one more complexity. To contain the spread of the pandemic, GoN introduced a "lockdown" of social and economic activities. This led to the closure of jobs mostly in the informal sector. Many migrants working in this sector lost their jobs. This happened both in Nepal and in countries where Nepali migrants worked. According to NPC (2020), about 708,000 individuals have lost their jobs either temporarily or permanently due to COVID-19. These numbers add to the unemployed population estimated at 900,000. An estimated 500,000 have entered the labour market. Nepali migrant workers returning to Nepal number 255,000 and 75,000 workers are unable to go for foreign employment due to the shrinking global demand. While putting pressure on Nepal's labour market, these will increase impacts on the economy, public health systems, and already stressed local employment. In many cases, historically poor and marginalized groups across gender, caste, and ethnicity categories will face greater challenges in accessing services and jobs. In this new context, climate change will lead to much higher L&D.

<u>Displacement</u>

In the past, Nepal experienced many floods and landslide events that have caused great L&D across the country. The 1953 landslides and flash floods in the hills of central Nepal were the first recorded climate-related L&D. The then government encouraged the affected families to resettle in the Chitwan Valley, which had just been opened up as an area of new settlement after malaria was eradicated with the application of Dichlorodiphenyltrichloroethane (DDT).

Not only landslides and floods but also drought has forced many families to move from their villages voluntarily. In 2016, the village of Samjong in Nepal's Upper Mustang District at an elevation of 4,100 m, facing persistent drought conditions for almost a decade, had to be relocated to the village of Namashung in the same region. Many families from the hill districts of Paanchthar in the east and Gulmi in the west have moved due to drinking water shortages. Villagers from Yashok (Panchthar) region (NPC, 2013) migrated to Jhapa, Morang, and Sunsari districts in the Tarai, while those from Gulmi migrated mostly to Butwal Municipality, Rupandehi District, and a few to Pokhara Municipality, Kaski District. From Gulmi some families also migrated to the districts of Kapilvastu, Nawalparasi, and Dang. Though some families have moved to new places they have not sold their properties in their places of origin.

In other cases, families have abandoned their place of living, finding no buyers for their land, houses, or cattle. Utensils are abandoned and houses are in a dilapidated state as families simply lock the door and leave their property with no caretaker. The major distinction between migrants from Gulmi and those from Panchthar is that the latter do not expect that they will ever return. The former group, however, expects to return when the water situation improves, and they are hopeful that it will. Migrants from Panchthar who work in the paddy fields of Jhapa and Morang on a contractual basis say that they have no desire to return to their birthplaces. These are rather micro-level anecdotes but do point to larger level policy questions as GHG continues to be emitted at a faster pace, their concentration goes up leading to higher average global temperature and climate change. The displacement of the locals of Kavre and Panchthar for drought stress, Mahottari for floods, Udayapur for landslide, and Gulmi for the flow of emigrants is illustrated in **Table 20** (NPC, 2013).

Table 20: Number of Households Displaced Due to Environmental Stressors.

	VDC/Municipality	Displaced households (no)	Reference period	Destination
Panchthar	Yashok	20	May 2013	Jhapa, Morang, Sunsari
	Ranigaon	16	April – June 2013	
	Syabargumba	200	2001- 2013	
Udayapur	Saune	10	7 households after 2001; 3 households before	Nearby places
	Hardiya	200	Some before 2000; some during 2004 floods; many after 2008 floods	They have settled on the bank of the river but move back when the plain gets flooded.
	Jogidaha	100		
	Sundarpur	200		
Mahottari	Kishannagar	10	Some households before 2000, some during 2004 floods, many of them after flood of 2008	Settled on the riverbank but move back when the plain gets flooded.
	Gonarpur	150		
	Kaluwa	100		
	Bagaiya	150		
	Bhataliya	100		
	Jaleswor municipality	100		
Kavre	Panchkhal	4	April – June, 2001-2013	To the valleys of the respective VDCs
	Sathighar BHagawatisthan	78		
Gulmi	Dauwa	40	After 2008	Baletaksar, Butwal, Palpa
	Baletaksar	4	Within the last 2-3 years	
	Jaisithok	4	April – June 2013	
	Rimuwa and Bamgha	133	In the last 2-3 years	

The study has identified several households being displaced due to drought, landslides, and floods. It showed that most families from the hill districts of Panchthar and Gulmi were displaced after the water shortage became severe. Villagers from the Yashok region had migrated to Jhapa, Morang, and Sunsari districts in the Tarai, while those from Gulmi went to Butwal Municipality, Rupandehi District, or, in fewer numbers, to Pokhara Municipality, Kaski District, and the neighboring districts of Kapilvastu, Nawalparasi, and Dang.

Should climate change-induced migration happen on an even larger scale across Nepal, a new policy response would be required (Adhikari et al., 2021). The displacement thus induced will be a new complex layer on the migration landscape and merits much deeper analysis to understand its implications for human mobility. These lessons can inform international discussions on development, disasters, and climate change so that human mobility is considered in ways that offer clarity on various aspects of human mobility and displacement. They should help avoid ambiguity about traditional forms of displacement and those triggered by climate change as part of L&D. Currently existing provisions send confusing messages to national governments, which try to implement them in line with their development objectives. In the evolving international climate regime and national policy environments, inquiry into displacement dynamics is an important opportunity to address the needs of vulnerable groups who are likely to be forced to move. That said, there are difficult conceptual challenges in assessing displacement as an element of climate change-induced L&D.

Step 10: Identifying future risk and loss and damage from climate-induced disasters

Information that enables the characterization of a future climatic hazard scenario and is sourced either from the data from past hazard occurrence or models for assessing the risk of loss and damage. However, both sources, past hazard-based and model-based information, at best enable an approximation of the anticipated hazard and thus involve uncertainty. Future scenarios of climatic hazards can be inferred using the scenarios of temperature, precipitation, and climate extreme indices as indicators which can be expressed in descriptive terms.
The climatic hazards may become more frequent, widespread, long-lasting, or intense under future climate change. There might be multiple events at the same time across different regions, which may turn to be catastrophic. Coupled with degrading ecosystems and biophysical processes under climate change, the climatic hazards may create chronic stresses and catastrophic shocks. The manifestation of climate change may be observed in the following forms (

Change in variability and extremes:

- Rainfall variability, seasonality – droughts, predictability
- Changes in peak precipitation intensity (flood and landslide risk)
- Changes in storm activity/behavior/geographic distribution
- Heatwaves, wildfires, pollution events, etc.

Long term changes/trends in average conditions:

- Warmer, wetter, drier, more saline groundwater
- Shifts in climatic zones, ecological/species ranges

Abrupt /singular changes:

- Monsoon shifts, circulation changes
- Landscape and ecosystem transitions
- Glacial lake outbursts

The VRA provides opportunities for assessing the future risk of climate induced hazards and extreme indices. There are also probabilistic models / mathematical model already used to quantify and qualify the loss and damage from climate induced disasters. Few are explained below.

- Catastrophe Risk Models: Catastrophe risk models use Monte Carlo1 methods to estimate potential losses based on the probability, magnitude, and location of specific hazards – as well as the corresponding exposure of that location – and the corresponding exposure of that location (Ibid). The damage function calculated in this exercise is then used to project actual property losses for specific events, determining, among other things, the likelihood of a predetermined loss being exceeded in a given year

- CATSIM (Catastrophe Simulation): CATSIM is a simulation model created by the International Institute for Applied Systems Analysis (IIASA) to assess disaster risks in a particular country or region. The methodology is designed to assist in natural disaster risk mitigation planning by analyzing fiscal and economic risk and weighing the benefits and costs of various risk reduction strategies.

5. Responding to Loss and Damage

5.1. Approaches to Minimize Loss and Damage from Climate Change

Ways to reduce L&D from climate change include increasing resilience before the occurrence of an extreme weather or slow-onset event – for example, by strengthening flood defences – and establishing mechanisms to provide financial or social protection support to those who have already experienced L&D. It can include technology and practices, finance, policy, and legal measures, and mainstreaming climate change resilience across all investments and policy decisions (Byrnes and Surminski, 2019).

The Comprehensive Risk Management Framework (**Figure 19**) suggests that targeted approaches to avoid and minimize L&D from climate change impacts should build on sustainable development. These tools should aim at reducing vulnerability.

Figure 20: Comprehensive risk management framework

Source: Roberts and Pelling, 2018

Different literature suggests that there are different ways of responding to L&D depending on its nature (**Table 21**). Mostly, incremental, and transformative options are suggested. The incremental options are those that are conventionally being implemented through DRR and CCA programmes, which address specific risks and help minimize potential L&D. Some examples include adaptation measures such as building check dams to prevent erosion, paying a premium for agricultural insurance, conservation of degraded ponds, etc. The transformative options include approaches that change the system so that people and livelihoods exposed to risks are safeguarded. These approaches include relocation of settlement from landslide-prone areas, providing people access to new livelihood options such as the shift from traditional subsistence farming to the service sector, etc.

Table 21: Responding to Loss and Damage

Nature of Loss and Damage	Ways to Address Loss and Damage

Avoidable Impacts due to inadequate mitigation, an adaptation of risk management	• Reduce GHG emissions • Remove constraints to adaptation • Improve the effectiveness of adaptation • Enhance disaster risk reduction (preparedness) • Increase resilience and coping capacity
Unavoidable Mitigation, adaptation, or risk management are ineffective, for example, due to locked-in emissions	• Social protection and safety nets • Resettlement • Assisted migration • Insurance solutions • Compensation

Source: Van der Geest and Schindler, 2017

An approach to dealing with risk is using appropriate techniques to be better prepared when a hazard strikes and reduce the impacts. Such actions may involve the promotion of activities that minimize the adverse effects of a hazard, protecting, for example, schools, health posts, and communication towers. Installing a flood warning system is one example of preparedness. The other approach to dealing with risk is shifting the burden of impact to another party through insurance. A farmer, for example, may contact a local microfinance institution, self-help group, or insurance company to cover some of his/her risk of crop failure.

5.1.2. Transformational change in risk management: Nepal has already put an integrated disaster risk financing and support model to the test. One of the more innovative projects has been the pooling of assets insurance, which began in urban areas and is now being expanded to other areas. Another initiative has relocated high-risk settlements to a more secure location. Around 300 houses have been relocated to a safer location as of September 2021. To assist in the development of an integrated settlement in safe locations, the government is providing financial grants to purchase land in a safer location.

This year, for example, NDRRMA received NRs 240291.54 USD to assist disaster victims. The money was used to build temporary shelters for people whose homes were completely destroyed by the Monsoon of 2021. According to the NDRRMA database, 573 beneficiaries from eight districts received a total of 240711.63 USD.

There are also positive examples of disaster-damaged heritage sites being rebuilt. Out of which, 586 cultural heritage sites and 373 monasteries have been reconstructed as of September. Further, 195 cultural heritage sites are under construction. Similarly, 114 monasteries are under construction.

Insurance schemes: An example of risk transfer

Insurance provides financial compensation to those suffering from a failure by transferring risk to a company. In this way, insurance protects subscribers from financial losses. The transfer occurs through an insurance policy that is a contract between the insurer and the insured. In such a policy, a person who buys insurance pays a regular premium as a service, and the money is paid back to him or her if a failure occurs or something unfortunate happens.

Generally, there are two types of insurance: a) life insurance and b) non-life insurance. Life insurance is a protection against the loss of income that would result from the sudden death of the insured person. It can be further categorized into a) term life insurance and b) whole life insurance. The term life insurance stays in effect for a specified period whereas the whole life insurance normally covers an individual until his or her death. Non-life insurance is mainly concerned with the protection of L&D other than life, like the damage to houses and crops.

In Nepal, the insurance industry started in 1947 with the establishment of Nepal Insurance Company Limited. An Insurance Act was enacted in 1949 that led to the establishment of many insurance companies. In 2000, there were nine working insurance companies in Nepal (Gurung, 2010). That number has now risen to 40. 19 of these deal with life insurance, 20 with non-life insurance, and one offer both life and non-life insurance. In terms of ownership, three companies are fully owned by foreign insurance companies, 18 are under private ownership and the GoN owns one company. The total number of branches of these insurance offices is 340. The subscription to insurance policies in Nepal shows an increasing trend. It is said that the performance of Nepali insurance companies both in life and non-life insurance is satisfactory. It is also said that the greater the presence of insurance companies, the greater the possibility of economic development as the number of institutional investors increases with the rise in opportunities for insurance.

Agriculture shared 26.2% of Nepal’s GDP in 2019/20 and an estimated 25.8% in 2020/21 (MoF, 2020), it is the main basis for the livelihoods of 66 percent of the population who are smallholders practicing traditional farming. However, agriculture is vulnerable to the vagaries of weather, and climate change is adding new risks. As the impact of climate change grows, productivity will drop, and the smallholders’ livelihoods will suffer. To minimize the damages that likely will follow, agriculture insurance can be helpful. It will provide compensation to farmers for commodity damages and enable them to adopt newer options (useful technologies to enhance productivity, for example).

An increase in awareness among farmers about agriculture insurance and government initiatives have led to the growth of insurance businesses. The development of agriculture insurance in Nepal was initiated in 2013 with the introduction of the 'Crop and Livestock Insurance Directive 2013'. GoN subsidizes 75 percent of the premium for agricultural insurance. Insurance companies collaborate with local microfinance institutions and work to increase the access of farmers to agricultural insurance. The Insurance Board has assigned mandatory areas of work to general insurance companies and urged them to provide agricultural insurance services in all districts.

Presently, agricultural insurance covers almost all major crops and livestock products with subsidies and compensation in case of complete or partial loss or damage. Agricultural insurance cover 26 products under animal categories like goats, fish, birds, cow/buffalo, pig, horse category, insects, and other domestic livestock. Crop insurance includes rice, ginger, orange, turmeric, mushrooms, and other crops (Agriculture Insurance Directives, 2077). The Medicinal and aromatic plants are also covered. The agricultural insurance portfolio as a proportion of the total insurance portfolio has been increasing; it is now about 10 percent of the total. 20 insurers are authorized to sell insurance schemes throughout Nepal. Their premium rates differ depending on the type of business insured.

In response to the Covid-19 pandemic, the Insurance Board of Nepal released a standard for implementing Covid-19 insurance schemes across the country. The government announced that for the fiscal year 2020/21 the Covid-19 insurance scheme was free for public servants but paid for by the government. The terms of this insurance policy are similar to those of the insurance policy issued for critical illness. This policy is divided into two categories in terms of the face amount offered: (i) Category A and (ii) Category B. The key features of Covid-19 insurance coverage are illustrated in **Table 22** below:

Table 22: Premium Details

Details	**Category A**	**Category B**
Face Amount	Rs. 100,000	Rs. 50,000
Premium	Rs. 1,000/person	Rs. 500/person
	Rs. 600/person for insurance coverage of all family members	Rs. 300/person for insurance coverage of all family members
Grace Period	15 days from the date of the commencement of the policy for the insurance claim	
Claim	The insured can make insurance claims after they test positive in a PCR test for Covid-19	

In Category A, an individual is charged NPR 1,000 to register for the scheme, which is worth up to NPR 100,000 per person, and NPR 600 is charged for each member of a family. In Category B, an individual is charged NPR 500 for the scheme, which is worth up to NPR 50,000 per person, and NPR 300 is charged for each member of a family.

When coronavirus insurance schemes were first introduced in April 2020, Nepal had very few cases. It looked as if the country was not going to be severely affected, and insurance companies launched their schemes with this assumption. As the total number of cases has exceeded 635,188 as of June 29, 2021, this policy has come under serious stress.

In Nepal, property insurance provides coverage against L&D caused by earthquake shock, fire, landslides, and floods. Insurance schemes depend on the valuation of properties and the consideration of risk factors. People rarely ensure their properties as it appears to be a gamble for them. Damage may happen the day after the purchase or may not happen for years or never. Thus, many people show little interest in buying insurance. According to the Insurance Information Institute, less than US$3.50 is spent per capita annually in Nepal on property and casualty insurance against nearly US$ 2,300 spent each year in the U.S. (UNISDR, 2015).

Insurance can thus play a role in compensating for L&D due to climate change. Its use would require changing operational rules, establishing pre-warning systems, and reforming policy. Nonetheless, questions about the limits of insurance in tackling threats from climate remain. How will families at the highest risk, who also have the lowest incomes, afford insurance? How do existing insurance practices provide safety from the more frequent and destructive impacts due to climate change? These questions need answering.

At a theoretical level, social perceptions of risk are also important to recognize. Government departments seek to minimize risk, while the market takes risks to make a profit. Environmental groups, on the other hand, emphasize the high risks of the chosen approach and the failure of the government to inform the public about the adequacy and/or inadequacy of its strategies. Farmers usually live with risk. The recognition that there are diverse perceptions of risk helps keep the policy landscape plural in dealing with the challenges of complex environmental problems such as that of assessing L&D and in designing, and taking adaptive actions, and avoiding maladaptation (Linnerooth-Bayer et al., 2013).

5.2. Developing an Action Plan for Responding to Risks

While there are several measures already implemented in Nepal through various projects and programmes for resilience building, risk reduction, preparedness, and risk transfer, the purpose of developing an action plan or responding to risks is to identify options that can deal with residual impacts and risks, which could, otherwise, potentially result in loss and damage. The options to address loss and damage can be classified into incremental, fundamental, and transformative. The following are some of the examples of the options proposed by the study conducted by Traction Action Nepal (Singh et al., 2021).

The incremental options are those that are conventionally being implemented through Adaptation and DRR programmes, which address specific risks and help minimize potential loss and damage. Examples include mitigation measures such as building check dams to prevent erosion, paying a premium for agricultural insurance, and conservation of degraded ponds.

The fundamental options include unconventional approaches to dealing with risks such as distribution of flood-tolerant paddy seeds and construction of new ponds.

The transformative options include approaches that change the system so that people and livelihoods exposed to risks are safeguarded. These approaches include relocation of settlements from landslide-prone areas, providing people access to new livelihood options such as the shift from traditional sustenance farming to the service sector.

The identification of options depends upon the socio-economic, technological, and ecological aspects that should be assessed based on the institutional and resource capacities available and then plan approaches to increase the missing capacities.

5.3. Nepal's Position in International Negotiations and Related Discussions

The 2015 Paris Agreement called upon all nations together to adopt ambitious efforts to mitigate climate change-causing greenhouse gases (GHGs). The agreement also calls for enhancing support for developing countries so that they can adapt to the impacts of climate change. GoN submitted its second NDC in 2020 under the Paris Agreement for the 2021-2030 period, under Articles 4.2 and 4.11 and Decision 1/CP.21 paragraph 23 and 24, and other relevant provisions of the Paris Agreement. The NDC considers the principle of common but differentiated responsibilities and respective capabilities, considering national circumstances. Nepal envisions achieving socio-economic prosperity by building a climate-resilient society. The strategy will present a vision towards net-zero greenhouse gas emissions by 2050.

An important area of interest to the GoN as part of the policy is assessing climate-induced L&D. Nepal's National Climate Change Policy 2019 and Environment Protection Regulations 2020 also emphasize the need to conduct research on the L&D associated with climate change impacts and implement measures to reduce climate change-related vulnerabilities. NAP, which is under preparation, aims to reduce the country's risks and vulnerability to climate change and facilitate the integration of climate change adaptation into policies, programs, and activities across all sectors and levels. NAP process considers the country's climatic and geographic characteristics as well as opportunities and challenges associated with climate adaptation and development. As part of NAP, the government recently completed the VRA.

The VRA has generated evidence showing that the impact and L&D from climate-induced disasters are massive in Nepal and will increase in the future.

There is clear evidence that climate impacts will be more intense. Many of the damaging extreme weather events of recent years will become routine. For the LDCs facing the greatest challenges from climate impacts, risks, and vulnerability, a long-term climate response will need to go beyond reducing emissions. The L&D agenda is still not advancing as per the expectations of countries like Nepal. The LDCs are fighting hard to ensure all parties recognize the need for scaled-up action and support for L&D. This includes understanding where the limits of adaptation exist in different contexts and identifying how technical, capacity building, and financial support could be provided. The following are some of the expectations of Nepal from global negotiations:

- **L&D as a stand-alone permanent agenda**: There is a need to properly acknowledge L&D in equivalence with mitigation and adaptation. For this, Nepal urges the parties to agree on making L&D a permanent agenda item of the UNFCCC's subsidiary bodies so that they can recommend appropriate decisions to the governing bodies of the UNFCCC and the Paris Agreement.

- **Operationalization of the Santiago Network on L&D**: The COP25 established Santiago Network on Loss and Damage to catalyze technical assistance to developing countries. To operationalize the network, Nepal, as part of the LDCs expects a decision by COP26 on institutional arrangement of the network, including clearly defined mandate and functions and operational resourcing so that it can respond to the needs of the least developed countries.

- **Loss and Damage Finance**: The developed country parties must fulfill their promise to enhance action and support to address L&D as a core function of the WIM. For this, parties need to agree on providing new and additional climate finance and mechanism for L&D so that vulnerable developing countries like Nepal can implement actions for L&D. Similarly, Nepal expects separate L&D finance in the negotiations leading to the post-2025 climate finance architecture.

- **Further Actions:** The COP 26 should produce a strong decision and recommendation on the inclusion of L&D in the Global Stocktake being conducted in 2023. In addition, Nepal encourages parties to the inclusion of L&D in all the reporting mechanisms of the UNFCCC and the Paris Agreement such as the NAPs, NDCs, Adaptation Communications, and National Communication Reports.

5.4. Existing Information System in Loss and Damage in Nepal

The information available on disaster-related L&D are mostly available from the government database system such as the DRR portal. This system, however, only includes limited information on the economic losses from the disasters after a quick post-disaster damage and loss assessment. This is very quick and based on mostly information gathered from police and local authorities.

The information and database system particularly targeting the assessment of L&D is not currently available. However, in Nepal, three sets of databases related to climate-related L&D are available.

Hydrometeorology: Since 1962, DHM has been regularly monitoring climate-related data throughout the country. DHM maintains nationwide networks of 337 precipitation stations, 154 hydrometric stations, 20 sediment stations, 68 climatic stations, 22 agrometeorological stations, 9 synoptic stations, and 6 Aero-synoptic[2]. Besides, DHM also maintains flow and sediment records of rivers. The 1970s and 1980s literature do present watershed level erosion values (Carson, 1985) but recent information on watershed-scale run-off, erosion, and sediment flow remains to be updated. Every year, DHM publishes a summary of data in bulletins and the data is available in electronic form. For the last few years, DHM is involved in community-based flood early warnings and also provides messages on daily weather via social media platforms including mobile phones and the proposed TV channel (MoF, 2021).

BIPAD Portal*:* Nepal's Ministry of Home Affairs (MoHA) began collecting and archiving data and information of disaster incidents occurring across the country into its Disaster Portal Disaster Information Management System (DIMS). The portal includes a) Geographic location of incident b) Incident date c) Incident type d) Human losses: e) Economic damage from 2010 onward. The NDRRMA has now established and manages the Bipad Portal, which includes data on deaths and losses at the Palika level collected by Nepal Police's Incident Reporting Mechanism (IRM). During the 2020 monsoon season, data on landslide disasters that resulted in human deaths (gender-disaggregated), injuries, missing persons, and estimates of total economic loss were collected and added to the Bipad Portal. The database does not yet include information on damage to other infrastructure or ecosystems, as well as non-economic loss and damage. It is, therefore, necessary to include NELD and damage other infrastructure and ecosystems as part of the Bipad Portal.

DesInventar.Net: *www.desinventar.net, hosted by UNDRR*, includes a systematic database of disasters that have occurred in Nepal from 1971 January to December 2013. DesInventar covers earthquakes, floods, landslides, drought, and epidemic events, and at all scales of disaster impact. It is a system incorporating diverse types of disasters on a regional and national scale. It enables a look to accumulate the climate change-related disasters at national and regional levels. The database includes event, region, district, village, date, cause, description of the cause, source, magnitude, deaths, injured, missing, houses destroyed, houses damaged, victims, affected, relocated, evacuated, losses (US$), losses (US$ local), damages at crops in a hectare, lost cattle, and damages to roads. The data is mostly collected from newspapers namely Gorkhapatra, the Department of Water Induced Disaster Prevention (DWIDP), and its special bulletins.

5.5. Challenges of the Database System in Context of L&D

The disaster database is a good beginning but has several weaknesses that must be overcome systematically. The portal includes limited direct L&D data and does not include non-economic L&D data. Estimating indirect L&D at an operational level is indeed not only difficult methodically but the scale and purpose complicate assessment. The few estimates of indirect L&D are generally available for a specific disaster of a larger scale and are often multiplication of direct losses using subjective assumption.

[2] http://dhm.gov.np/contents/resources

The other limitation of the database is in capturing the impacts of slow-onset events. There are conceptual challenges to this task. One challenge comes from the time frame to determine the impacts. Non-economic L&D accrue over some time, over many months, years, or maybe decades. How long such L&D should be assessed? Another key question also emerges: How can indirect L&D estimates from climate change be adjusted as weather characteristics change? L&D estimates necessitate iteration, continuous reviews, and updates over weeks, months, or perhaps years after the event. To capture such impacts in the disaster database, revised estimates must be made available regularly. This is a difficult proposition considering already existing challenges of resources and capacity constraints surrounding the development of data architecture.

Although UNFCCC has presented the definition of L&D, the UNFCCC system has not accepted it officially. It is referred to as potential losses. It also refers to avoided losses that did not materialize due to investments in risk management options. This is also true of risk reduction investments made in reconstruction to improve community resilience and support climate change adaptation. Disaster databases do not capture and include such costs. Regardless, disaster losses whether from climate-related or non-climatic hazards are a complex outcome of the intersection of the magnitude of the hazard, exposure to it, the quality of natural ecosystems, infrastructure, the socio-political context of the actors hit, and the rules-in-use as articulated in the conceptual framework. An increase in the number of infrastructures at risk or more population exposed to hazard without an increase in event's severity forced by climate change can also increase L&D. Other range of factors such as actors' preparedness to respond to risk and the support they receive in the process also determine their ability to recover from a disaster.

Unlike the emission of greenhouse gases, whose sources are broadly known, climate-induced L&D does not have one direct impact indicator. Thus, an integrated risk-based framework for disasters spawned by climate variability and climate change may be an entry point for assessing L&D. Such an approach may also find resonance with the disaster risk management approach (Huggel et al., 2013) that has received increasing attention as an accepted methodological framework for assessing climate-induced L&D (Gall, 2015). Because risk is a function of hazard, exposure, and vulnerability, any attempt of assessing L&D from climate change needs to incorporate interplay among these attributes. For climate change-induced L&D, both vulnerability and exposure are important.

Other challenges need to be recognized too. While in disaster risk, immediate impacts are considered, climate change L&D is the outcome of climatic variability and future climate change spawned weather events. Thus, data on future vulnerability and exposure will also be equally important as the outcome of the complex interplay of extreme rainfall, exposure of actors and their vulnerability, natural ecosystem, and infrastructure. While climate change may increase the frequency or intensity of certain climatic events, socio-economic context, human decision-making within the institutional context also determines exposure and vulnerability.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

In Nepal, the L&D due to climate change is increasing. Climate-induced disasters cause around 65% of all disaster-related annual deaths. The average annual economic loss from climate-induced disasters is about 0.08 per cent of the GDP (2018/19 figures at the current price). In extreme years like the 2017 Tarai floods, the economic loss and damage from the single disaster event was around 2.08 per cent of the GDP (2017/18 figures at the current price). Multiple studies have predicted an increase in L&D caused by climate-induced disasters in the future.

The last few years have provided more evidence on loss and damage from climate-induced disasters in Nepal. According to NDRRMA, in 2020, the landslide damaged around 12 million USD in the Raskot municipality of Kalikot district. Furthermore, as per the damage caused by a single day of rain in Manang district, which was the highest average annual and monthly rainfall in the last two decades, the 2021 monsoon is estimated to be worth 9.5 million USD.

The assessment of L&D is necessary. However, it will not be easy to assess them for two reasons. First, the ability to attribute impacts to specific weather events has not been established. Second, there is no globally accepted approach to assessing climate change-induced L&D. Both reasons create wrangling in global negotiations, where legal and political imperatives are likely to pose a major hurdle in making L&D a means to support developing countries.

The study has made attempts to assess L&D through literature surveys, expert interviews, and stakeholder consultation. The prevalence of COVID-19 pandemic limited field visits and conducting case studies. The available information and databases are insufficient in assessing climate-induced L&D. Climate science is not well established for it. A standard methodological framework or mechanism for assessing L&D is lacking.

The global debate of L&D has been rooted in the national context and specific to the impacts of climate change that is beyond adaptation and disaster risk reduction. In coping and adapting to the adverse impacts, it is realized that there are limits and constraints to adaptation and DRR measures which often lead to residual risks. Besides, there are unavoidable risks of climate change impacts where adaptation and risk mitigation measures are not feasible.

A country suitable definition of L&D is proposed that includes the actual and/or potential negative manifestations of climate change on sudden-onset extreme events, and slow-onset events; the lack of capacity of people in Nepal's mountains, hills, and Tarai to cope with or adapt; the over-stretched country's natural ecosystem, infrastructure and institutions; and the losses of life, livelihoods, including losses of cultural heritage as a result of the limits and constraints.

Using a systematic method to assess L&D, as envisioned by this proposed mechanism, can help strengthen Nepal's national narrative on climate change impacts to inform the global dialogue on L&D through platforms such as the WIM. Indeed, the WIM needs to address many climates change challenges that developing countries like Nepal face. Inadequate investment in climate science research, limited understanding of the residual impacts, and adaptation deficits about L&D are other challenges that WIM needs to address. This proposed approach can also help GoN develop a transparent L&D assessment process for the UNFCCC, as well as meet reporting requirements of the SFDRR.

This approach could also help Nepal argue and negotiate for additional financial and other supports to deal with climate change-induced L&D in the UNFCCC process. The approach could help strengthen governance to address climate risks and vulnerabilities, build the resilience of water, energy, and agriculture sectors and minimize the disaster risks that people face. The outcomes from the application of the mechanism could also help the private sector to innovate and invest in climate-resilient solutions such as including expansion of insurance to address L&D.

In terms of responding to the impacts and risks of climate-induced disasters loss and damage, a transformational and integrated approach is needed. The risk can be minimized through technological interventions, practices, indigenous and improved knowledge systems, improved communications, policy and legal measures, and institutional innovations among others. Dealing with risk is also shifting the burden of impact to another party through insurance.

Nepal has already put an integrated disaster risk financing and support model to the test. One of the more innovative projects has been the pooling of assets insurance, which began in urban areas and is now being expanded to other areas. Another initiative is to relocate high-risk settlements to a more secure location. NDRRMA has reallocated around 300 houses to a safer location. To assist in the development of an integrated settlement in safe locations, the government is providing financial grants to purchase land in a safer location.

L&D must be considered as part of Nepal’s ongoing comprehensive disaster risk management efforts while seeking support from global UNFCCC architecture as well for climate actions. Nepal needs additional climate finance, technology, knowledge, and intuitional support to deal with increased L&D. Appropriate support can help Nepal’s capacity to deal with shocks and stresses, including taking actions to adapt to present and future climate change impacts. At their core, these support activities must enable affected people to recover from the impacts of climate-induced disasters and “build forward better”.

6.2. Recommendations

Assessing L&D in Nepal needs to pursue standardizing the process of data collection mechanism within the disaster risk landscape that is now in place in the form of a portal (https://bipadportal.gov.np). In addition, Nepal's climate dynamics need to be improved increasing investment in climate science that will assist in building a comprehensive risk assessment approach. These efforts will help minimize exposure, vulnerability, and L&D. It is appropriate for Nepal to pursue a comprehensive approach to the assessment, including climate risk management considering all abnormal weather events that lead to disasters and resulting L&D. Furthermore, to capture the diversity of impact caused by climate-related disasters and extreme events, non-economic loss and damage should be assessed separately from economic loss and damage.

To that end, policymakers and practitioners in Nepal need an approach that allows them to assess L&D caused by anthropogenic climate change, estimate the cost, and design and implement policies to minimize them. The approach proposed includes both rapid onset and slow-onset hazards and provides measures to identify and act to lessen their impacts on people. To institutionalize the process, the following recommendations are proposed:

Ministry of Forests and Environment (MoFE)

- To address climate change-induced L&D, the Ministry of the Forests Environment (MoFE), as the nodal agency for climate change, must facilitate and coordinate the updating of vulnerability and risk information, as well as assessment approaches. The NDRRMA and the Ministry of Health oversee disaster issues in Nepal, according to the Disaster Risk Reduction and Management Act (2017, 2019). In collaboration with the NDRRMA and others, the MoFE must review indicators and assessment mechanisms through monitoring and feedback for systematic monitoring, updates, and revision.
- MoFE must also advocate/lobby for increased investment at the national, provincial, and local levels to build institutional capacity. This must include a dedicated budget, infrastructure/equipment needed, information and data, and technical capacity support (experts, etc.). This budget should go to identifying sources of vulnerability and residual impacts due to climate change and adaptation deficits, developing strategies for taking remedial actions.
- MoFE must play a major role in expanding the understanding of economic and non-economic L&D and in defining acceptable, tolerable, intolerable risks and adaptation limits.
- MoFE should support facilitating the piloting of the approach for assessing L&D. The piloting should also lead to answering the questions related to institutional architecture that will assess climate change-induced L&D in the country's local and sub-national levels. Some of the actions that need to be undertaken include enhancing in-country capacity to use climate models, developing and ground-truthing climate change and other socio-economic scenarios, and finally developing a more realistic and robust assessment of climate change-induced L&D.
- The Ministry of Forests and Environment should strengthen REDD-IC to address wildfire management and the REDD++ mechanism. By investing in the forestry sector, it is necessary to establish a wildland fire management program to offset heat-trapping emissions.

Department of Hydrology and Meteorology (DHM)

- DHM should create, maintain, and update a database that covers issues such as collection, indicator consensus, data standardization, synthesis, and storage. Some of the actions that need to be undertaken include enhancing in-country capacity to use climate models, developing and ground-truthing climate change and other socio-economic scenarios, and finally develop a more realistic and robust assessment of climate change-induced L&D.
- DHM needs to prioritize increasing research on climate science. It must consolidate weather information such as temperature, rainfall, and wind to feed into the above assessment. It must also focus on modelling climate, and, in partnership with other agencies, examine climate impacts on various sectors. Data from DHM's satellite, high altitude measurements by the increasing station in high altitude areas, and daily and automatic stations must be used to further refine and create new climate scenarios, as well as align them with regional and global scenarios.
- DHM has proposed rainfall thresholds for landslides and floods. These figures are also used in the BIPAD portal as a guide. This is a useful starting point, but the information must be linked with other triggers and ambient land conditions for developing a combined general threshold for landslides and floods used for making a realistic assessment.
- DHM must also build on its efforts on impact-based forecasting and now-casting for thunderstorms, cloudbursts, and flash floods.

- In Nepal, the number of rainfall stations needs to be increased, an exercise that must consider the overall management of the stations installed and the use, analysis, and dissemination of the data collected. Both additional financial and human resources must be allocated for management.
- In the past, investments have been made in flood warning systems that helped minimize the loss of human lives. It will be helpful to assess the benefits such systems have provided in avoiding L&D. This assessment must estimate increased investments in capacity development for preparedness.
- DHM needs to begin work in developing Nepal Integrated Drought Information Mechanism (NIDIM) as a multi-agency partnership that will coordinate drought monitoring, forecasting, planning, and information at the national, provincial, and local levels. Development of the proposed NIDIM must coordinate with other stakeholders such as MoFE, the Department of Agriculture, the National Planning Commission, the Food and Agriculture Organization, and the World Food Program to link the mechanism with dynamics in agriculture and food systems.

National Disaster Risk Reduction and Management Authority (NDRRMA)

- The Disaster Risk Reduction and Management Act of 2017 (DRRMA Act 2017) and its Regulations (DRRMA Regulations) of 2019 include disaster risk reduction and climate change adaptation actions that can help build synergies between the two streams. NDRRMA must strengthen its role as a facilitator and coordinate risk-reduction activities with ministries, departments, and other stakeholders. To that end, the Authority must effectively coordinate with all levels of government, inter-ministerial arrangements, and the private sector on risk assessment, risk reduction response, and recovery from climate hazards mainstreaming tasks by ensuring that the National Council for Disaster Risk Reduction and Management's plans, programs, and decisions are implemented.
- In light of this challenge, NDRRMA should collaborate with MoFE and other relevant agencies to continue to work on developing a robust, transparent, and reliable national mechanism for assessing climate-related L&D as part of its larger disaster risk reduction and humanitarian action data architecture. This mechanism can also assist GoN in developing a transparent L&D assessment process for the UNFCCC, as well as meeting the Sendai Framework for Disaster Risk Reduction's reporting requirements (SFDRR).
- The National Disaster Risk Reduction and Management Act (NDRRMA) should carry out multi-hazard risk trend and scenarios analysis that considers both rapid and slow onset events, as well as their potential consequences. To address the specific issues of a particular locality and hazard, a context-specific, tailor-made response is required.
- NDRRMA should work with MoFE and other agencies to provide support to Palikas in implementing response measures to mitigate the risks of L&D.
- The NDRRMA and DHM have proposed landslide and flood rainfall thresholds. These figures are also used as a guide for the impact-based forecasting dashboard in the BIPAD portal. This is a good start, but it needs to be combined with other triggers and ambient land conditions to create a combined general threshold for landslides and floods that can be used to develop a more accurate early warning system and realistic assessment.
- NDRRMA, Department of Forests and Soil Conservation, and DHM must also build on their efforts on impact-based forecasting and now-casting for forest fires, thunderstorms, cloudbursts, and flash floods.

Ministry of Federal Affairs and General Administration

- Local governments' capacity for assessment coordination and collaboration, as well as the development of a localized policy framework for assessment, must be built at the local level. The role of MoFAGA, stakeholders and development partners will be critical in capacity building and technical facilitation to help local government to address the issues and challenges posed by L&D.

Rural and Urban Municipalities and Provincial government

- The local government officials must be engaged so that they understand the multifaceted aspects of climate change-induced L&D. Making information on climate change, its impacts, and adaptation strategies available to local governments and local stakeholders in a language that they understand needs to be a continuous process for effective policymaking and applications. To that end, experts and local stakeholders must maintain regular dialogue, keeping the specific context of the local governments in mind.
- All local governments must prepare a baseline profile with details on infrastructures and natural ecosystems to serve as a reference for calculating economic damage, and gradually include the non-economic costs necessary for assessing total L&D. Combined with hazard maps, the baseline will help in risk reduction actions, including more effective rescue and responses after a hazard strikes.
- The technical staff members of the local government (Palika) need to be involved in assessing L&D. For example, the Junior Technical Assistant (JTA) of Palika can help assess the agricultural loss due to a disaster incident but need mentoring and capacity-building support. To work on L&D assessment, a dedicated team has to be formed. The team must include data collectors and IT and database support human resources. The Palika must have access to computers, tools, and skills with maintenance support and a dedicated budget.
- It is also important to respond effectively to lower the risks of L&D. It can be done through transformative adaptation and DRR technology and practices.
- The provincial government can specifically play a role in consolidating data and creating a database on L&D by coordinating well with the Palikas.
- Local governments must develop assessment coordination and collaboration capabilities, as well as a locally tailored assessment policy framework. The role of MoFAGA, stakeholders and development partners will be critical in terms of capacity building and technical facilitation of the framework's methodologies.
- Local and provincial governments should have the ability to collect, maintain, and process the data needed to assess damage and loss.

Department of Mines and Geology (DoMG)

- The DoMG is mandated to undertake and coordinate all landslide hazard assessments including landslide susceptibility in Nepal. The landslide hazard information should be used to establish landslide L&D.

Department of Water Resources and Irrigation (DoWRI)

- The DWRI is mandated to undertake and coordinate all flood hazard assessments in Nepal. The flood hazard information should be used to establish flood-related L&D.

Department of Forests and Soil Conservation

- The department manages forest fire observations using satellite imageries. It also provides technical and financial support to communities to manage forest fire risks. The department should build its capacity to assess, monitor, and respond to the impact of climate change.

Other agencies

- Other government agencies, including the civil society, development agencies, I/NGOs, and the private sector can support MoFE/ NDRRMA/DHM in creating a database and information collection mechanisms. Besides, these agencies can help the government to generate evidence, and access and mobilize climate financing for addressing L&D.

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Annex: Loss and Damage: A case study of flooding of Melamchi

Nepal receives more than 80 percent of rainfall during the monsoon season which starts from the second week of June to the last week of September. Monsoon supports agriculture but also brings soil erosion, landslide, and flood that also leads to disasters and heavy loss of lives and properties every year. Across Nepal from east to west and south to north, in the monsoon, while some parts are highly affected whereas others face low-intensity rains.

On 15th June 2021, large parts of Melamchi municipality of Sidhupalchowk district were buried under debris brought by catastrophic floods in the Melamchi and Indrawati rivers. Nepal's Bipad Portal reported that 5 people died, 6 were injured and, 20 were missing due to the flood. Multiple factors triggered by the rain resulted in the catastrophic flood.

Annex Table 1 shows that the monthly average precipitation/rainfall of the Indrawati river basin (in Sindhuplachowk district) for the duration of 1971-1990 and 1998- 2018. It shows that the average rainfall in June from 1971-1990 was 467.9mm and was 409.0 mm for 1998-2018. However, 5 days rainfall data of 5 stations of Melamchi river basin is 101.6 mm on average. Table 2 shows that on 12th June Sermathang, Dhap, and Gumthang stations received high rainfall. The rainfall triggered a landslide that blocked the river and when the dam breached flood occurred.

Annex Table 23 Average monthly precipitation/rainfall in mm of Indrawati river basin for different time intervals

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg. Annual
1971-1990	18.2	28.2	47.8	74.5	140.1	467.9	752	675.7	380.3	89.3	13.6	19.5	2707.2
1998-2018	42	56	67	88	195	409.00	714	576	308	90	25	26	2596

Source: data from 1971-1990 referred from Indrawati river basin study report, 1998-2018 climate – data .org

Annex Table 24 Five days rainfall recorded in five stations of Melamchi river basin from June 12-16, 2021

Station name	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun	5 days total
Chautara	1.2	8.2	4.4	4.2	5.2	23.2
Sermathang	110.2	33	11.8	18.8	29.4	203.2
Bahrabise	13.8	17.8	4.6	4.8	4	45
Dhap	58	34.6	9.2	10.8	10.4	123
Gumthang	60.2	29	8.2	8.6	7.6	113.6
Average rainfall (mm)	**48.68**	**24.52**	**7.64**	**9.44**	**11.32**	**101.6**

Source: NDRRMA- Nepal Flood and Landslide Incident Report 1

The rainfall in the Melamchi river basin obtained from the NASA satellite for 10-15 June 2021 is shown in (Table 3).

Annex Table 25 Rainfall based on NASA

Date	10	11	12	13	14	15
Rain (mm)	9.9	22.2	30.3	30.3	123.8	24.4

Source: NASA quoted in reference 6 (https://www.onlinekhabar.com/2021/06/974746).

In the Nakote hydrological station in the Melamchi River, the water level had initially decreased from 5m to 3m and then rose to 6m in a short time indicating that the sudden increase would be a result as indicated by preliminary studies dam breach. The high flood also brought a massive number of boulders, gravel, and sand. The deluge caused devastation. The earthquake of 2015 has weakened the geology of the Sindhupalchowk district.

The rain on the weak landscape of the hilly terrain led to landslides. From 1981 to 2019 Bhotekoshi and Sunkoshi watersheds has recorded 47 landslides, of which 5 had occurred in non-monsoon months and 42 in the monsoon. Rainfall triggered most of the landslides (Lamichhane et.al 2021).

A study on the climate change impact on diversion strategies of the Melamchi water supply project had projected that the average precipitation in the Melamchi river basin will increase by 6-18% under RCP 4.5 and RCP 8.5 respectively by 2085s (Shrestha & Babel 2017). This will increase the intensity of floods and landslides in the coming years and elevate the cost of economic and non-economic loss in Nepal's fragile districts.

The recent flood also affected Nepal's Manang and Lamjung districts. The disaster led to the displacement of 867 families with 414 houses fully damaged and 97 houses partially damaged. The preliminary economic losses in Melamchi alone were estimated to be NRs 1 billion. The details of loss and damage in the three districts are shown in table 4.

Annex Table 4 Loss and Damage in three districts of Nepal during June 10-16, 2021

District	Non-Economic losses			Economic losses					
	Dead	Missing	Injured	Fully damaged houses	Partially damaged houses	Hydro power	Road	Bridges	Others
Sindhupalchowk	5	20	6	337	0	1	obstructed in many places	13 suspension, 7 motorable	10 trout farm, 1 green city park
Manang	0	0	0	59	20	1	65km road	5 suspension, 1 bailey	None
Lamjung	0	0	0	18	77	12	damaged at different section	none	2 community building, 1 government building

Source: NDRRMA- Nepal Flood and Landslide Incident Report 1

Bipad portal has reported that 55 dead, 32 missing, and 127 injured throughout the country from April 14 to 25 June 2021 due to climate-related disasters (flood, landslide, heavy rainfall, windstorm, and thunderbolt). 205 houses were destroyed and 130 partially damaged. The economic losses were estimated at NRs 7, 94, 55,830 excluding the loss and damage due to the flood in Sindhupalchowk, Manang, and Lamjung during June 10-15.

It is likely that with climate change, the frequency and intensity of the climate-triggered disaster events will increase. Unless the capacity and strength of disaster preparedness and coping capacity is improved, the poor and vulnerable people have to bear loss and damage in the coming days.

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