Assessment of Climate-Induced Loss and Damage in Bhutan

Department of Environment and Climate Change, Ministry of Energy and Natural Resources, Royal Government of Bhutan and United Nations Development Program- Bhutan, 2025

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List of acronyms

BTR	Biennial Transparency Report
BES	Bhutan Ecological Society
CNR	College of Natural Resources
DEC	Dzongkhag/District Environment Committee
DECC	Department of Environment and Climate Change
DLGDM	Department of Local Governance and Disaster Management
DMDF	Department of Macro-fiscal and Development Finance
DoA	Department of Agriculture
DoL	Department of Livestock
DoE	Department of Energy
DoFPS	Department of Forests and Park Services
DHS	Department of Human Settlement
DoW	Department of Water
DPBP	Department of Planning, Budget and Performance
FRLD	Fund for Responding to Loss and Damage
GDP	Gross Domestic Product
GECDP	Gender, Environment, Climate Change, Disaster and Poverty
GLOFs	Glacial Lake Outburst Floods
GNH	Gross National Happiness
KMGBF	Kunming-Montreal Global Biodiversity Framework
L&D	Loss and Damage
LDC	Least Developed Countries
MoAL	Ministry of Agriculture and Livestock
MoENR	Ministry of Energy and Natural Resources
MoF	Ministry of Finance
MoH	Ministry of Health
MoHA	Ministry of Home Affairs
MoIT	Ministry of Infrastructure and Transport
MRG	Mainstreaming Reference Groups
MRV	Monitoring, Reporting and Verification
NAP	National Adaptation Plan
NBC	National Biodiversity Centre
NBSAP	National Biodiversity Strategies and Action Plan

NCHM	National Center for Hydrology and Meteorology
NDC	Nationally Determined Contribution
SIDS	Small Island Developing States
SNLD	Santiago Network on Loss and Damage
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WIM	Warsaw International Mechanism for Loss and Damage

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FOREWORD

Bhutan's First National Assessment of Climate-Induced Loss and Damage (L&D) is a milestone effort led by the Department of Environment and Climate Change, Ministry of Energy and Natural Resources and UNDP-Bhutan. The assessment provides the country's first comprehensive, evidence-based picture of the economic and non-economic impacts of climate change across all sectors and regions, and offers a critical foundation for policy, planning, and international engagement. This will constitute the Kingdom of Bhutan's first knowledge product on loss and damage and is expected to play a substantive role in facilitating the dissemination of information and enhancing understanding on climate-induced loss and damage.

Bhutan's fragile mountain ecosystems, dispersed settlements, and climate-dependent economy make the country highly vulnerable to both extreme events-such as Glacial Lake Outburst Floods (GLOFs), landslides, flash floods, windstorms and forest fires and slow-onset processes including glacial retreat, shifting precipitation, and ecosystem degradation. These impacts are already contributing to significant loss and damage, threatening food and water security, infrastructure, energy systems, biodiversity, cultural heritage, and human wellbeing. Macroeconomic estimates indicate that climate risks could reduce GDP by up to 3 percentage points by 2050, with current average annual losses amounting to 6.9% of GDP.

Grounded in a country-led and participatory process, this assessment reflects extensive consultations across sectors and districts, resulting in Bhutan's L&D definition, L&D Signatures, and the establishment of a L&D National Task Force. This calls for a National L&D Framework and a centralized data repository to address existing gaps and strengthen coordinated action.

As Loss and Damage becomes a central pillar of global climate action-reinforced by the establishment of the Fund for Responding to Loss and Damage (FRLD), this assessment positions Bhutan to articulate its needs, mobilise support, and advance climate-resilient development. The Royal Government of Bhutan remains committed to protecting its people, ecosystems, and cultural heritage, and to contributing constructively to the global discourse on climate-induced loss and damage.

I commend all stakeholders, national and international experts, L&D TaskForce member representatives from DECC, DoFPS, DoW, DoE, NBC, DHS, DMDF, DoL, DoA, NCHM, DLGDM, NCWC, CNR, BES and partners who contributed to this important endeavour. Their collective efforts reflect our shared commitment to a safer, more resilient, and sustainable future for all Bhutanese

Karma Tshering
Chairman, National Environment Commission
Secretary, Ministry of Energy and Natural Resources

Executive summary

This report represents Bhutan's first comprehensive, country-led assessment of climate-induced Loss and Damage (L&D), establishing a foundation for evidence-based policy, planning, and international collaboration. Supported by the Ministry of Energy and Natural Resources, Department of Environment and Climate Change and United Nations Development Program Bhutan (UNDP), the assessment provides an integrated view of observed and projected economic and non-economic losses across sectors and regions in the country. The assessment is particularly timely as Bhutan navigates the dual transition of Least Developed Country (LDC) graduation and increasing climate vulnerability while striving to maintain climate-resilient and sustainable development pathways consistent with its commitment to carbon neutrality and pursuit of Gross National Happiness (GNH).

Bhutan's steep mountains, fragile ecosystems, and climate-dependent economy where agriculture, hydropower, and forestry underpin livelihoods and public revenues – expose it to a broad spectrum of climate-related hazards and vulnerabilities. Extreme events such as Glacial Lake Outburst Floods (GLOFs), flash floods, landslides, forest fires and windstorms, alongside slow-onset processes including glacial retreat, ecosystem degradation, and shifting seasonal precipitation, threaten water and food security, energy systems, infrastructure, biodiversity, human health, cultural heritage, and broader development outcomes. These are expected to cause and already contribute to substantial loss and damage, broadly understood as the residual adverse effects of climate change that occur despite adaptation or when adaptation fails.

Globally, Loss and Damage (L&D) has emerged as the third pillar of international climate action, alongside mitigation and adaptation. The establishment of the Fund for Responding to Loss and Damage (FRLD) at COP28 in 2023, part of a broader operationalisation of governance mechanisms for L&D, provides a critical window of opportunity for Bhutan to address the escalating losses and damages associated with climate change. Climate-induced loss and damage are broadly understood as residual impacts after adaptation occurs or fails.

Bhutan's assessment adopts a country-led, inclusive, and participatory approach. The assessment process involved national stakeholder workshops and consultations that engaged representatives from diverse sectors and all the

districts, culminating in the adoption of Bhutan's L&D definition and L&D Signatures, and the establishment of a National Task Force on Loss and Damage. This process reflects Bhutan's commitment to integrating local knowledge, national priorities, and vulnerable communities' perspectives in addressing climate-induced loss and damage. The assessment is structured around the six identified L&D signatures that capture Bhutan's distinctive climate hazards, vulnerabilities, and loss and damage. These include: (i) Food and water insecurity due to changes in temperature, erratic precipitation, windstorms, droughts, and land degradation; (ii) Impacts on human health and wellbeing due to heatwaves, forest fires, landslides, and floods; (iii) Infrastructure and property damage due to floods, GLOFs, windstorms, and landslides; (iv) Impacts on terrestrial and freshwater ecosystems due to changes in temperatures, glacier melt, and forest fires; (v) Energy insecurity due to glacier melt, changes in precipitation, and GLOFs; and (vi) Impacts on cultural heritage due to glacier melt, floods, and forest fires.

The findings indicate that Bhutan is already facing substantial climate-induced economic losses, which are projected to grow as climate change impacts accelerate. Macroeconomic estimates indicate that climate risks could reduce Gross Domestic Product (GDP) by up to 3 percentage points by 2050, with an Average Annual Loss from climate-related events currently evaluated at 6.9% of GDP (USD 169.3 million).[1,2] Climate-induced loss and damage are significant and span across all sectors. These include declining agricultural productivity, livestock and crop losses, increasing water insecurity, infrastructure damage (roads, power, water systems), and loss of ecosystem services and biodiversity. Non-economic losses such as disruption of education, mental health impacts, loss of cultural and spiritual heritage, and over time erosion of social and cultural identity are severe, yet poorly documented, reflecting gaps in existing conventional reporting systems. Catastrophic events such as GLOFs exemplify the severe projected loss and damage, underlining the urgent need for preventative measures. The country also faces recurrent and localized hazards including landslides, flash floods, and erratic precipitation, which cumulatively

[1] World Bank Group, 2025. Bhutan Country Climate and Development Report. © World Bank.
[2] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), n.d. *Bhutan Country Profile, Risk & Resilience Portal* [online].
UNDP Presentation at the *Capacity Development Training Workshop on Building Disaster and Climate Resilience in Bhutan in Critical Sectors*, 21–25 July 2025, Punakha, Bhutan.

cause damages on par with major extreme events. However, these cumulative impacts often go unreported in current disaster assessments, leading to an underestimation of their true scale and consequences in the context of climate change. Case studies from recent extreme weather events and slow-onset events showcase how both direct and cascading losses manifest across multiple sectors and how communities are often shouldering the costs of climate-induced loss and damage.

This assessment proposes the establishment of a national L&D framework and a centralised data repository, alongside a set of priority interventions. Despite substantial progress in disaster risk management and climate change adaptation, existing institutional and data systems remain fragmented, and no dedicated mechanism currently exists to capture climate-induced loss and damage, particularly non-economic and cumulative impacts. A central recommendation is the establishment of a national L&D framework supported by a centralized data repository that builds on and leverage existing initiatives, including the Risk and Resilience Portal, Gross National Happiness Survey, Climate Services Toolkit, and Climate Change Monitoring Reporting and Verification (MRV) system. Nexus area on *agriculture, health, and ecosystem services*, emphasizing climate-smart agriculture, ecosystem restoration, nature-based solutions, and improved monitoring and forecasting. Nexus area on *infrastructure, human settlements, and energy*, including strengthening early warning systems for GLOFs, enhancing infrastructure resilience, modernising risk mapping and response planning, and diversifying energy sources. Strengthened coordination, data sharing, and guidance on L&D costing and reporting are also critical to ensure integrated action across sectors.

Addressing financing needs is essential to ensure the implementation and sustainability of L&D measures. The assessment demonstrates that Bhutan's unique set of climate vulnerabilities and impacts leads to financing needs to extend across preventive and reactive approaches, spanning interventions that assess and address pervasive cumulative impacts from small-scale extreme events and slow-onset events, and minimise and recover from significant projected losses, particularly those associated with GLOF events. National and international climate finance, including mechanisms under the Fund for Responding to Loss and Damage (FRLD) and the Santiago Network, should be leveraged to support high-priority interventions.

Despite demonstrating global leadership in climate action, Bhutan is increasingly facing unavoidable climate-induced loss and damage that cannot be addressed by mitigation and adaptation alone. This assessment highlights the urgent need to mobilise resources to strengthen Bhutan's capacity to prevent, minimise, and respond to climate-induced loss and damage. Moving forward, international financial and technical support will be essential to complement national efforts, enabling Bhutan to safeguard communities, protect biodiversity, preserve its unique cultural heritage, and maintain a climate-resilient development trajectory. Bhutan's experience and efforts provide valuable insights for country-led, evidence-based approaches that contribute to the evolving global understanding and governance of climate-induced loss and damage.

1 Introduction

1.2 Contextualizing Global Climate Change in Bhutan

Climate change represents one of the most urgent and complex challenges confronting the global community, with pervasive impacts observed across all continents, ecosystems, and economic sectors. Global mean surface temperatures have already risen by approximately 1.1°C above pre-industrial levels, contributing to increased frequency and intensity of extreme weather events, accelerated glacial and ice-sheet retreat, rising sea levels, and altered precipitation regimes. According to the IPCC Sixth Assessment Report (2023), climate-related hazards are intensifying, with disproportionate effects on vulnerable populations in developing countries, who often have limited adaptive capacity and rely heavily on climate-sensitive activities for their livelihoods. Globally, economic costs are mounting rapidly. A recent study estimated residual damages from climate-related events to range from USD 290-580 billion in 2030, with projections suggesting these could reach USD 1-1.7 trillion by 2050.[3] These escalating risks highlight that mitigation and adaptation alone are insufficient to address the full spectrum of climate impacts.

Bhutan's geographic, topographic, and socio-economic context amplifies its climate vulnerability. A small, landlocked country in the Eastern Himalayas, Bhutan's diverse topography, fragile mountain ecosystems, and varied climatic conditions increase its exposure to climate-related hazards. Limited arable land and dispersed human settlements further heighten sensitivity to the impacts of climate change. Key economic sectors, particularly agriculture, hydropower, and forestry, rely on a predictable climate and are vulnerable to extreme weather events, including Glacial Lake Outburst Floods (GLOFs), flash floods, landslides, and erratic monsoons.[4] Such events interact with slow-onset events, including

[3] Markandya, A., González-Eguino, M, 2019. *Integrated Assessment for Identifying Climate Finance Needs for Loss and Damage: A Critical Review*. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (eds) *Loss and Damage from Climate Change: Concepts, Methods and Policy Options*. Climate Risk Management, Policy and Governance. Springer, Cham.

[4] Royal Government of Bhutan, 2021. *Updated Nationally Determined Contribution (NDC) of Bhutan*. Thimphu: National Environment Commission.
United Nations Development Programme, 2022. Bhutan: National Adaptation Plan Readiness Project – Final Report. Thimphu: UNDP Bhutan.

rising temperatures, shifting precipitation regimes, and ecosystem degradation, to exacerbate risks to food and water security, biodiversity, infrastructure, and human well-being. Consequently, Bhutan, which is ranked as the 41st most vulnerable country globally to climate change impacts, is considered among the countries most vulnerable to climate-induced loss and damage.[5]

With a constitutional mandate to preserve 60 per cent forest cover and commitment to remaining carbon-neutral in perpetuity, Bhutan has long been recognised as a global leader in environmental stewardship and climate ambition. Yet despite its significant adaptation efforts, Bhutan remains vulnerable to the escalating impacts of climate change. This is exemplified by the recent devastating and extreme rainfall event, along with the associated floods, landslides, and windstorms, which affected the country on 4-5th October 2025, causing extensive damage to lives, livelihoods, and critical infrastructures (See Section 4.8 and Annex. Seventeen glacial lakes are classified as dangerous and at risk of GLOFs, with destructive events such as the 1994 event demonstrating the scale of risks to lives, livelihoods, and infrastructure. Hydropower – accounting for around 13 per cent of GDP and contributes markedly to national government revenues – faces risks from changing hydrological regimes. Agriculture – directly employing nearly 60 per cent of the population – is increasingly threatened by climate variability and impacts of extreme events.

Because of these vulnerabilities, coupled with its minimal contribution to global greenhouse gas emissions and contribution as a global carbon sink, Bhutan embodies the necessity for comprehensive climate action that integrates loss and damage interventions to address residual impacts that cannot be prevented or effectively managed through mitigation and adaptation.

1.3 Loss and damage and Its Relevance for Bhutan

The anchoring of Loss and Damage in international climate policy is the outcome of decades of sustained advocacy by developing countries, particularly Least Developed Countries (LDCs) and Small Island Developing States (SIDS). These countries argued that mitigation and adaptation finance alone were insufficient in the face of escalating and unavoidable climate impacts. As Chair of the LDC

[5] Notre Dame Global Adaptation Initiative, 2024. Bhutan – Country Index. University of Notre Dame, South Bend.

Group, Bhutan was a powerful voice in the negotiations and contributed to ensuring that loss and damage gained recognition on the global agenda. Advocacy efforts from developing countries led to the establishment of the Warsaw International Mechanism (2013), the integration of loss and damage under Article 8 of the Paris Agreement (2015), the creation of the Santiago Network (2019) to deliver technical assistance, and the historic establishment of the Loss and Damage Fund at COP27 (2022), operationalised at COP28 (2023) and named as the Fund for Responding to Loss and Damage (FRLD). The first Global Stocktake (2023) confirmed that the world is not on track to limit warming to 1.5°C. It also projected that climate-related economic losses in developing countries may range from USD 290-580 billion annually by 2030.[6] The global momentum surrounding loss and damage presents opportunities for Bhutan to engage with new mechanisms, while underscoring the need for enhanced institutional and technical capacity to access and deploy them effectively.

Bhutan is entering a pivotal stage in its national development journey. Having graduated from LDC status in 2023, the country has demonstrated remarkable progress on development indicators. However, graduation also carries implications for access to concessional finance and international support. At the same time, its commitments to carbon neutrality, 60% forest cover, and sustainable development, rooted in Gross National Happiness (GNH), limit its options for economic growth to finance adaptation. Climate change, therefore, represents a profound risk to Bhutan's aspirations under the 21st Century Economic Roadmap, which aims to achieve high-income status by 2030, and to the goals of the 13th Five-Year Plan (2024–2029), collectively serving as the country's transition strategy post-graduation from the LDC status. The World Bank's latest Climate and Development Report warns that Bhutan could face significant GDP losses with a reduction of 3% by 2050 under hotter and drier climate scenarios, though investments in climate-resilient infrastructure could reduce such losses by up to 40 percent.[7]

[6] Markandya, A., González-Eguino, M., 2019. Integrated Assessment for Identifying Climate Finance Needs for Loss and Damage: A Critical Review. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (eds) Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance. Springer, Cham.

[7] World Bank Group, 2025. Bhutan Country Climate and Development Report. © World Bank.

Recognising the wide range of societal issues climate change presents, Bhutan has been strengthening its climate governance frameworks. The Climate Change Policy (2020) sets out the strategic objective of remaining carbon neutral while protecting citizen wellbeing and mobilising finance, technology, and capacity-building to address climate change.[8] The National Adaptation Plan (2023) outlines long-term adaptation pathways across seven priority sectors and, crucially, acknowledges that even robust adaptation will not prevent all impacts.[9] The Climate Change Research Roadmap (2021–2025) highlights critical knowledge gaps, noting that fragmented research, weak institutional coordination, and limited resources constrain evidence-based policy.[10] These national frameworks underscore the urgency of expanding Bhutan's efforts not only to adapt to climate change, but also to prevent, minimise, and address climate-induced loss and damage.

The rationale for this assessment and report is threefold. First, it provides empirical evidence of climate-induced loss and damage, thereby strengthening Bhutan's ability to engage with and benefit from global mechanisms such as the FRLD and Santiago Network. Second, it informs national development planning, ensuring that approaches and measures to address climate-induced loss and damage are aligned with the implementation of the 13th FYP and the pursuit of the 21st Century Roadmap. Third, it addresses critical data and institutional capacity gaps, thereby contributing evidence and ultimately to support the development of governance systems necessary for sustained monitoring and response to climate-induced loss and damage.

This assessment thus comes at a decisive moment. Globally, as loss and damage becomes institutionalised as a core pillar of international climate action, and nationally, as Bhutan undertakes its most ambitious phase of economic transformation while navigating vulnerabilities associated with graduating from LDC status. Anchored in Bhutan's constitutional mandates, climate policies, and

[8] Royal Government of Bhutan, 2020. Climate Change Policy of the Kingdom of Bhutan. National Environment Commission, Thimphu.
[9] Royal Government of Bhutan, 2023. National Adaptation Plan of Bhutan. National Environment Commission, Thimphu.
[10] Royal University of Bhutan, National Environment Commission Secretariat, and United Nations Development Programme, 2020. A Roadmap and Strategy for Strengthening Climate Change Research in Bhutan 2021–2025. Thimphu: Royal University of Bhutan and UNDP.

development strategies, the assessment will help safeguard resilience, protect development gains, and position Bhutan to play a leading role in shaping the evolving global architecture on loss and damage.

1.4 The Loss and Damage Governance Landscape

The institutionalisation of loss and damage within international climate policy represents the culmination of decades of advocacy by developing countries, particularly the most climate vulnerable. It reflects a gradual transition from political recognition to institutionalisation and operationalisation of dedicated policy mechanisms. This process has given rise to four interconnected institutional arrangements and frameworks, each serving a distinct but complementary role (Figure 1).

For Bhutan, this evolving L&D governance landscape presents a window of opportunity: the Warsaw International Mechanism (WIM) supplies the political and policy anchor for national engagement; the Santiago Network offers a conduit for targeted technical assistance and capacity development; and the Fund for Responding to Loss and Damage (FRLD) represents the first dedicated financial mechanism through which resources may be mobilised for both extreme events and slow-onset processes. Taken together, these instruments establish an integrated governance ecosystem comprising policy, technical, and financial assistance that Bhutan can proactively align with national priorities to accelerate implementation of prevention, preparedness and remedial measures.

The **Warsaw International Mechanism for Loss and Damage (WIM)**, established in 2013 at COP19, was the first dedicated mechanism to address loss and damage associated with climate change impacts in developing countries. It was tasked with advancing knowledge and understanding of loss and damage, strengthening dialogue and coordination among relevant stakeholders, and catalysing action and support through finance, technology and capacity-building. Importantly, the WIM serves as the overarching governance platform and political anchor for subsequent institutional developments. At the policy and institutional level, Bhutan can leverage the WIM's convening function and technical guidance to mainstream L&D into national planning and to legitimise domestic institutional arrangements.

The **Paris Agreement of 2015** consolidated this progress by embedding loss and damage in the core global climate architecture through Article 8, which explicitly recognises the importance of "averting, minimising and addressing" impacts that exceed adaptation capacities. However, the accompanying COP decision 1/CP.21 made clear that Article 8 does not involve or provide a basis for any liability or compensation, reflecting longstanding concerns among developed countries regarding legal responsibility.[11] While this limitation curtailed expectations around reparations, Article 8 established the conceptual framework for governing loss and damage, laying the groundwork for new institutional responses.

On this basis, the **Santiago Network** for averting, minimising and addressing loss and damage was created at COP25 in 2019 to catalyse the provision of technical assistance to developing countries facing severe climate impacts. The network became operational in 2024, with UNDRR and UNOPS serving as co-hosts, and now plays a central role in identifying national and regional needs, connecting governments with relevant organisations, and facilitating the flow of expertise and capacity-building. By promoting access to knowledge and technical assistance, the Santiago Network can support countries' ability to avert and minimise loss and damage by enhancing preparedness and response capacities. For Bhutan, engaging with the Santiago Network would help address critical evidence and institutional gaps, enabling the development of project concepts that meet both national priorities and the technical expectations of international funders.

The institutional architecture was further completed with the establishment of the **Fund for Responding to Loss and Damage (FRLD)** at COP28 in Dubai in 2023, a landmark decision after decades of negotiation. The FRLD is the first dedicated financial mechanism for loss and damage, designed to provide timely and targeted resources for climate-related emergencies, slow-onset events, displacement, planned relocation, and climate-resilient reconstruction. Structured as a financial intermediary fund under the World Bank's trusteeship for an initial four-year period, the FRLD has received more than USD 788.8

[11] United Nations Framework Convention on Climate Change, *Decision 1/CP.21: Adoption of the Paris Agreement*, FCCC/CP/2015/L.9/Rev.1, 21st Conference of the Parties, Paris, 30 November–11 December 2015.

million in pledges from 28 contributors as of June 30th, 2025.[12] Similar to Article 8, the FRLD is based on principles of cooperation and facilitation rather than liability or compensation. Yet, it represents an unprecedented breakthrough in mobilising finance for the most vulnerable. The FRLD provides a new, dedicated financing channel that Bhutan can prepare to access for a range of activities, including rapid response to extreme events, slow-onset loss management, planned relocation, and climate-resilient reconstruction.

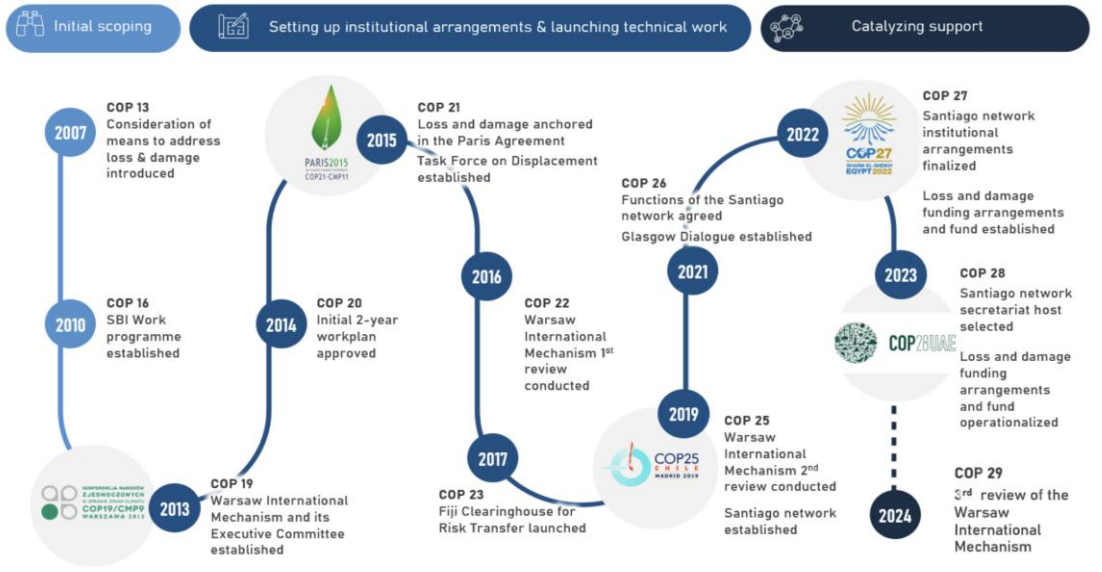


Figure 1. Representation of milestones on loss and damage in international negotiations on climate change (Source: UNFCCC, 2024)[13]

Taken together, these three institutional pillars – the WIM, the Santiago Network, and the financial mobilisation provided by the FRLD – constitute a comprehensive governance ecosystem for addressing loss and damage. This institutionalisation not only reflects a historic shift in the global climate regime, but also firmly positions loss and damage alongside mitigation and adaptation as a core pillar of international climate action.

The recognition of loss and damage as a critical pillar of global climate action prompted its integration into key policy frameworks such as National Adaptation

[12] Fund for Responding to Loss and Damage, 2025. Available from: https://www.frld.org/pledges
[13] United Nations Framework Convention on Climate Change, March 2024. *Loss and Damage Online Guide*, UNFCCC (Executive Committee).

Plans (NAPs), Nationally Determined Contributions (NDCs), and Biennial Transparency Reports (BTRs). A comprehensive review of 41 NAPs shows that 49% of developing countries explicitly reference loss and damage, reflecting a significant shift toward acknowledging adaptation limits. Notably, in 2024, for the first time, the UNFCCC explicitly invited countries to report on loss and damage in their BTRs. These developments highlight a growing political and institutional commitment to integrating loss and damage into national planning. Concurrent with engagement with these global mechanisms, Bhutan should use the present momentum to integrate L&D into its domestic reporting and planning processes. This would improve coherence across mitigation, adaptation and loss-and-damage workstreams, enhance the credibility of Bhutan's requests for technical and financial support, and facilitate the tracking of expenditures and outcomes through national systems.

Looking forward, however, several challenges remain. At the global level, scaling up loss and damage finance remains a pressing priority, as current pledges fall far short of estimated needs. Ensuring equitable access, particularly for Least Developed Countries and vulnerable communities, will also be critical to avoid reinforcing existing inequalities. Finally, stronger coordination between loss and damage mechanisms and adaptation, disaster risk reduction, and development planning processes will be essential to ensure coherence and maximise impact. Addressing these challenges will determine whether the institutionalisation of loss and damage can deliver on its promise to protect lives, livelihoods, and ecosystems in an era of intensifying climate impacts.

1.5 Aim, objectives and scope

This report aims to contribute to Bhutan's efforts to establish a robust institutional and knowledge framework to support effective responses to climate-induced loss and damage occurring in the country's different regions, characterised by specific biophysical, social, and climatic conditions.

Bhutan has undertaken significant efforts to establish and enhance its systems for climate disaster management and related institutional arrangements. These efforts are illustrated in a recent report published by UNDP Bhutan & Department of Local Governance and Disaster Management titled "Analysis and need assessment for advancing disaster data architecture for climate-induced loss and damage in Bhutan".

Closely examining existing disaster management practices and institutional arrangements in Bhutan, this report aims to identify key synergies, gaps, and opportunities for developing and supporting the institutionalisation of loss and damage, thereby strengthening Bhutan's readiness to mobilise resources to address climate-induced loss and damage.

Specific objectives of the report are:

- Assess and analyse Bhutan's climate-induced losses and damages caused by extreme weather events and slow-onset events, identifying vulnerable sectors, regions, and communities.
- Identify and, when possible, quantify both economic and non-economic climate-induced losses and damages in the high-impact selected sectors.
- Develop specific recommendations to increase institutionalisation of loss and damage, identify priority actions, and support access to technical and financial assistance.

1.6 Methodology and participatory approach

In line with Bhutan's efforts to **develop a country-owned and localised approach to inform policies and mechanisms for L&D, this assessment report was guided by an iterative approach involving participatory elements to co-produce knowledge on climate-induced loss and damage**. The analysis is based on secondary data collected through document review, as well as primary data collected during key informant group interviews, a national stakeholder capacity-building workshop that involved group exercises and interactive sessions, stakeholder consultations, and observations during field visits to sites recently impacted by extreme weather events.

An iterative approach allowed for the gradual refinement of methods and analytical focus as evidence was consolidated. A tailored assessment framework comprising five steps was developed, drawing on scientific literature and international policy guidelines on loss and damage (see Section 3.5). This framework defined the dimensions that guided both the document review and subsequent data analysis. Data triangulation was used to enhance the validity and reliability of the findings, a particularly important measure given the limited

availability of primary datasets and the dispersed nature of institutional knowledge on climate impacts in Bhutan.

On August 11th and 12th 2025, **key informant group interviews** were conducted with over 55 individuals from 13 key government agencies and development partners in Bhutan to assess climate-induced Loss and Damage (L&D). The discussions focused on identifying sector-specific risks, institutional and technical challenges, and strategic priorities for strengthening Bhutan's capacity to address L&D. The consultations also aimed to inform the present assessment of climate-induced loss and damage and the development of a national L&D framework and to explore opportunities to access financial and technical support from the Fund for Responding to Loss and Damage (FRLD) and the Santiago Network for Loss and Damage (SNLD). The discussions were held with relevant officials and directors of 13 departments and agencies:

- Department of Environment and Climate Change - MoENR
- National Center for Hydrology and Meteorology - NCHM
- Department of Local Governance and Disaster Management – MoHA
- Department of Livestock - MoAL
- Department of Agriculture - MoAL
- Department of Energy - MoENR
- Department of Water - MoENR
- Department of Surface Transport - MoIT
- Department of Human Settlements - MoIT
- Department of Infrastructure Development - MoIT
- National Statistics Bureau - NSB
- National Biodiversity Centre - NBC
- Department of Forests and Park Services - MoENR

A three-day **National Stakeholder Consultation Workshop on Climate-Induced Loss and Damage (L&D)** was held on August 13th, 14th, and 15th, 2025, in Thimphu. Jointly organised by the Department of Environment and Climate Change (DECC) and UNDP Bhutan, the workshop gathered over 70 stakeholders with representatives from ministries, agencies, and district (*Dzongkhag)*, civil society organisations, and the private sector (See list of

participating agencies and organisations in Annex A.1 and workshop agenda in Annex A.2).

The workshop contributed to the **co-production of data with participants to support a locally driven** approach to this assessment of climate-induced loss and damage. During the workshop, participants engaged in several group exercises aiming to foster discussions and the production of knowledge on various dimensions of loss and damage through a collective, participatory process.

In addition, **field visits and observations** were conducted in Punakha and Wangdue dzongkhags (districts) involving the following:

- Observations of two sites of recent landslides and flood
- Visit to the hydrometeorological station of Yebesa along *Mo-chhu*u river in Punakha
- Visit of GLOF Early Warning System Control Room at Wangdue
- Observations of Punatsangchhu I and II hydropower projects construction sites

This field visit also involved a stakeholder discussion at the district level with representatives from different sectors, local government, and the Deputy Governor of Punakha district.

Secondary data were also collected through a **literature review and document review** of key policy documents and reports between June and October 2025 (see Annex A.3). The review focused on identifying data on loss and damage at the national and sub-national level, as well as relevant policy mechanisms and institutional arrangements.

1.7 Assumptions and limitations

The present assessment is based on a limited data sample due to the lack of centralised databases on climate-related events and associated losses, damages, and costs. To identify the types of loss and damage observed or projected in Bhutan, the assessment relied on reported climate impacts in national policy documents, complemented by regional and international data where local evidence was insufficient. Proxy estimates were used where direct measurements were unavailable, for example, drawing on sectoral productivity

data, disaster damage reports, and modelled projections of climate impacts for macro-level estimates. Where data gaps were evident, they were explicitly noted, and triangulation with additional data sources was undertaken to approximate trends wherever possible. This approach ensured that both observed and potential future climate-induced loss and damage were considered, while also highlighting priority areas where further data collection and research are required.

Assumptions and limitations are as follows:

- **Data availability and fragmentation:** Bhutan currently lacks a dedicated system to inventory climate-induced losses and damages, so quantitative data remain scarce and fragmented. This leads to partial assessments and, as a result, an expectedly significant underestimation of associated costs. The numbers presented in the report aim to reflect general trends and approximate the magnitude of climate-induced loss and damage associated with specific types of events.
- **Underreporting and cumulative effects:** Small-scale events and associated losses and damages are often not reported, as affected people tend to cope with them independently. This results in underreporting and, consequently, an underestimation of the cumulative impacts on individuals' lives, livelihoods, and Bhutanese society.
- **Absolute versus relative:** It is important to note that while loss estimates and associated costs may appear modest in absolute terms, their relative weight is considerable when viewed against Bhutan's overall economic scale and prevailing income levels as a small nation of less than 1 million people, thereby emphasising the disproportionate burden these impacts have on the country.
- **Attribution:** While attribution studies for extreme weather events are gaining recognition globally, such studies are not available in Bhutan. Therefore, attribution is approached qualitatively, based on established scientific findings on the effects of climate change that are found in the latest IPCC Assessment Report (AR6).
- **Adaptation versus loss and damage:** Effective adaptation contributes to preventing and minimising loss and damage. Accordingly, this

assessment recognises that many measures aimed at preventing, minimising, and reducing the risks of loss and damage can also fall under the scope of adaptation. At the same time, loss and damage is understood to refer to the residual impacts of climate change that occur when mitigation and adaptation are insufficient or absent a distinction reflected in both scientific literature and policy discussions.

- **Inclusiveness and representation**: Although a substantial number of stakeholders were consulted, including representatives from all dzongkhags, time constraints inevitably limited the possibility of involving a broader range of representatives from all districts.

2 State of knowledge on loss and damage

Since its progressive institutionalisation in the global climate policy architecture, the concept of loss and damage has given rise to a rapidly growing sub-field of climate change research that incorporates approaches and theories from diverse disciplines, including climate science, disaster risk studies, economics, development, sociology, and law. This section provides an overview of state-of-the-art knowledge on loss and damage in science and policy, and outlines key dimensions relevant for assessing climate-induced loss and damage.

2.1 Understanding loss and damage – Key terminology

Although no definition of climate-induced loss and damage has been formally adopted in the international negotiations on climate change, the UNFCCC refers to the following:

> *Loss and damage associated with the adverse effects of climate change, including impacts related to extreme weather events and slow-onset events.*[14]

Two types of loss and damage are defined as follows: **economic losses** referring to loss of **resources, goods and services that are commonly traded in markets;** and **non-economic losses** referring to the remainder of items that **are not commonly traded in markets including 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**.

In both science and policy, loss and damage is broadly understood as the **negative or adverse** outcomes of climate impacts **that cannot be avoided, when mitigation and adaptation do not occur or fail**. Risks of loss and damage can, however, subsist even *after* effective adaptation, requiring specific pre-

[14]United Nations Framework Convention on Climate Change, *Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010: Addendum, Part Two – Action taken by the Conference of the Parties at its sixteenth session, Decision 1/CP.16 (The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention)*, FCCC/CP/2010/7/Add.1 (2011) [online].

event measures (e.g. contingency funds, social protection and insurance).[15] There are, however, multiple perspectives and conceptualisations of loss and damage, each emphasising key dimensions.[16] An overview of definitions and conceptualisations found in scholarly literature and policy is provided in Table 1.

Table 1. List of definitions and their related field/approach.

Field/approach	Definition / Conceptualisation	Source
UNFCCC/WIM	Loss and damage associated with the adverse effects of climate change, including impacts related to extreme weather events and slow-onset events	UNFCCC (2010)
Comprehensive risk management	L&D may refer to actions dealing with the residual, adverse impacts of climate change which remain after mitigation and adaptation measures have been adopted.	Mechler et al. (2019)
Sociology / Value-based approach	Climate-related loss arises when people are dispossessed of things that they value, and for which there are no commensurable substitutes.	Barnett et al. (2016)
Political economy and value-based approach	Loss of the ability to derive benefits from objects or phenomena of value as a result of climatic and socioeconomic drivers.	Dorkenoo (2024)

Approaches rooted in comprehensive risk management typically frame loss and damage through the lens of **adaptation limits, vulnerability, and risk.**[17] Sociology-oriented approaches, meanwhile, highlight notions of **harm, value, and commensurability** as central to loss and damage. Barnett et al. (2016)

[15] UNEP, 2023. Adaptation Gap Report 2023: Underfinanced. Underprepared. Inadequate investment and planning on climate adaptation leaves the world exposed. Nairobi.

[16] Boyd, E., James, R. A., Jones, R. G., Young, H. R., & Otto, F. E. L., 2017. A typology of loss and damage perspectives. Nature Climate Change, 7(10), 723–729.
Mechler, R.; et al., 2019. Science for Loss and Damage. Findings and Propositions. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (eds) Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance. Springer, Cham.

[17] Schinko, T., & Mechler, R, 2017. Applying Recent Insights From Climate Risk Management to Operationalize the Loss and Damage Mechanism. Ecological Economics, 136, 296–298.

conceptualise climate-related loss as arising "*when people are dispossessed of things that they value, and for which there are no commensurable substitutes*".[18] Other perspectives, drawing on political-economic and vulnerability analysis, emphasise the importance of conditions of **access to resources and values**. Dorkenoo (2024) defines climate-induced loss and damage as the "*loss of the ability to derive benefits from objects or phenomena of value as a result of climatic and socioeconomic drivers*".[19] This perspective underscores the significance of examining the interplay between political-economic drivers and climate change in contributing to climate-induced loss and damage. In addition, legal and rights-oriented perspectives highlight critical aspects such as **responsibility, equity, compensation and justice**.[20] This is illustrated in the recent International Court of Justice Advisory Opinion that confirmed that states violating their international obligations can face legal consequences under the law of state responsibility, including undertaking or paying for reparations for incurred climate-related harm.

Several terms and concepts found across the diverse definitions are considered central to understanding, assessing, and addressing loss and damage. These include climate risk and hazard, vulnerability, extreme weather events, slow-onset events, climate justice, and values. Each of these terms and their relationship to and implications for loss and damage are described in Table 2.

[18] Barnett, J., Tschakert, P., Head, L., & Adger, W. N., 2016. A science of loss. Nature Climate Change, 6(11), 976–978.

[19] Dorkenoo, K., 2024. Seeing loss through land: On the emergence of disproportionate climate-related loss and damage in agrarian Cambodia. Lund University.

[20] Toussaint, P., 2023. Loss and Damage, Climate Victims, and International Climate Law: Looking Back, Looking Forward. Transnational Environmental Law, 1–26.
Nordlander, L., 2023. Human Rights and Climate Change: The Law on Loss and Damage (p. 208). Scopus.

Table 2. Summary of terms related to loss and damage.

Key term	Relevance to loss and damage	Associated questions and considerations
Climate drivers and hazards	Identifying types of extreme weather events and slow onset events and their likelihood under different emissions scenarios	■ What are the most prevalent extreme weather events/slow-onset events? ■ What are the most impactful or likely events?
Vulnerability	Evaluating exposure to climate risk and capacities to cope with/adapt to climate impacts	■ What adaptation measures have been undertaken? ■ Have adaptation limits been reached? ■ What support measures/resources are present?
Value(s)	Assessing the value (economic and non-economic) associated with objects and phenomena that climate change and related impacts put at risk	■ What benefits are derived from the object or phenomena at risk and by whom?
Temporality	Evaluating what is likely to be damaged or lost and on what time scale	■ What is at risk of being damaged or disappearing now or in 5/10/20 years?
Climate justice and responsibility	Evaluating the level of responsibility and the degree of compensation or redress that is sought	■ What are the most appropriate measures given the harm incurred? ■ Can it be recovered /redressed/compensated?
Attribution	Evaluating the role of climate change	● How likely is it that this event occurred because of climate change?

2.2 Governing loss and damage – Priorities and Challenges

The governance of loss and damage encompasses the legal, institutional, financial, and political mechanisms through which affected countries and communities can prevent, minimise, address and seek redress for climate-induced loss and damage. As the impacts of climate change accelerate in scope and intensity, the governance of loss and damage has emerged as one of the most pressing and complex issues on the global climate agenda. This section examines the evolving architecture for governing loss and damage, identifying the key priorities and challenges that lie ahead.

Despite recent advances in integrating loss and damage into global climate policy mechanisms, the absence of reporting guidelines under the UNFCCC remains a significant challenge. Countries have begun to include loss and damage considerations in their climate policy documents, such as NDCs, NAPs, and BTRs. However, these efforts have been ad-hoc and primarily based on existing data systems that are not necessarily adapted to collecting data specific to loss and damage. Numerous data gaps exist, hindering countries' abilities to report effectively on the extent of losses and damages they incur, and consequently, identify and formulate needs for financing and recovery measures.

Moving forward, one significant aspect remains to synthesise existing data relevant for loss and damage assessment and avoid duplication in data collection, in particular, aligning the architecture for tracking loss and damage with existing disaster risk management systems. Few countries have started to implement institutional arrangements specifically dedicated to loss and damage, particularly for data collection, analysis, and reporting.

Climate-induced loss and damage exert significant pressures on countries' budgets and resources, underscoring the need for additional financing and rapid disbursement. Many countries are already diverting substantial funds from their national budgets to address the impacts of climate change. One key issue moving forward will be to effectively track existing finance flows directed towards preventing, minimising, and addressing climate-induced loss and damage at national and sub-national levels, while establishing a clear distinction from finance allocated for adaptation and disaster risk reduction.

2.3 Financing loss and damage – Needs and opportunities

Loss and damage (L&D) finance refers to funding provided to developing countries to address climate-induced loss and damage. Funding for loss and damage remains one of the most critical and politically sensitive aspects of global climate finance. This section outlines current estimates of funding needs, pledges made to date, and ongoing challenges in operationalising effective loss and damage finance.

Although methodologies vary, recent assessments indicate that the global funding needs to address loss and damage are substantial and growing rapidly. The **Vulnerable Twenty (V20) Group**, representing climate-vulnerable economies, estimates that its member countries have suffered losses of over **USD525 billion in the past two decades**.[21] Recent estimates suggest that developing countries could face between **USD 290 billion and USD580 billion per year in loss and damage costs by 2030**, rising to **USD 1-1.7 trillion annually by 2050**.[22] These projections underscore the magnitude of climate-induced economic disruption already underway.

The establishment of the FRLD at Sharm El-Sheikh was accompanied by a series of initial pledges from 28 countries, with 22 countries having signed contribution agreements (Figure 2). Together, these pledges amounted to approximately **USD 788.8 million**, a positive political signal but just a **fraction (less than 0.2%) of the annual estimated needs** for loss and damage finance.

[21] V20 Group, 2022 Climate Vulnerable Economies Loss Report 2000-2019, V20 & Climate Vulnerable Forum.

[22] Markandya, A., González-Eguino, M., 2019. Integrated Assessment for Identifying Climate Finance Needs for Loss and Damage: A Critical Review. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (eds) Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance. Springer, Cham.

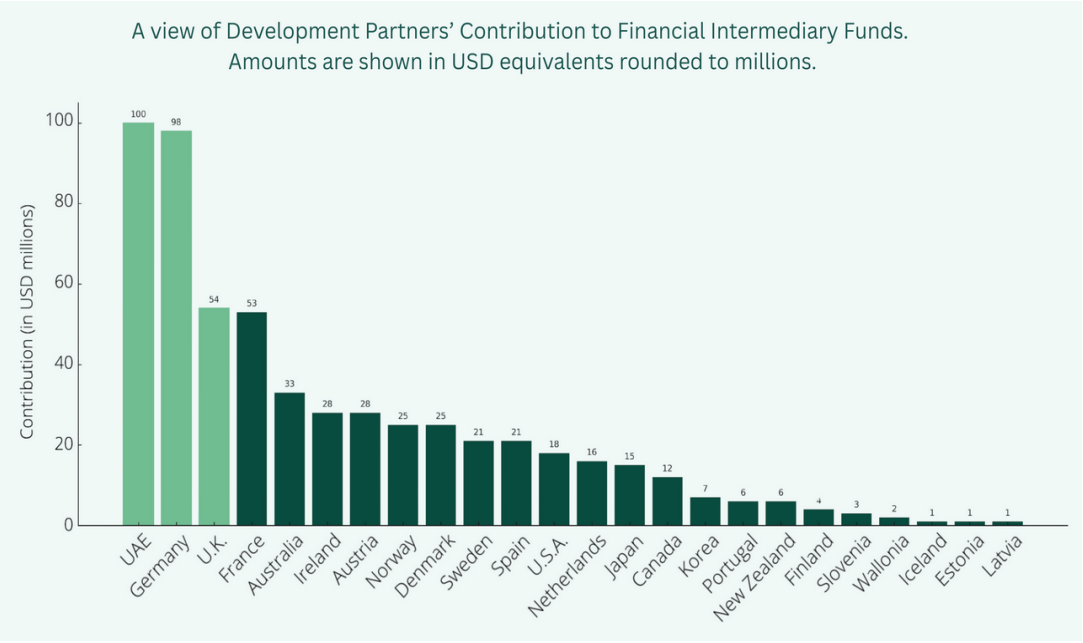


Figure 2. Overview of pledges by countries. Source: Fund for Responding to Loss and Damage.[23]

At its 5th meeting in Bridgetown, the FRLD Board agreed that the Fund will open an early call for proposals under the **Barbados Implementation Modalities (BIM)** after its 6th Board meeting, which took place on 9-11 July in Cebu, Philippines. An initial amount of USD 250 million is expected to be disbursed by the end of 2026, with grants ranging from USD 5 million to USD 20 million. The Board decided that SIDS and LDCs should receive at least 50% of the fund's resources in this initial disbursement period. Due to its recent graduation from LDC, Bhutan, however, will need to access the remaining 50% of financing for all other developing countries. These decisions provide a strategic window of opportunity for countries that are eligible to access necessary funding to address climate-induced loss and damage and contribute to and improve the Fund's subsequent calls and long-term operational model through sharing best practices and experiences.

[23] Fund for Responding to Loss and Damage, 2025. https://www.frld.org/pledges

3 Operationalising Loss and Damage in Bhutan

3.1 Bhutan's climate risks, hazards and vulnerability profile

Bhutan faces acute climate vulnerability due to its location within the fragile eastern Himalayan ecosystem, its extreme topographical variations, and its high dependence on climate-sensitive sectors. The kingdom is ranked as the 41st most vulnerable country globally to climate change impacts,[24] with projections indicating temperature increases slightly above the global average and intensifying hydro-meteorological hazards that threaten the nation's water security, agriculture, hydropower generation, and biodiversity. Any assessment of climate change hazards, vulnerabilities, and impacts must be contextualised in the geographically and environmentally diverse conditions of the country, ranging from the subtropical conditions of the south with high humidity and heavy rainfall to the harsher alpine high-altitude conditions of the north, characterised by freezing conditions in the winter and cooler summers.

Bhutan's climate vulnerability stems from its unique geographical position in the eastern Himalayas, with elevations ranging from 100 to over 7,000 meters above sea level. The country has three distinct climatic zones: hot subtropical conditions in the south, covering approximately 29% of the national territory, cool temperate climates in the central inner Himalayas, about 43%, and alpine conditions in the northern highlands, about 28%.[25] More than 70% of the country's annual rainfall occurs during the southwest Indian summer monsoon from June to September, making Bhutan highly dependent on monsoon variability for its water resources and agricultural systems.[26]

As indicated in the National Adaptation Plan, Bhutan has limited long-term historical datasets on temperature and rainfall, with consistent records only available since 1996. The summary presented below mainly draws on data from the latest National Center for Hydrology and Meteorology (NCHM) analyses of

[24] Notre Dame Global Adaptation Initiative, 2024. Bhutan – Country Index. University of Notre Dame, South Bend. Available at: https://gain-new.crc.nd.edu/country/bhutan
[25] National Statistical Bureau (NBS), 2025. Statistical Yearbook of Bhutan 2025. Thimphu: National Statistical Bureau, Royal Government of Bhutan.
[26] Dorji, S., 2025. Climate Change Projection for Bhutan. *The Druk Journal*, Volume 11, Issue 1.

historical and climate projections as well as Asia Development Bank's (ADB) Climate Risk Profile report.

Historical records indicate a clear warming trend in Bhutan over the 20th century, with annual temperatures increasing by just under 1°C. Daily minimum temperatures have been rising at a faster pace than maximum temperatures, and the warming trend has accelerated significantly since the 1990s.[27] [28] Precipitation patterns have also shifted, with increases recorded from 1970 onwards and sharper increases observed since 1990.[29] The frequency of extreme weather events has been rising (Figure 5). More than 18 Glacial Lake Outburst Flood (GLOF) events have been recorded since the 1950s.[30]

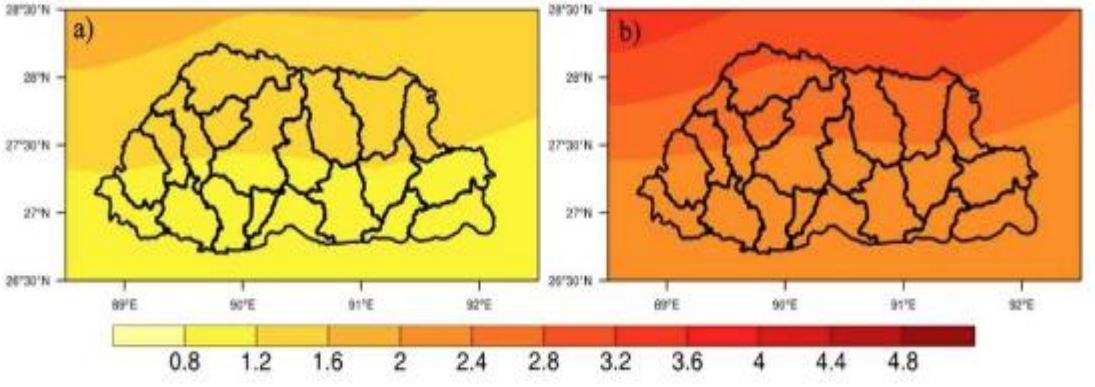
According to NCHM's latest Climate Projection Report from 2024,[31] across all Shared Socioeconomic Pathways (SSPs), mean annual temperatures in Bhutan are projected to rise (Figure 3):

- By mid-century (2040–2069), warming is expected to range from 1.6°C under SSP1-2.6 to 2.3°C under SSP2-4.5 and 2.7°C under SSP3-7.0 relative to the 1981–2010 baseline.
- By the end of the century (2070–2099), temperature increases could reach 1.8°C under SSP1-2.6**,** 3.0°C under SSP2-4.5, and up to 5.2°C under SSP3-7.0.

Regional variations indicate that more significant warming is projected for northern and central highland areas, with Gasa dzongkhag expected to experience increases of 1.55°C by 2040 and 2.5°C by 2060 under worst-case scenarios. Thimphu faces similar projections with 1.4°C by 2040 and 2.3°C by 2060.

[27] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.
[28] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.
[29] Dorji, S., 2025. Climate Change Projection for Bhutan. The Druk Journal, Volume 11, Issue 1.
[30] Rinzin, S, 2023. GLOF hazard, exposure, vulnerability, and risk assessment: A comprehensive study of four potentially dangerous glacial lakes. Journal of Hydrology. 617, 128826.
[31] National Center for Hydrology and Meteorology, 2024. Climate Projection Report of Bhutan: Insights from CMIP6 Projections. Thimphu: Royal Government of Bhutan.

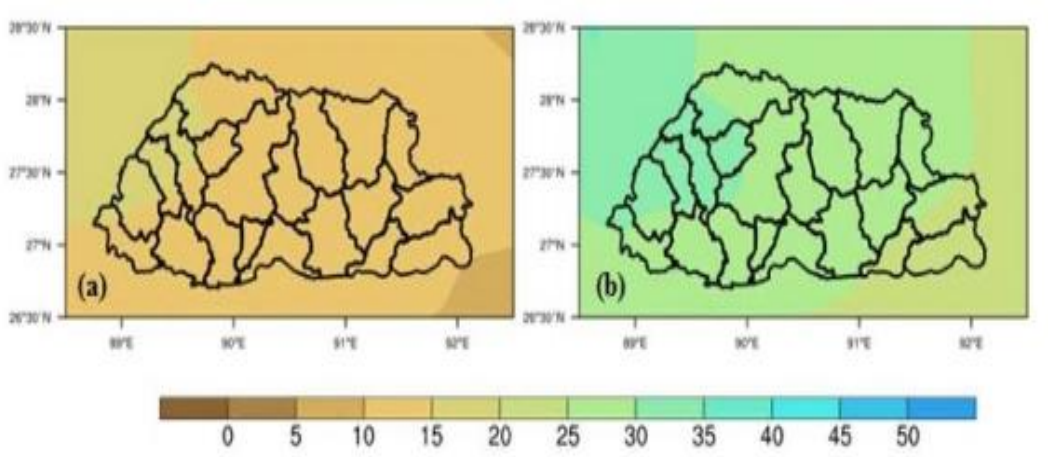
Annual precipitation levels are projected to increase under all scenarios, but with strong seasonal variation (Figure 4). In particular, summer monsoon rainfall is projected to intensify, with an increase in heavy precipitation events, while winter months are likely to become drier. The spatial distribution shows that increases in rainfall are concentrated in northern, western, central and southwestern districts, while some eastern and southeastern areas may experience decreases in rainfall.



Panel (a) shows the difference in annual mean temperature (°C) between 2020-2050 and present-day climate. Panel (b) shows the difference in annual mean temperature (°C) between 2070-2099 and present-day climate (Source: NCHM 2019).[32]

Figure 3. Projected annual mean temperature under RCP 4.5 scenario.

[32] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.



Panel (a) shows difference in annual mean precipitation between 2020-2050 and present-day climate and panel (b) shows difference in annual mean precipitation between 2070-2099 and present-day climate (Source: NCHM 2019).

Figure 4. Projected annual mean precipitation under RCP 4.5 scenario.

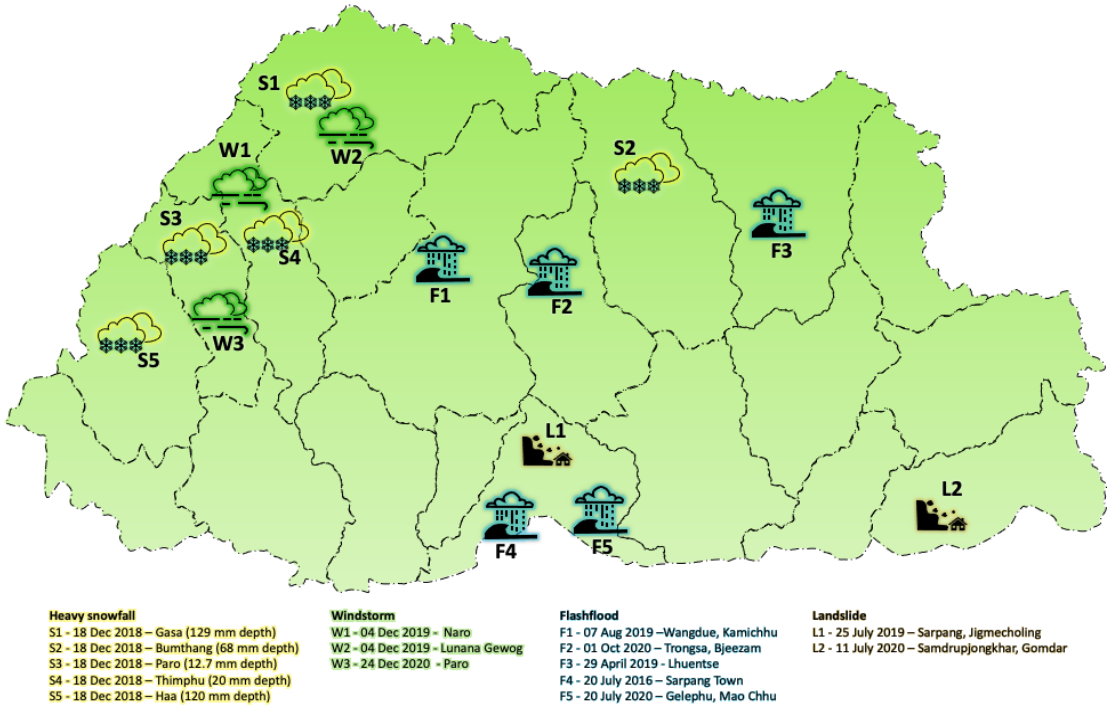


Figure 5. Map representing extreme weather events in Bhutan recorded by NCHM 2016-2020.

Flash floods and other flood events are significant climate hazards in the country, with economic impacts on human health and livelihoods expected to grow and reach 4% of GDP by the 2030s.[33] The concentration of agricultural land and infrastructure along drainage basins makes them highly vulnerable to heavy monsoon rains, GLOFs, and other flood events. Recent years have seen unprecedented extreme weather, including the devastating floods in Dechencholing, Thimphu, in August 2024.[34] Over 7,700 people are estimated to be affected by flooding annually, with projections indicating this could reach 10,700 by 2030.[35]

[33] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

[34]Asia News Network, 2025. *A year of extreme weather in Bhutan.* Asia News Network. Asia News Network, 2025. *Bhutan feels the heat as Asia's climate crisis escalates.* Asia News Network.

[35] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

Glacial Lake Outburst Flood (GLOFs) represent one of the most significant climate-related hazards for Bhutan. With over 700 glaciers covering 1.6% of the territory and 2,674 glacial lakes, of which 17 are considered potentially dangerous, the country faces unprecedented GLOF risks.[36,37] Glaciers are retreating at rates of 30-60 meters per decade, with debris-covered glaciers melting at 30-35 meters annually and clean glaciers retreating at 12-15 meters per year. The formation of supraglacial lakes due to accelerated glacier retreat has increased the proportion of lake-terminating glaciers from 14% in 2000 to 22% in 2019.[38]

Landslides are expected to grow in frequency and intensity under future climate change scenarios. Landslides, primarily triggered by intense rainfall on steep terrain, are projected to increase. Scenarios under RCP4.5 indicate a 10–30% increase in mean annual rainfall by 2050 and a 5–15% intensification of summer monsoon rainfall, with extreme rainfall events exceeding 32% magnitude projected toward the end of the century.[39,40] This intensification of the hydrological cycle suggests greater variability, with more rainfall concentrated in short-duration extremes rather than sustained seasonal flows.

Windstorms, though less represented in models, have already caused recurrent damage to crops and infrastructure in highland gewogs, with events in 2019–2021 illustrating exposure to westerly wind disturbances.[41]

Forest fires represent one of the most severe and immediate climate-related threats to Bhutan's unique ecosystem, with mounting scientific evidence demonstrating that climate change is altering fire behaviour, frequency, and impact across all of the kingdom's forest types. Climate risk assessments reveal

[36] National Center for Hydrology and Meteorology, Royal Government of Bhutan, 2019. Bhutan Glacier Inventory 2018. Thimphu: Royal Government of Bhutan.
[37] ICIMOD, 2001. Inventory of Glaciers, Glacial Lakes and Glacial Lake Outburst Floods Monitoring and Early Warning Systems in the Hindu Kush-Himalayan Region Bhutan.
[38] King, O., Bhattacharya, A., Bhambri, R. et al., 2019. Glacial lakes exacerbate Himalayan glacier mass loss. *Sci Rep* 9, 18145.
[39] Royal Government of Bhutan (RGoB) and UNDP, 2021. National Adaptation Plan of Bhutan. Gross National Happiness Commission and United Nations Development Programme, Thimphu.
[40] National Center for Hydrology and Meteorology (NCHM), 2020. Climate Projections for Bhutan: National Report, Thimphu: Royal Government of Bhutan.
[41] Department of Disaster Management (DDM), 2021. Annual Disaster Report 2020–2021. Thimphu: Royal Government of Bhutan.

a concerning trajectory where forest fire risks are intensifying under both moderate and severe climate change scenarios.[42]

Glacier retreat, drying of water sources, and droughts are particularly prevalent slow-onset events in Bhutan. Bhutan's 700 glaciers are experiencing accelerated retreat, which is negatively affecting the country's water security. Of the 7,399 water sources identified nationally, 69 have already dried up, and 1856 (25.1%) are in the process of drying.[43] This represents a critical threat to people living in the Himalayas and nearly 2 billion people downstream. Furthermore, drought patterns exhibit seasonal divergences. While monsoon precipitation is projected to increase, winter aridity is expected to intensify, with wetter summer conditions and declining water flows during the winter.[44] This is particularly concerning in the southern and eastern dzongkhags.

Heatwave probability is projected to increase significantly. While the current median probability is approximately 2%, this figure is expected to rise sharply, reaching between 20% and 36% by the 2090s.[11] Thimphu is particularly exposed to increases in heat waves. By 2040, over 95% of its residents are projected to experience temperature increases of 1–1.5 °C, with worst-case scenarios suggesting a rise of 3.5–4 °C by the end of the century.[45]

3.2 A country-owned and locally driven approach to L&D assessment

As part of Bhutan's efforts to localise global frameworks on climate-induced loss and damage, a national stakeholder workshop and consultations were convened (Figure 6). These dialogues brought together participants from diverse sectors and districts, representing constituencies across the country. The workshop included several group exercises.

For these exercises, participants were divided into six groups, each with a specific thematic focus (Environment and Natural Resources, Social, Local

[42] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.
[43] National Center for Hydrology and Meteorology, Royal Government of Bhutan, 2023. Bhutan Hydromet Journal, Volume II.
[44] National Center for Hydrology and Meteorology, 2020. Climate Projections for Bhutan: National Report. Thimphu: Royal Government of Bhutan.
[45] National Center for Hydrology and Meteorology, 2024. Climate Projection Report of Bhutan: Insights from CMIP6 Projections. Thimphu: Royal Government of Bhutan.

Government, Economic, Infrastructure, Data and Governance), throughout the workshop. During breakout sessions, these groups discussed and collectively developed documents focusing on:

- **Bhutan's L&D definition and L&D signatures**
- **Selecting L&D indicators for assessment**
- **Mapping Policies and Institutions for L&D**
- **Identifying Priority Issues, Interventions and Sectors**

A central component of the workshop was the co-development of **Bhutan's own national definition of Loss and Damage (L&D) and the identification of L&D signatures** through a participatory approach. The methodology was guided by the *Compendium on Comprehensive Risk Management Approaches* prepared by the Warsaw International Mechanism (WIM) Executive Committee.[46] This report introduced the concept of a "loss and damage signature," defined as: *the combination of a specific type of potential or materialised loss and damage caused by a particular hazard*. Building on this framing, an exercise was designed to apply the concept to Bhutan's own context. Participants were divided into six groups, each tasked with developing a definition of L&D relevant to Bhutan's realities and identifying the most salient L&D signatures. Elements of each of the definitions were then gathered into one definition, which was edited collectively during a subsequent plenary session.

In addition, the groups participated in an exercise to identify relevant L&D measurement indicators in their respective sectors and thematic work areas, and discuss challenges faced in selecting indicators. On the final day of the workshop, the groups worked to identify key L&D issues and proposed related interventions. The exercise also required participants to identify the lead agency and collaborating agencies for the specific intervention, identify the national policy or priority with which the intervention aligns, and finally prioritise these interventions with a ranking from 1 to 5 (highest to lowest).

The workshop also involved the proposal and adoption of a new **L&D Task Force** for Bhutan's Loss and Damage Assessment, composed of members from various government representatives, civil society, and academia (Annex A.4).

[46] UNFCCC WIM Executive Committee, 2025. Compendium on Comprehensive Risk Management Approaches Vol.2.

The Task Force's responsibilities aim to ensure that the assessment and development of concept notes and proposals for assistance are inclusive, technically sound, and aligned with Bhutan's national priorities and international commitments. Moving forward, it is expected that the Task Force will serve as a basis for the development of a working group.

By generating a national L&D definition and L&D signatures through an inclusive and participatory approach, Bhutan ensured that the outcomes were grounded in local realities while aligned with the WIM's technical framework and guidelines. The result is a national articulation of loss and damage that both reflects Bhutan's unique vulnerabilities and contributes to the evolving global discourse on climate change impacts. The definition and TORs were then submitted to the newly formed L&D Task Force for refinement and adoption.

Stakeholders from across Bhutan at the National Workshop on Climate-Induced L & D

Participants engaged in group discussions

Generating a national L&D definition and L&D signatures

Figure 6. Photos from the national stakeholder consultation workshop on climate-induced loss and damage.

3.3 Bhutan's Loss and Damage definition and L&D signatures

Bhutan's definition of Loss and Damage:

> *Loss and Damage refers to the adverse impacts of climate change on Bhutan's people, culture, environment, and economy, arising from extreme weather events including but not limited to floods, Glacial Lake Outburst Floods (GLOFs), landslides, forest fires, heatwaves, windstorms, and erratic precipitation patterns and slow-onset events such as glacial retreat, droughts, monsoon breaks, and changing temperatures. It encompasses*

> *both economic and non-economic losses, including harm to lives and livelihoods, health, natural resources, cultural heritage, infrastructure and erosion of traditional knowledge. These losses are particularly severe due to Bhutan's mountainous and fragile ecosystems and disproportionately affect the vulnerable groups and communities. They occur despite Bhutan's significant efforts to remain carbon neutral and climate-resilient, undermining its pursuit of Gross National Happiness.*

Complementary to this definition, Bhutan identifies six **L&D signatures**:

1. Food and water insecurity due to changes in temperatures, erratic precipitation, windstorms, droughts, and land degradation
2. Impacts on human health and wellbeing due to heatwaves, forest fires, landslides, and floods
3. Infrastructure and property damage due to floods, GLOFs, windstorms and landslides
4. Impacts on terrestrial and freshwater ecosystems due to changes in temperatures, glacier melt, and forest fires
5. Energy insecurity due to glacier melt, changes in precipitation, and GLOFs
6. Impacts on cultural heritage due to glacier melt, floods, and forest fires

3.4 Institutional arrangements and data systems for L&D

Bhutan has already established several institutional arrangements and data systems that provide an important foundation for developing a national Loss and Damage (L&D) Framework. Existing structures for disaster risk management, climate services, climate action transparency, and environmental monitoring, together with the country's unique Gross National Happiness (GNH) survey framework, offer valuable entry points for integrating L&D considerations. While these systems were not originally designed to capture the full spectrum of climate-induced economic and non-economic losses, they represent significant assets that can be expanded, modernised, and leveraged. Building on these existing mechanisms will not only ensure efficiency and continuity but also promote national ownership of the L&D Framework.

3.4.1 Institutional arrangements and policies for Loss and Damage

The Climate Change Policy of the Kingdom of Bhutan 2020, although using other terminology than "Loss and Damage", acknowledges Bhutan's high vulnerability to climate hazards such as Glacial Lake Outburst Floods (GLOFs), landslides, flash floods, windstorms, and forest fires, as well as the adverse impacts of climate change on health, livelihoods, infrastructure, and ecosystems, all of which are core dimensions of the Loss and Damage framework. Policy objective two focuses on building resilience and reducing vulnerability. This includes assessing adaptation needs across sectors, recognising the special needs of vulnerable groups, enhancing climate information systems, and measuring resilience. However, the policy does not address residual impacts, despite adaptation efforts or when they fail, which is a key element of Loss and Damage. Moreover, although it outlines mechanisms for accessing international climate finance, including support for adaptation and mitigation and calls for private sector engagement, capacity building, and research, there is no dedicated financial instrument or strategy for compensating irreversible losses, such as cultural heritage degradation or permanent livelihood disruption.

T**he National Climate Change Committee (NCCC)** and the **Climate Change Coordination Committee (C4)** are mandated to oversee the implementation of climate policy, including the monitoring, coordination, and integration of climate actions. It also encourages the collection of gender-disaggregated data. However, there is no institutional mandate or mechanism specifically designed to assess, report on, or address Loss and Damage. Additionally, a national framework for monitoring non-economic losses, such as displacement, psychological trauma, or biodiversity loss, is currently lacking.

The Kunming-Montreal Global Biodiversity Framework (KMGBF) provides a comprehensive strategy to halt biodiversity loss, including a target (target 8) to "Minimize the Impacts of Climate Change on Biodiversity and Build Resilience".

NBSAP: In alignment with KMGBF, the National Biodiversity Strategies and Action Plans (NBSAP), 2025 has the same target as it recognises that climate change is an escalating threat to biodiversity, with shifting temperature and precipitation patterns altering species distributions, disrupting ecosystem processes, and increasing the frequency of climate-related hazards. It also highlights that drier and windier conditions linked to climate change are

intensifying both the scale and severity of forest fires, which represent a significant pressure on forest biodiversity and degrade soil, fragment habitats, and disrupt natural regeneration, resulting in long-term biodiversity loss and increased carbon emissions. The NBSAP, 2025 records 261 fire incidents, affecting approximately 28,000 ha of forest between 2020 and 2024. It also records that treelines are advancing by approximately one metre per year, reducing the range of cold-adapted species.

The Disaster Management Act of Bhutan 2013 recognises climate-induced hazards such as floods, landslides, and GLOFs, and establishes an institutional framework for disaster risk reduction and emergency response. It provides for relief, rehabilitation, and reconstruction following disasters and creates a Disaster Management Fund for response and recovery. It focuses on sudden-onset disasters, with limited provisions for slow-onset events (e.g., glacial retreat, drought), nor does it explicitly recognise or define “Loss and Damage” as a distinct climate impact category. There is no legal mechanism for addressing residual losses that extend beyond adaptation and recovery, and it lacks provisions for non-economic losses.

The Disaster Management Framework of Bhutan is integrated with the country's unique socio-economic development philosophy, Gross National Happiness, and its acute vulnerability to natural hazards, including earthquakes, Glacial Lake Outburst Floods (GLOFs), flash floods, landslides, and forest fires. It recognises the critical link between development and disasters, emphasising that sustainable development is not possible without embedding disaster risk management into all planning and development activities. It adopts a multidisciplinary and multi-sectoral strategy, encouraging all administrative wings and communities to foster disaster resilience. The Framework explicitly aims to shift from reactive disaster response to proactive disaster risk management, recognising the roles of various organisations and ensuring that their activities align with national disaster risk management goals.

Bhutan’s Disaster Management Framework has a strong grounding in traditional disaster risk management and aligns with some elements of L&D under WIM. However, it lacks explicit incorporation of comprehensive L&D aspects, such as financial mechanisms for compensation, formal integration of non-economic losses, management of impacts of slow-onset events, robust data systems, and international coordination as mandated by the Warsaw Implementation

Mechanism. Addressing these gaps would enhance Bhutan's capacity to fully integrate L&D in line with international frameworks and access support to cope with climate change impacts that exceed adaptation limits.

The Operational Guidelines for Disaster Financing 2017 focus on disaster response, relief, immediate restoration of essential public infrastructure, and recovery and reconstruction activities. The financing arrangements facilitate timely access to funds for immediate relief and restoration, with clear roles and procedures defined within the government framework. However, it lacks explicit coverage for the broader full spectrum of climate-induced Loss and Damage, such as slow-onset events, non-economic losses, and long-term recovery financing. It operates through government budget allocations specifically tied to disaster management, and thereby lacks a distinct, dedicated financing arrangement or fund addressing L&D from climate change.

In summary, the following key aspects would be valuable to consider moving forward when developing institutional frameworks to assess, report, and address climate-induced loss and damage in Bhutan:

- Bhutan's existing institutional framework to address climate impacts is primarily focused on disaster risk management and response, with limited explicit incorporation of non-economic losses or residual losses that go beyond adaptation measures such as loss of cultural heritage, biodiversity, and human mobility. It focuses on tangible damage and socio-economic impacts, with less emphasis on psychological, cultural, and social losses.
- While the current framework addresses hazards like Glacial Lake Outburst Floods (GLOFs), the integration of slow-onset event impacts related to climate change is less explicit.
- It does not currently have provisions for targeted financial instruments or compensation mechanisms specifically for L&D.

3.4.2 Data systems for Loss and Damage

Bhutan has undertaken significant efforts to develop its institutional structure for disaster and climate change risk management. The recent report published by UNDP Bhutan & Bhutan's Department of Local Governance and Disaster

Management, which conducted an analysis and need assessment for advancing disaster data architecture for climate-induced loss and damage in the country, provides a comprehensive overview of the strengths and weaknesses of existing data systems and their relevance for L&D.[47]

Existing data management systems relevant to L&D focus primarily on capturing the effects and risks associated with natural disasters, including flash floods, GLOFs, earthquakes, landslides, windstorms, fires, pests, diseases, and droughts. One of the key findings of the report on needs assessment for disaster data in the context of L&D is that these data systems and indicators are fragmented and lack standardised protocols for monitoring and reporting the outcomes of events. As a result, existing monitoring systems are not operable across agencies and administrative levels.

Although a portal is in development, there is currently no fully operational centralised database for disaster data management at the national level under the DLGDM, nor is there a mechanism for data sharing with the National Statistics Bureau (NSB). Additionally, the Disaster Management Information System (DMIS) reportedly contains missing and inaccurate data. The limited sectoral reporting that exists is based on the mandates of specific agencies and operationalised through the line agencies of the respective ministries. Some agencies collect data on extreme weather events to determine their impacts, which are used for internal purposes but not shared with external stakeholders.

The use of different software platforms and systems further restricts data sharing and synchronisation, while limited information sharing between agencies restricts data utilisation in policy and in harmonising practices. Moreover, gaps and challenges in data collection, data quality assurance, interoperability and scalability are replicated across administrative levels, in that different district agencies of the same ministry follow their own procedures.

The lack of standardised protocols, digitalisation, and integrated data management makes identifying the relevance of monitoring disasters and extreme weather events for L&D assessments challenging, as missing or inadequate data today can hamper the reliability and accuracy of L&D

[47] United Nations Development Programme, 2024. *Analysis and Need Assessment for Advancing Disaster Data Architecture for Climate-Induced Loss and Damage in Bhutan*. Thimphu: UNDP Bhutan.

assessments in the future. The development of a GIS-based database management system, known as GeoNode, which integrates geospatial data for hazard profiling, shows promise for overcoming some of these challenges in disaster monitoring. However, data on natural disaster events are not necessarily related to L&D, as they also pertain to, for instance, earthquakes or weather events that are not necessarily connected to climate change. Additionally, they fail to capture slow-onset processes associated with climate change.

Looking ahead, key informant discussions and stakeholder consultations highlighted four key data systems and frameworks as particularly relevant to support the development of data systems for L&D. These include:

- **Climate Services Toolkit (CST) for Bhutan**: The National Center for Hydrology and Meteorology (NCHM) could serve as a central repository and agency for gathering and sharing climate services and forecasting for climate-induced loss and damage data. The NCHM already reports on larger extreme weather events and continuously monitors climate data, including temperature and rainfall, at the district level. This is illustrated in the NCHM report on extreme weather events from 2016 to 2022[48]. However, these assessment reports are highly infrequent and incomplete, often based on newspaper articles and information shared via WhatsApp messages. Reviving, modernising, and institutionalising the CST could help support efforts on L&D.

- **Bhutan's Risk and Resilience Portal:** Bhutan is in the final phase of launching its new *Bhutan Risk and Resilience Portal*. This web-based platform provides localised, high-resolution climate projections and spatial analysis tools to support evidence-based adaptation and risk-informed planning. This portal contains several modules including one on disaster-related loss and damage, which could provide data necessary for climate-induced loss and damage assessment in the future provided that the module is adapted to the future L&D Framework.

[48] National Center for Hydrology & Meteorology, 2022. *Records of Extreme Weather Events in Bhutan: July 2016 – July 2022*. Thimphu: Royal Government of Bhutan.

- **Bhutan Climate Change Monitoring Reporting and Verification (MRV) System:** Bhutan is currently engaging with the Global Environment Facility's Capacity-Building Initiative for Transparency (CBIT) under the Enhanced Transparency Framework (ETF) of the Paris Agreement, including development of tools, institutional arrangements, and tracking platforms for climate finance and transparency. Bhutan is in the process of establishing an updated platform dedicated to consolidating data on climate finance flows, identifying climate-relevant budgets and expenditures, tracking mitigation and adaptation support, and improving institutional capacity for transparency. This platform could play an important role in a national L&D Framework by making spending on adaptation, disaster risk reduction, and resilience visible and distinct, and thereby contributing to estimating additional financing flows needed for L&D specifically. It could integrate and tag actual L&D-specific finance flows, helping to showcase the already incurred costs of climate-induced loss and damage in Bhutan.

- **Gross National Happiness Survey:** Bhutan's GNH Survey, conducted by the Centre for Bhutan & GNH Studies, measures wellbeing through a holistic index based on 33 indicators across nine domains**:** psychological wellbeing; health; education; time use; cultural diversity and resilience; good governance; community vitality; ecological diversity and resilience; and living standards. The Gross National Happiness (GNH) Survey, while primarily designed to measure wellbeing, offers significant potential for Loss and Damage (L&D) assessments if integrated with climate change dimensions. Its ecological diversity and resilience domain already captures aspects of environmental health, biodiversity, and ecosystem functioning that are central to understanding non-economic losses. Similarly, domains covering health, psychological wellbeing, and community vitality provide insights into non-material losses—such as mental health impacts, social disruption, and reduced wellbeing—that conventional disaster assessments can overlook.

3.5 Assessment framework

The assessment of climate-induced loss and damage in Bhutan required the development of a tailored framework. Data on climate events, impacts, and loss and damage in the country is sparse and fragmented, and the absence of consistent and harmonised datasets poses significant challenges for compiling and measuring the full spectrum of loss and damage. To overcome these constraints, a context-sensitive framework was designed based on terminology presented in Chapter 2, which draws upon available international guidance on Loss and Damage, including recent technical reports from the Executive Committee of the Warsaw International Mechanism for Loss and Damage (WIM). The framework is described in detail below and illustrated in Figure 8.

1. ***Climatic-Impact Drivers:*** *identify climate conditions that (will) affect elements of society or ecosystems,*[49] *with a focus on changes in the likelihood, frequency, and intensity of both extreme weather events and slow-onset events.*

This involves reviewing analyses of historical data and climate projections under different emissions scenarios for specific event types. This step is also relevant for climate attribution, which seeks to determine the extent to which observed or projected events can be linked to climate change. While attribution can be conducted through either probabilistic event attribution or process-based approaches, in many countries, including Bhutan, limited data availability constrains the use of probabilistic methods, making qualitative or process-based assessments the most feasible approach for understanding climatic influences on specific hazards.

2. ***Climate-related Hazards/Events:*** *identify prevalent types of extreme weather events and slow-onset events.*

The UNFCCC proposes a classification of events, including extreme events such as storm surges, tropical cyclones, floods, and heatwaves; and slow-onset events, including glacial retreat, loss of biodiversity, salinisation, ocean

[49] Intergovernmental Panel on Climate Change (IPCC). (2021). FAQ Chapter 12: Climate information for regional adaptation. *In* Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (V. Masson-Delmotte et al., Eds.). Cambridge University Press.

acidification, sea level rise, desertification, increasing temperatures, and land and forest degradation. However, such classifications must be contextualised to national circumstances. In Bhutan, this meant focusing on hazards of relevance, which are landslides, floods, Glacial Lake Outburst Floods (GLOFs), forest fires, windstorms, changing precipitation patterns, and glacial retreat.

3. ***Types of loss and damage:*** *identify categories and types of loss and damage.*

Although losses and damages are often closely interconnected and occur in a cascading manner, categorisation is useful for analytical purposes. The UNFCCC proposes an initial categorisation in its online guide on loss and damage, comprising economic losses with subcategories of income and physical assets, and non-economic losses, covering losses related to individuals, society, and the environment (Figure 7). In this assessment, the L&D Signatures framework proposed by the WIM is used to identify specific combinations of hazards and associated losses and damages that are most prevalent in the country. While the identified L&D signatures (See Section 3.3) are closely interlinked and influence one another, categorising them separately provides a valuable analytical framework for assessment and planning purposes.

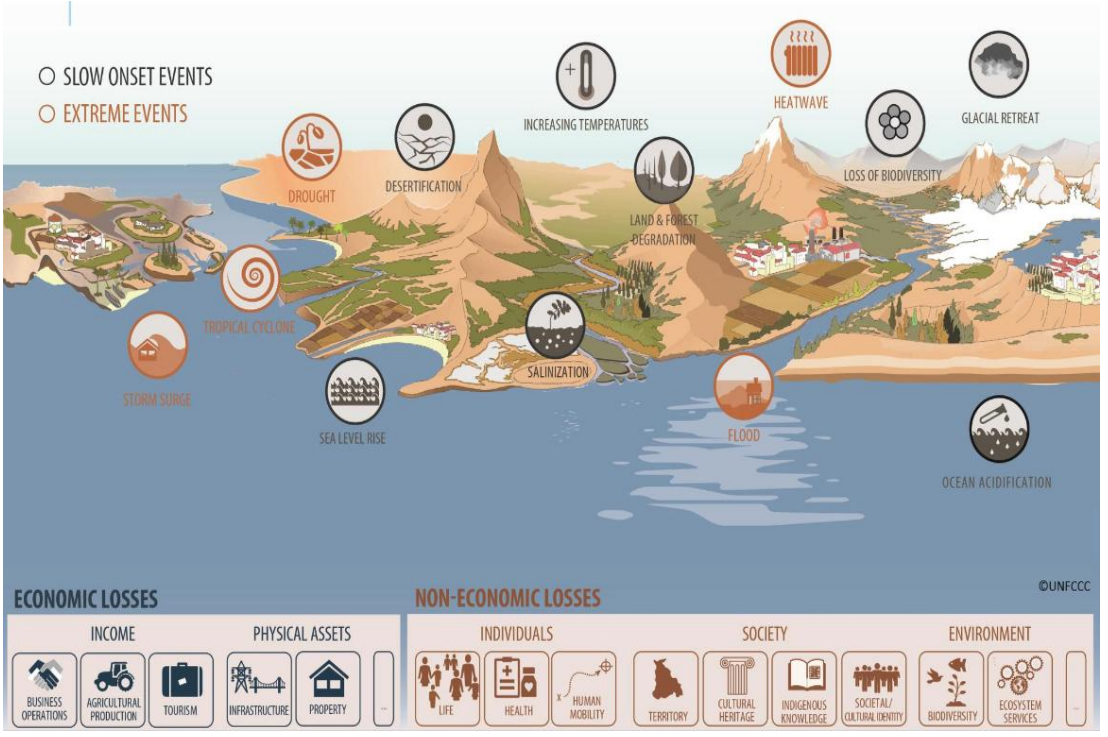


Figure 7. Representation of categories of climate events and loss and damage (Source: UNFCC, 2024).

4. ***Evaluation, Quantification, and Costing:*** *evaluate the extent, degree of severity, and identify the costs associated with different losses and damages.*

Evaluating the extent of loss and damage should take into consideration the value of the objects or phenomena affected. While evaluation or quantification tends to focus on establishing economic values that aim to inform financing or compensation needs, integrating complementary indicators that extend beyond monetary value is essential. This is particularly the case when engaging with evaluation processes at the individual or household level, as well as when examining non-economic losses and damages. Quantification for such losses and damages is not always possible. It is also necessary to account for prevention costs, the costs of the losses and damages themselves, and the costs of remedial or recovery measures, as all inform planning and financing priorities.

5. ***Prevention, Response, and Recovery measures:*** *Identify prevention, response, and recovery measures based on the type of loss and damage, its degree of severity, and recoverability.*

Measures can be classified as ex-ante (implemented proactively to reduce risk and minimise loss and damage) or ex-post (applied reactively after an event to support recovery, reconstruction, and rehabilitation). Some interventions may be short-term, requiring rapid implementation in the immediate aftermath of a loss or damage event, while others are longer-term, designed to be implemented continuously to enhance adaptive capacity and reduce the potential for residual risk and loss and damage over time. In this assessment report, measures were identified by participants in the national stakeholder workshop and consultations, in line with a country-led and country-owned approach to L&D.

Finally, **inclusivity considerations** must be integrated throughout the assessment, particularly when evaluating the extent of loss and damage, as well as the associated prevention/response/recovery measures. Particular attention should be paid to the differentiated effects of climate hazards and events on various groups whenever disaggregated data is available. Beyond the assessment, a **prioritisation** process can be undertaken according to the severity and likelihood of specific events, as well as the types and breadth of climate-induced loss and damage.

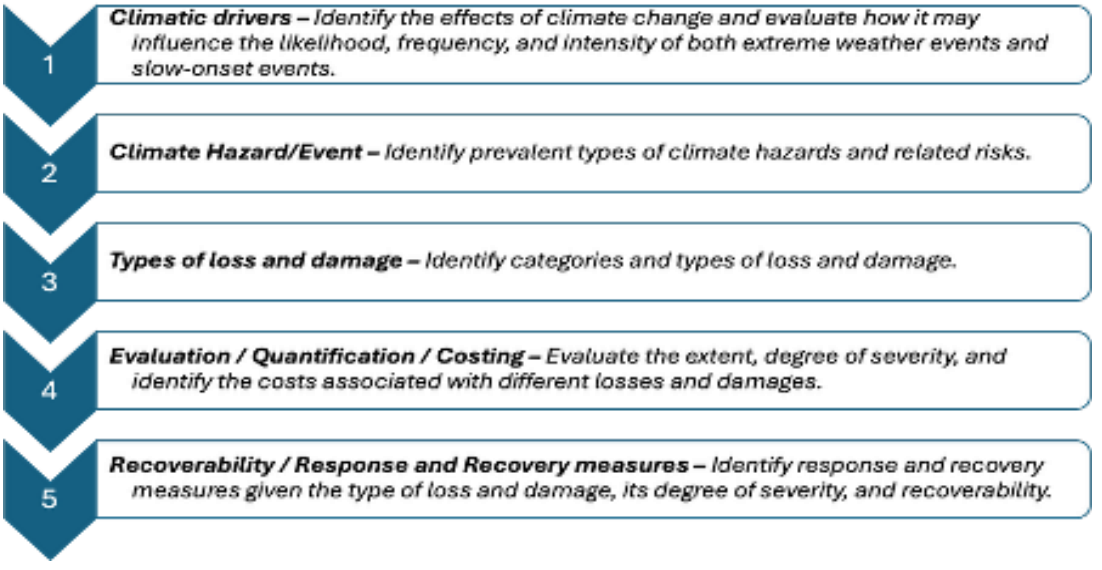


Figure 8. Diagram representing the assessment framework.

4 Assessing Loss and Damage in Bhutan – Findings

This section presents the key findings from the assessment of loss and damage in Bhutan, drawing on national data, sectoral analyses, and case study evidence. It provides a comprehensive picture of available evidence on how climate risks and impacts translate into both economic and non-economic loss and damage across the country. It is important to note that Bhutan currently lacks a dedicated institutional mechanism for documenting, monitoring, and reporting climate-induced loss and damage or economic costs from climate-related events. This limitation restricts the availability of robust, comprehensive data on the full scope of climate impacts and associated climate-induced loss and damage on the economy and society.

The section begins with macro-level estimates of economic losses in the country. This is followed by an assessment of the available data and evidence for economic and non-economic loss and damage for each L&D signature identified as most relevant to Bhutan's context. These signatures illustrate the interlinked, cascading, and often compounding nature of climate-induced loss and damage. For each signature, the most prevalent and significant categories of loss and damage are outlined, accompanied by a summary of available evidence and a set of potential indicators for measurement proposed by workshop participants. The evidence originates from various policy documents, scientific reports, a list of climate-induced disaster data provided by key informants (See Annex A.5), and a preliminary report of the rapid assessment for losses damages incurred during 4-5th October 2025 extreme weather events (See Annex A.8). The section concludes with four illustrative case studies that bring forward the lived experiences of economic and non-economic losses, both observed and projected.

Together, these findings demonstrate the multifaceted nature of climate-induced loss and damage in Bhutan and highlight the need for policies, financing mechanisms, and response measures to address observed and projected climate-induced loss and damage in the country.

4.1 Macroeconomic estimates of climate-induced loss and damage in Bhutan

Recent analyses offer insights into the scale of potential climate-induced losses and damage nationwide. The most current macro-level estimates are drawn from three key sources: Bhutan's First Biennial Transparency Report to the UNFCCC (2024), UNESCAP's Risk and Resilience portal, and the World Bank's Bhutan Country Climate and Development Report (2025). These analyses represent the most up-to-date and comprehensive efforts to quantify climate risks and their economic implications for the country.

The World Bank's Climate and Development Report provides the most detailed **macroeconomic analysis of climate change impacts and projected loss and damage on Bhutan's GDP through 2050**. It analyses the country's economic vulnerability to climate shocks under different climate scenarios for two development pathways: a baseline scenario with limited economic diversification and an alternative scenario with increased diversification. The analysis centres on five primary channels framing climate-induced shocks affecting the economy: changes in hydropower generation due to variations in river runoff; alterations in rainfed and irrigated crop yields affecting crop revenue; damages from inland flooding; impacts on capital stock from road damage and increased maintenance; and bridge damage and maintenance issues due to recurring peak precipitation events, leading to fluvial flooding.

Under a baseline macroeconomic scenario with limited diversification and minimal adaptive investments, **dry/hot climate conditions are projected to reduce GDP by 3% by 2050**.[50]

An analysis by UNESCAP finds that **Average Annual Loss (AAL) in Bhutan in the current baseline scenario amounts to 6.9% of GDP, representing USD 169.3 million.**[51] This number increases to 7% (USD 171.9 million) in a 1.5-degree scenario and 7.1% (USD 173.8 million) in a 2-degree scenario. Bhutan AAL as a

[50] World Bank, 2025. Bhutan Country Climate and Development Report: Paving the Way for Resilient and Diversified Economic Growth. Washington, DC: The World Bank Group.
[51] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), n.d. *Bhutan Country Profile, Risk & Resilience Portal* [online].

percent of GDP is the highest in ESCAP's South and South-West Asia subregion.[52]

The macro-level assessments presented above chiefly centre on the economic dimension of climate-induced loss and damage. These need to be complemented by additional data to capture the full scale of climate impacts on Bhutan's society and environment. Climate-induced loss and damage is a cross-sectoral issue that affects multidimensional phenomena that are inherently value-based.

4.2 L&D Signature 1: Food and water insecurity due to changes in temperatures, erratic precipitation, windstorms, droughts, and land degradation

While Bhutan is endowed with an abundance of water resources, climate change will likely exacerbate water insecurity in many regions of the country. Decreasing snow cover and melting of glaciers from rising temperatures can cause water reduction in the long term as water storage capacity is reduced[53,54]. Climate change will also change precipitation and flow patterns, with significant downstream consequences[55]. Climate change is also expected to impact the ecosystem services of forests that protect watersheds, providing clean drinking water.

Climate change is expected to heavily impact agriculture, with potentially significant consequences for food security. Only around 3% of land is cultivated agriculture land, while another 4% is used for meadows and pastureland.[56] Farmland is concentrated in the main drainage basins, 30% of which is on

[52] UNDP Presentation at the *Capacity Development Training Workshop on Building Disaster and Climate Resilience in Bhutan in Critical Sectors*, 21–25 July 2025, Punakha, Bhutan

[53] Royal University of Bhutan, 2020. National Environment Commission Secretariat, and United Nations Development Programme. A Roadmap and Strategy for Strengthening Climate Change Research in Bhutan 2021–2025. Thimphu: Royal University of Bhutan and UNDP.

[54] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.

[55] World Bank, 2024. Institutional Strengthening and Modernization of Hydromet and Multi-hazard Early Warning Services in Bhutan: A Road Map for 2024–2034. Prepared in collaboration with the National Center for Hydrology and Meteorology, Royal Government of Bhutan. Washington, DC: The World Bank.

[56] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

sloping fields[57], making them vulnerable to flash floods and landslides[58]. One consequence is the reduction of available farmland, in addition to lost crops and livestock.

Another prominent climate change effect that is likely to exacerbate crop losses and food security concerns is changing precipitation patterns, given that farming in Bhutan is mainly rainfed. Only 18% of arable wetland fields are irrigated, mainly by inefficient open canal gravity-fed systems, while 61% of dryland fields have no - adequate irrigation facilities. Measures of temperature changes in Bhutan from 1996 to 2017 indicate a slight rise in temperatures[59]. Projections indicate a further increase of 0.80-1.60 degrees Celsius from 2021 to 2050 and up to 2.80 degrees Celsius by 2100 under a low-to-moderate global emissions scenario. Meanwhile, rainfall is projected to increase by 3% to 10% until 2060 across the country, with a greater increase during the monsoon season. Some parts of the country are likely to experience a decrease in rainfall during the winter season[60], while others are expected to experience more irregular and often excessive rainfall[61]. Drier weather reduces the availability of water for irrigation and increases the risks of soil erosion and nutrient loss, leading to yield reductions.

A temperature rise will also influence vegetation growth and phenology, leading to increased weed pressure for some crops and altering cropping patterns. Incidents of pests and diseases are likely to grow and shift in location prevalence due to changes in insect ranges and water sources[62]. The resulting losses and damages to **agricultural production** will have negative implications for the 41.7% of the employed population engaged in agriculture and livestock sectors, as well

[57] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.
National Center for Hydrology and Meteorology, 2018. *Climate Change in Bhutan*. [online]
[58] United Nations Development Programme, n.d. Bhutan Climate Change Adaptation Profile. UNDP Asia-Pacific Regional Hub.
[59] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.
[60] World Bank, 2024. Institutional Strengthening and Modernization of Hydromet and Multi-hazard Early Warning Services in Bhutan: A Road Map for 2024–2034. Washington, DC: World Bank.
[61] National Center for Hydrology and Meteorology, 2024. Climate Projection Report of Bhutan: Insights from CMIP6 Projections. Thimphu: Royal Government of Bhutan.
[62] International Center for Tropical Agriculture (CIAT) and World Bank, 2017. Climate-Smart Agriculture in Bhutan. CSA Country Profiles for Asia Series. Washington, DC: International Center for Tropical Agriculture and World Bank.

as their economic contributions, which accounted for 11.84% of GDP in 2024[63]. Such impacts are already creating challenges for farmers[64]. A 2019 study indicated that extreme weather events, including droughts, windstorms, and rainfall fluctuations, resulted in crop losses of 1-19%[65]. Additionally, livestock rearing will be affected as fodder production is reduced, and pastureland is degraded. Beyond the losses of crop yields and produce quality due to extreme weather events, as well as the loss of livestock, climate change may lead to the loss of valued traditional crop varieties[66]. These effects will vary geographically, as their severity will depend on the location. For instance, Samtse, Dagana, Punakha, and Sarpang, where approximately 51% of total rice production occurs, are expected to experience high to very high increases in precipitation[67].

Reduced access to food and water not only impacts household income and food & nutrition security but also significantly affects **physical and mental health**, including nutrition levels, particularly among vulnerable groups such as children, women, and the elderly.[68] In the most severe cases, water and food & nutrition insecurity can contribute to loss of life, especially where coping capacities are weakest. While systematic studies on the health impacts due to climate change remain limited in Bhutan, emerging evidence and local observations pointing to growing risks. Often noted anecdotally, climate change impacts frequently drive rural-urban migration as a form of distress mobility, arising from reduced access to farm lands and water caused by changing environmental conditions resulting from climate change.

[63] National Statistics Bureau (NSB), 2025. Statistical Yearbook of Bhutan 2025. Thimphu: National Statistics Bureau, Royal Government of Bhutan.
[64] Chhogyel, N., & Kumar, L, (2018). Climate change and potential impacts on agriculture in Bhutan: A discussion of pertinent issues. Agriculture & Food Security, 7(1), 79.
[65] Chhogyel, N., Kumar, L., & Bajgai, Y, (2020). Consequences of Climate Change Impacts and Incidences of Extreme Weather Events in Relation to Crop Production in Bhutan. *Sustainability*, *12*(10), 4319.
[66] United Nations Development Programme, n.d. Bhutan Climate Change Adaptation Profile. UNDP Asia-Pacific Regional Hub.
[67] National Center for Hydrology and Meteorology, 2024. Climate Projection Report of Bhutan: Insights from CMIP6 Projections. Thimphu: Royal Government of Bhutan.
[68] National Commission for Women and Children Royal Government of Bhutan, 2020. Gender and Climate Change in Bhutan with a Focus on Nationally Determined Contribution Priority Areas: Agriculture, Energy, and Waste.

The most prevalent types of loss and damage associated with food and water insecurity are **agricultural production, health, life, and human mobility (**Figure 9 and Table 3). Potential indicators related to this signature are listed in Table 4.

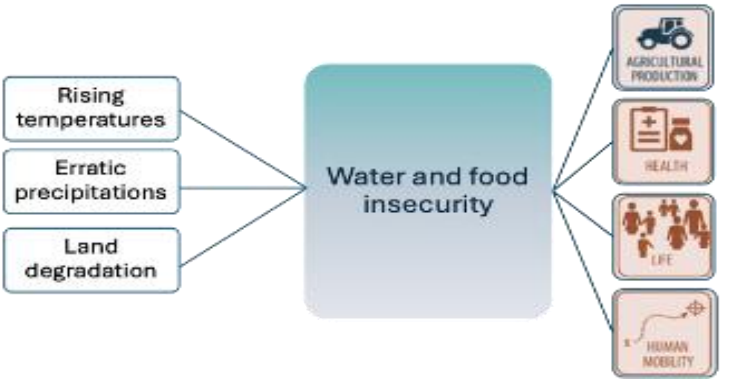


Figure 9. Diagram representing L&D signature 1.

Table 3. Reported observed and projected loss and damage for L&D signature 1.

Category	Reported observed and projected loss and damage
Agricultural production	■ Based on reported data, between 2016 and 2024, Bhutan experienced an average annual crop loss of USD 568,035, with peak losses exceeding USD 1.1 million in 2021. On average, 1,643 acres of farmland are affected each year, threatening food production and rural incomes. These figures reflect damage to staple crops such as potatoes, paddy, maize, and vegetables—core to both subsistence and market farming. ■ The recent extreme rainfall, floods, and landslides events across Bhutan on 4-5th October, 2025, caused widespread damages to crops and livestock. As per the latest preliminary assessment on October 10, 2025, an estimated 300 livestock had been lost. About 370 acres of agricultural land were damaged, affecting 517 households, resulting in an estimated production loss of 300 metric tons and a total

	damage valued at approximately Nu.12 million (equivalent to USD 150,000). Assessments are still ongoing. ■ In 2024, Tsirang District alone reported USD 442,228 in losses to fruits, spices, and flowers, underscoring the localized intensity of climate shocks. ■ Between 17th and 20th October 2021, severe and continuous rainfall damaged 2,500 acres of farmland, harvested paddies and ripe standing paddy crops across 18 districts, especially in the western, eastern, and central dzongkhags. This was equivalent to 2,400 metric tons of crops. [69] In Punakha district, 3382.29 acres and 664 households were affected with the estimated cost of lost harvested paddy reaching USD 198,941 as per documents provided by key informants. ■ In April 2022, a windstorm and heavy rain damaged approximately 127 acres of maize fields in Dagana dzongkhag. ■ In 2010, nearly 4,800 households were affected as flash floods and landslides damaged 809 hectares of farmland and 16 hectares of pastureland, also killing 1,000 livestock throughout the country[70]. ■ The 1994 GLOF event from Luggye Tsho damaged 797 hectares of land. ■ Observational evidence of increased occurrences of pests and diseases outbreak affecting livestock with correlation to sustained high temperatures reported by key informant interviewees. ■ It is important to note that the cumulative effects of small-scale events such as monsoon breaks and early or delayed

[69] World Bank, 2024. Institutional Strengthening and Modernization of Hydromet and Multi-hazard Early Warning Services in Bhutan: A Road Map for 2024–2034. Washington, DC: World Bank.
[70] ICIMOD, 2016. Flood Early Warning Systems in Bhutan: A Gendered Perspective. ICIMOD Working Paper No. 2016/13. Kathmandu, Nepal: ICIMOD.

	onset of monsoon, are currently not systematically recorded but are significant.
Health	■ Drying springs combined with flooding contamination are reportedly increasing risks of waterborne diseases but evidence is not systematically recorded. ■ Recent research shows a quantifiable relationship between diarrhoea cases and temperature rise with an increase of 0.6% for every degree rise in maximum temperature 5% for every millimetre of rainfall.[71] ■ Evidence of climate change impacts on nutrition levels due to decreasing food security is not available. One study projects that there could be approximately 46 climate-related deaths per million due to lack of food availability by 2050 under RCP8.5.[72]
Life	■ Evidence of mortality cases linked to waterborne diseases outbreaks exacerbated by water insecurity and climate change is currently limited.
Human Mobility	■ Observational evidence on cases of people moving and shifting mobility patterns due to water sources drying up reported by government officials and extension officers during key informant interviews.

[71] Wangdi, K., Clements, A.C., 2017. Spatial and temporal patterns of diarrhoea in Bhutan 2003–2013. BMC Infect Dis 17, 507.

[72] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.
Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., . . . Scarborough, P, 2016. Global and regional health effects of future food production under climate change: a modelling study. The Lancet: 387: 1937–1946.

Table 4. Examples of indicators for L&D Signature 1.

Measurement indicators	Costing indicators
■ Number of people without adequate food or water	■ Household income expenditure on additional food ■ Cost of food provision (relief measures) and supply chain enhancement ■ Cost of improving access to water and infrastructure ■ Cost of emergency food and water aid
■ Area of agricultural land unusable	■ Market value of (equivalent) land in Nu/ ■ Cost of restoring the land
■ Weight/volume/proportion of agricultural yield loss	■ Market value of lost yield
■ Number of agricultural facilities (e.g. greenhouses) damaged	■ Cost of reparation
■ Area of pastureland unusable	■ Market value of fodder equivalent
■ Number of livestock deaths (e.g. drowned, injured)	■ Market value of livestock
■ Number of irrigation schemes disrupted; area of agricultural land serviced	■ Cost of reparation
■ Number of invasive species/ new pest/diseases detected	■ Cost of controlling or removing invasive/pest/disease
■ Kilograms of crop yield lost to pests and diseases	■ Market value of lost yield

■ Number of water supplies disrupted, and number of communities/ families serviced ■ Number of water sources drying	■ Cost of reparation; cost of alternative water access ■ Cost of reparation and management
■ Area for non-timber forest products degraded in hectares	■ Loss of monetary value

4.3 L&D Signature 2: Impacts on human health and wellbeing due to heatwaves, forest fires, landslides and floods

There is sparse information available on climate-induced losses and damages related to **health and wellbeing.** The most documented ones are loss of life from flash floods, storms, and GLOF events. Less identifiable impacts, often commented on as a potential consequence of climate change but lacking documented cases, include the increasing geographic range of vector-borne tropical diseases, such as malaria and dengue, and the spread of waterborne diseases due to decreases in access to safe drinking water[73]. The psychological distress of constantly worrying about GLOF events, given that there are seventeen potentially dangerous glacial lakes, constitutes a significant burden directly attributable to the atmospheric concentration of CO2 affecting glacial melting rates[74].

Temperature data reported by the NCHM[75] suggest that, while average temperatures have been relatively stable over the past few years, registered minimum and maximum temperatures have shifted markedly across the country in recent years. This, and future projections of temperature rise, have significant consequences for people's health and well-being due to heat and cold stress in areas that are not prepared for them. Extreme weather events such as

[73] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.
[74] National Center for Hydrology and Meteorology (Bhutan), 2023. State of Climate, 2023. Thimphu: Royal Government of Bhutan.
[75] National Statistical Bureau (NBS), 2025. Statistical Yearbook of Bhutan 2025. Thimphu: National Statistical Bureau, Royal Government of Bhutan.

heatwaves, floods, and forest fires place direct strain on public health, with rising risks of respiratory and cardiovascular illnesses, injuries, and psychological stress, alongside indirect effects on nutrition and disease patterns. These events also result in **loss of life**, disproportionately impacting those with limited adaptive capacity, such as rural populations with constrained access to healthcare.

Beyond losses and damages associated with health, climate shocks also disrupt **education** by displacing families, damaging infrastructure, or forcing temporary school closures, thereby affecting children's learning and long-term opportunities. The cumulative toll of these impacts undermines individual and community wellbeing.

The most prevalent categories of loss and damage associated with impacts on health and wellbeing are **health, life, and education (**Figure 10 and Table 5). Potential indicators related to this signature are listed in Table 6.

Figure 10. Diagram representing L&D signature 2.

Table 5. Reported observed and projected loss and damage for L&D signature 2.

Category	Reported observed and projected loss and damage
Health	■ Water contamination during heavy rains and floods is exacerbated by a rising trend in occurrences of extreme weather events. ■ Increasing geographic range of vector-borne tropical diseases, such as malaria and dengue.

	■ Recurrent forest fires exacerbated by climate change are leading to a degradation in air quality levels at some periods of the year, increasing respiratory and cardiovascular risks to sensitive groups. ■ There is evidence that floods, in particular risk of GLOFs, are impacting the mental health of populations living in zones identified as high-risk.
Life	■ At least 177 people were reported dead or missing from heavy rainfall, landslides and flood events between 1968 and 2023 according to data provided by key informants (See Annex A.5). ■ The recent extreme rainfall, floods, and landslides events across Bhutan on 4-5th October 2025, caused the death of one person and disappearance of one person in Haa district. One person was also washed away in Wangduephodrang district. Assessments are ongoing. ■ Flash floods in 2023 washed away twenty-three people, several of whose bodies were never recovered, adding to psychological distress of affected families[76]. ■ The 1994 GLOF event caused twenty-one deaths, flash floods in the eastern part of the country in 2004 led to the loss of nine lives, and Cyclone Aila killed twelve people in 2009[77].
Education	■ Disruptions to schooling due to infrastructure damage are often reported. For example, in 2024 a flash flood event led to the water transmission pipe of a primary school being washed away in Gangtey.

[76] World Bank, 2024. Institutional Strengthening and Modernization of Hydromet and Multi-hazard Early Warning Services in Bhutan: A Road Map for 2024–2034. Washington, DC: World Bank.
[77] ICIMOD, 2016. Flood Early Warning Systems in Bhutan: A Gendered Perspective. ICIMOD Working Paper No. 2016/13. Kathmandu, Nepal: ICIMOD.

	■ The Dechencholing flood in Thimphu affected 64 students. ■ In 2015, access to Nahi primary school in Wangdue district was cut off due to flash floods. ■ Heavy rain events in 2017 in Lhuentse, damaged a suspension bridge, affecting 50 households and students of Thimyul Lower Secondary School.

Table 6. Examples of indicators for L&D Signature 2.

Measurement indicators	Costing indicators
■ Number of human deaths	■ Direct economic cost of death (health care costs until death, funeral/burial expenses, lost productivity/income)
■ Air quality index	■ Increased national healthcare costs
■ Number of hospital visits, during/ after event	■ Increased national healthcare costs
■ Number of people who report mental distress	■ Incomes lost due to inability to work ■ Costs of psychological support measures
■ Number of days lost in time and productivity	■ Incomes lost due to inability to work
■ Number of houses abandoned and/or number of people displaced	■ Cost of relocation
■ Degradation of urban green spaces due to heat stress	■ Cost of restoration

■ Occurrence of irregular disease outbreak	■ Cost of control measures/actions
■ Number of water sources contaminated; number of people affected	■ Cost of reparation; cost of alternative water source
■ Number of days of school closures due to climate-related events	■ Costs for provision of alternatives for schooling in case of prolonged disruption ■ Energy costs for cooling or heating

4.4 L&D Signature 3: Infrastructure and property damage due to floods, GLOFs, and landslides

Infrastructure and property damage is often incurred due to GLOFs, flash floods and landslides because human settlements and major industrial activities, not least hydropower dams, concentrate along the main drainage basins[78]. Physical property damages caused by extreme weather events are often included and sometimes estimated in assessments of extreme weather events. Several events have been reported, with highly variable estimates of the damages incurred. These events impact human settlements in rural, suburban, and urban areas, as well as public buildings, bridges, communication systems, industrial estates, irrigation and other agricultural facilities, and hydropower systems (including generation plants, transmission and distribution infrastructure), which together disrupt **business operations** more broadly. An analysis estimates that currently 7,700 people are affected by flooding, representing a cost of USD 33 million.[79]

[78] Yangzom, Karma, and Choden, Phuntsho, 2021. Climate Change and Water Resources in Bhutan. Journal of the Bhutan Ecological Society, Issue 4, pp. 26-38. Bhutan Ecological Society, Thimphu, Bhutan.
[79] World Bank Group and Asian Development Bank. 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

Landslides create substantial issues for road connectivity and limit critical accessibility to more remote parts of the country for trade, commerce, and general **mobility**[80], but related costs are not systematically documented. Impacts of climate change on mobility have implications for **tourism** but these also remain largely undocumented. Owing to its wide topographical range and mountainous landscape, a related emerging issue in Bhutan is Landslide Dam Outburst Floods (LDOFs), whereby narrow rivers in gorges become blocked by debris from landslides that create artificial dams that accumulate and burst, creating risks to downstream settlements and infrastructure[81].

The most prevalent categories of loss and damage associated with infrastructure and property damage are **Infrastructure, Business operations, Property, Mobility, and Tourism (**Figure 11 and Table 7). Potential indicators related to this signature are listed in Table 8.

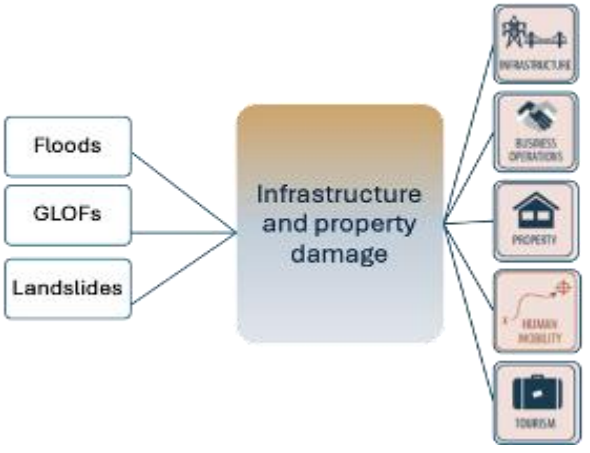


Figure 11. Diagram representing L&D signature 3.

[80] National Center for Hydrology and Meteorology, n.d. Climate Change and Impacts in Bhutan. Timphu: Royal Government of Bhutan.
[81] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.

Table 7. Reported observed and projected loss and damage for L&D signature 3.

Category	Reported observed and projected loss and damage
Infrastructure	■ Cost for monsoon restoration of existing roads across the country has increased by 112% from USD 1.8 m (Nu. 142.1m) in 2021-2022 to USD 3.5 m (Nu. 300.9 m) in 2024-2025. ■ The recent extreme rainfall, floods, and landslides events across Bhutan on 4-5th October 2025, affected a total of 29 bridges. Of these, 22 bridges were completely washed away, while seven sustained varying degrees of damage, severely disrupting connectivity and transport. ■ Flash floods in Gelephu, Phentsholing, and Lhuentse in 2023 damaged infrastructure and public property, including part of the Yungichhu Hydropower Plant[82]. ■ The 1994 GLOF event damaged 91 houses, and damages from the 2009 Cyclone Aila amounted to USD 17 million[83]. ■ Flash floods reportedly impacting infrastructure and property include those in Pasakha in Chhukha district in 2000, Ranjung in Trashigang district in 2004, which damaged the hydropower infrastructure, Phuntsholing and Pasakha in 2011, damages in Gasa in 2012 valued at USD 5 million, in the southern part of the country in 2016

[82] World Bank, 2024. Institutional Strengthening and Modernization of Hydromet and Multi-hazard Early Warning Services in Bhutan: A Road Map for 2024–2034. Washington, DC: World Bank.

[83] Royal University of Bhutan, National Environment Commission Secretariat, and United Nations Development Programme. 2020. A Roadmap and Strategy for Strengthening Climate Change Research in Bhutan 2021–2025. Thimphu: Royal University of Bhutan and UNDP.

	that damaged infrastructure, and a GLOF event from Memari Tsho in 2015 affecting local infrastructure[84,85]. ■ According to documents provided by key informants, in 2021-2025 and in Punakha district alone, fifteen flash floods and heavy rainfall events have caused damages reaching an estimated cost of USD 337,400. ■ Water provision infrastructures destructed on several instances including during flash flood events at Jakar Rongchhu, Lamai Goenpa, Bumthang, Dechencholing, Beta Rongchuu, Gangtey, and Wangdue Phodrang, in the year 2024 alone. ■ A recent study projects that 22,399 people, 2,613 buildings, 270 km of roads, 402 bridges, and 20 km^2 of farmland are exposed to potential GLOF inundation in Bhutan.[86]
Business operations	■ Road blocked due to extreme weather events lead to severe disruptions to businesses, local economy, and social services provision. For example, the only road linking the Gasa town to the rest of the country was damaged and led to it being cut off.
Tourism	■ Infrastructure and business disruptions related to floods and landslides affect tourism; however, no specific cost estimates are available.

[84] ICIMOD, 2016. Flood Early Warning Systems in Bhutan: A Gendered Perspective. ICIMOD Working Paper No. 2016/13. Kathmandu, Nepal: ICIMOD.
[85] National Center for Hydrology and Meteorology, 2019. Analysis of Historical Climate and Climate Projection for Bhutan. Thimphu: Royal Government of Bhutan.
[86] Rinzin, S., Dunning, S., Carr, R. J., Allen, S., Wangchuk, S., & Sattar, A., 2025. Redefining dangerous glacial lakes in Bhutan by integrating hydrodynamic flood mapping and downstream exposure data, EGUsphere [preprint online].

Property	■ The Dechencholing flood in Thimphu in 2024 led to 10 buildings being damaged including 4 under construction.[87] ■ Heavy rain in Gelephu district in 2019, led to reinforced concrete cement bridges near the domestic airport being washed away.
Mobility	■ Landslides and flash floods account for 240 of 305 roadblocks in 2024-2025, disrupting mobility and trade.

Table 8. Examples of indicators for L&D Signature 3.

Measurement indicators	Costing indicators
■ Length (kilometres) and quality (paved) of roads destroyed	■ Cost of reparation
■ Days of inaccessibility due to road closure	■ Cost of reparation; incomes lost
■ Number and length of bridges destroyed	■ Cost of reparation
■ Number of residences destroyed or damaged	■ Cost of reparation or market value
■ Number of vehicles destroyed or damaged	■ Cost of reparation or market value
■ Number of insurance claims	■ Monetary value of claims
■ Number of businesses disrupted	■ Income lost
■ Number of people displaced/ relocated	■ Cost of relocation

[87] National Center of Hydrology and Meteorology (NCHM) & Department of Geology and Mines (DGM), 2024. Site Assessment Report of Dechencholing Flash Flood Incident, 10 August 2024. Technical report submitted to the Ministry of Energy and Natural Resources, Royal Government of Bhutan.

4.5 L&D Signature 4: Impacts on terrestrial and freshwater ecosystems due to changes in temperatures, glacier melt, and forest fires

Bhutan's terrestrial and freshwater ecosystems are expected to experience substantial disruption as the impacts of climate change accelerate[88]. A recent study estimated the value of Bhutan's ecosystem services at USD 15.5 billion per year, 47% of which benefits people within the country via goods and services across national and local levels[89].

Bhutan's vast and well-conserved forests are key terrestrial ecosystems that are expected to undergo significant change. Forests cover 69.71% (2.68 million ha) of the national territory[90] and sequester approximately 11 million tons of CO_2 equivalent annually[91], equating to three times the country's total emissions. The forestry sector contributed 2.3% of GDP[92] and employs a small proportion of rural labour, including through small forest-based cottages and enterprises[93]. Beyond contributions to the national economy, forests provide vital socio-economic products for rural populations, including wood and non-wood forest products such as timber, medicinal herbs, and wild food. They also provide important recreational and cultural values.

While there has been significant attention to forests' role in Bhutan's climate change mitigation and adaptation strategies (for instance, in the NDCs and

[88] Hoy, A., Katel, O., Thapa, P., Dendup, N. and Matschullat, J., 2015. Climatic changes and their impact on socio-economic sectors in the Bhutan Himalayas: An implementation strategy, Regional Environmental Change, 16/5, pp. 1401–15,

[89] Kubiszewski, I., Costanza, R., Dorji, L., Thoennes, P. and Tshering, K., 2013. An initial estimate of
the value of ecosystem services in Bhutan, Ecosystem Services, 3 (2013), pp. E11–E21.

[90] Department of Forest and Park Services (DoFPS) Forest Monitoring and Information Division, 2023. National Forest Inventory State of Forest Report Volume I. Thimphu: Royal Government of Bhutan.

[91] Royal University of Bhutan, National Environment Commission Secretariat, and United Nations Development Programme, 2020. A Roadmap and Strategy for Strengthening Climate Change Research in Bhutan 2021–2025. Thimphu: Royal University of Bhutan and UNDP.

[92] National Statistics Bureau (NSB), 2025. Statistical Yearbook of Bhutan 2025. Thimphu: National Statistics Bureau, Royal Government of Bhutan.

[93] Asian Forest Cooperation Organization (AFoCO), n.d. Bhutan Country Profile.

national REDD+ programme[94]), less has been said about potential loss and damage incurred in Bhutan's ecosystems. Climate change could undermine the country's commitment to a carbon-neutral future as forest ecosystems change. For one, climate change is expected to impact tree stand growth and yields, as well as sequestration capacity, as tree species ranges shift from a warmer climate[95]. It will influence the spread and dynamics of invasive species, pests, diseases and parasites due to changes in phenology and the seasons[96]. Cloud forest ecosystems at critical elevations (around 1,700-1,900 masl in Dochula-Bajo series and 2,000 masl in Gedu-Darla series) are particularly vulnerable to temperature changes.

A primary climate change effect that is likely to produce substantial losses and damages to ecosystems is the increased risk and scale of naturally occurring and human-induced forest fire incidents. While most forest fires are caused by human activity, these are exacerbated by rising temperatures and prolonged dry spells.[97] Nationally collected data indicate that the destruction and scale of forest fires are substantial. Between 2023 and 2025, forest fires affected an area of 27,170 hectares, mainly chir pine forests. Trashigang, Thimphu, and Mongar are the districts most affected (See Annex A.6). Future projections indicate heightened fire risks during October to January dry seasons. The impacts of forest fires are expected to become more severe and unevenly spread in the future[98], especially in the eastern and central regions where pine and oak forests

[94] Department of Forests and Park Services (DoFPS), Ministry of Agriculture and Forests, Royal Government of Bhutan, 2020. National REDD+ Strategy & Action Plan of Bhutan. Thimphu, Bhutan: DoFPS, MoAF, Royal Government of Bhutan.

[95] Royal University of Bhutan, National Environment Commission Secretariat, and United Nations Development Programme, 2020. A Roadmap and Strategy for Strengthening Climate Change Research in Bhutan 2021–2025. Thimphu: Royal University of Bhutan and UNDP.

[96] World Bank, 2019. Bhutan Forest Note: Pathways for Sustainable Forest Management and Socio-Equitable Economic Development. Washington, DC: World Bank. ISBN 978-1-4648-1390-4.

[97] Rai M, 15 April 2023. *Human carelessness is the leading cause of forest fires in Bhutan*. The Bhutanese.

[98] Kim, J., Roh, M., Kinley, T., Lee, W.-K., & Wangyel, W. S., 2023. Prediction of forest fire risk according to climate change in Bhutan using a shared socioeconomic pathways (SSP) scenario and random forest. Journal of Climate Change Research, *14*(4), 385–393.

dominate. One study using simulation modelling found a doubling of fire hazards in Thimphu and Jakar owing to climate change.[99].

Bhutan's forests are home to many endangered mammal, bird and plant species that are expected to be affected by climate change, leading to loss of biodiversity values. Other endemic and medicinal plant species in alpine areas will experience increasing pressure. Key timber and non-timber forest resources are expected to decline and shift to higher elevations as temperatures and precipitation levels increase[100]. Such is the case for high-value export products such as cordyceps, for which export value reaches an estimated USD 1 million annually.[101] Climate change raises concern for the 105 endemic plant species and various globally threatened species found in Bhutan, including 27 mammals, 17 birds, one reptile, one amphibian, one invertebrate and seven plants[102]. Wetland-dependent species, such as black-necked cranes and white-bellied herons, are under increasing threat due to climate change, as wetland ecosystems adapt to higher temperatures, changes in precipitation patterns and water flow regimes, and extreme weather events. Critical habitats for wintering and breeding in wetland ecosystems may become unsuitable in the future. In turn, species migration and habitat shifts are leading to increased risks and occurrences of human-wildlife conflicts.

As climate change accelerates, forests and other ecosystems are expected to deteriorate. The potential impacts of climate change include forest fire incidents, a reduction in fodder availability, drying of water in streams and lakes, a reduction in timber and wood availability, a decline in biodiversity, and a reduction NTFPs availability. These losses and damage for Bhutan and its people, both in economic terms such as forestry sector production and jobs as well as losses of endemic species, biodiversity, ecosystem services, and tourism will require careful consideration.

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[99] Vilà-Vilardell, L., Keeton, W. S., Thom, D., Gyeltshen, C., Tshering, K., & Gratzer, G, 2020. Climate change effects on wildfire hazards in the wildland-urban-interface – Blue pine forests of Bhutan. Forest Ecology and Management, *461*, 117927.

[100] Choden, K., Nitschke, C. R., Stewart, S. B., & Keenan, R. J, 2021. The potential impacts of climate change on the distribution of key tree species and Cordyceps in Bhutan: Implications for ecological functions and rural livelihoods. Ecological Modelling, *455*, 109650.

[101] YK Poudel, 23 April 2025. *Thailand leads Bhutan's agro-export markets beyond India and Bangladesh*. Asia News Network (Thimphu).

[102] Dema, S., 2011. National action plan on biodiversity persistence and climate change: Bhutan.

The most prevalent categories of loss and damage associated with impacts on terrestrial and freshwater ecosystems are **Biodiversity, Ecosystem services, and Tourism (**Figure 12 and Table 9). Potential indicators related to this signature are listed in Table 10.

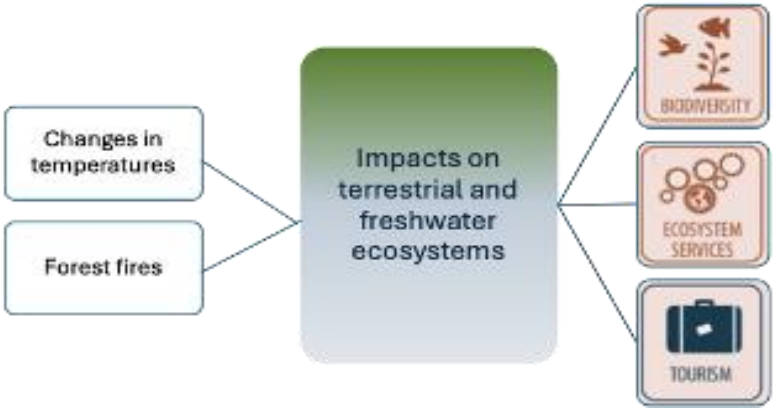

Figure 12. Diagram representing L&D signature 4.

Table 9. Reported observed and projected loss and damage for L&D signature 4.

Category	Reported observed and projected loss and damage
Biodiversity	■ Climate change is causing the upward advancement of alpine treelines through the encroachment of woody vegetation into alpine meadows, threatening both biodiversity and traditional livelihoods. For example, the snow leopard is increasingly under threat due to climate change's effects on vegetation and treeline shifts in alpine meadows on which the species relies[103]. ■ Decrease of native tree species combined with proliferation of weedy species are reported but their associated economic and non-economic implications are not documented.

[103] Department of Forests and Park Services, 2024. Snow Leopard Conservation Action Plan for Bhutan (2024-2033). Royal Government of Bhutan, Thimphu.

	■ Survey data from 2010 shows concerning population trends, with increases in some species (rabbit, wild boar, sambar, macaque) but declines in others (elephant, wild dog, tiger, hornbill, common crow, vulture).[104] ■ Global freshwater ecosystem indices show 85% decline in freshwater populations between 1970-2020, with migratory freshwater fish experiencing 81% population decline.[105] ■ A recent WWF-Bhutan perception survey showed that: 40% of respondents in Jigme Dorji National Park reported climate impacts on wildlife populations; 29% observed species range shifts and new wildlife near communities; 39% reported increased plant mortality and 16% noted changes in plant life cycles; 45% in Jomotsangkha Wildlife Sanctuary reported wildlife range shifts due to climate change.[68] ■ Observational data points to a rising trend in human wildlife conflicts further exacerbating the risks of biodiversity loss.
Ecosystem services	■ Between 2023 and 2025 alone, 274 forest fires incidents were recorded affecting an area of 27,170 hectares, mainly chir pine forests. Forest fire suppression engaged 21,605 staff members working over nearly 100,000 days, with costs rising substantially from USD 85,782 in 2023 to USD 585,300 so far in 2025. A preliminary economic valuation of timber loss by DoFPS found that an estimated USD 5.89 million loss in timber occurred only over the last peak fire season, covering five months between November 2024 and March 2025 (See Annex A.6). [106]

[104] National Biodiversity Centre, 2011. *National Action Plan Biodiversity Persistence and Climate Change*.
[105] WWF, 10 October 2024. *Press Release: WWF's Living Planet Report 2024 reveals a system in peril*, WWF Mongolia (Thimphu).
[106] DoFPS, Draft of National Forest Fire Prevention and Response Strategy (2024) shared DoFPS.
Asia News Network, 10 September 2025, *Bhutan's forest fires cost over US 5.89 million in timber losses in five months*.

	■ About 25% of 7399 springs assessed are found to be declining in flow and 1% are found to have completely dried up.[107] ■ Observational evidence from extension officers reported during key informant interviews describes a shifting of cordyceps growing areas, which is a key non-timber forest product and economic resources for collecting communities. ■ Community observations from the 2010 national biodiversity survey revealed declining populations of high-altitude medicinal plants including *Picrorhiza kurroa, Gentiana urnula*, and *Fritillaria species*, for which climate change appears to be a contributing driver.[67] ■ Five major pine die-back incidents occurred in the Pachhu-Wangchhu valley between 1992-2008, strongly correlated with higher temperatures and reduced precipitation.[67] ■ Cases of pest outbreaks are rising, with a case of bark beetle outbreak in spruce forests, increased mistletoe infestation incidence and moisture-stress related issues in blue pine forests. [67] ■ Other forms of losses to non-instrumental value of ecosystems, such as intrinsic and relational, are currently not assessed but expected to be significant.
Tourism	■ Bhutan's natural environment and biodiversity is a cornerstone of its tourism attractivity. While no estimates are available, over the long term it is expected that loss of biodiversity and glacial retreat will affect tourism revenue. However, these have not yet been quantified.

[107] Tshewang Dendup, Dendup Tshering, Sonam Tobgay, Fengjing Liu, 2024. Sources and pathways of spring flow and climate change effects in the Dungju Ri & Yude Ri catchments, Bhutan Himalaya. *Heliyon,* Volume 10, Issue 16, e36211.

Table 10. Examples of indicators for L&D Signature 4.

Measurement indicators	Costing indicators
■ Loss of quantity or quality of ecosystem services	■ Estimated loss of economic value of ecosystem services
■ Area of forest burnt	■ Estimated loss of timber value ■ Cost of restoration of burnt areas
■ Number of species endangered	■ Cost of enhancing conservation actions for endangered species
■ Area of habitat loss	■ Cost of rehabilitation/restoration
■ Number and capacities of tourism infrastructure (trekking trails, campsite facilities, parks) damaged	■ Cost of reparation ■ Lost incomes
■ Change in soil fertility/quality	■ Cost of soil remediation ■ Lost income from reduced yields
■ Invasive species/ new pest /disease detected	■ Cost of controlling or removing invasive/pest/disease
■ Proportion of native species population decline in forest fire-affected areas	■ Cost of restoration/ replanting native species in degraded forest lands

4.6 L&D Signature 5: Energy insecurity due to glacier melt, changes in precipitation, and GLOFs.

Hydropower is the dominant supplier of domestic electrical energy, accounting for nearly 100% of energy consumption, as well as the primary source of revenues for the government and a key driver of economic growth.[108] Between 2011 and 2020, for instance, electricity exports to India constituted an average of 10% of GDP, 33% of government revenue, and 35% of export value[109]. Additionally, 5,468 out of 11,673 megaunits of electricity generated in 2024 were exported, and hydropower enables Bhutan to offset approximately 4.4 million tons of CO_2 equivalent by exporting clean energy[110].

Multiple factors associated with climate change are expected to undermine hydropower production and, in turn, national energy security. Glacial melting and changes in rainfall patterns and precipitation will create temporal and spatial variations in water flows that are suboptimal for hydropower production. The increase in risks associated with floods, landslides and GLOFs due to climate change could severely disrupt critical infrastructure necessary for hydropower generation. Climate change impacts on hydropower production will translate into a range of economic and non-economic losses and damages. A World Bank report from 2021 predicted potential human health and livelihood damages to be 4% by the 2030s[111]. Changes in energy access could have detrimental knock-on effects on diverse health, economic productivity, and educational dimensions as people are left without energy or revert to biomass or fossil-fuel-based energy sources.

The most prevalent categories of loss and damage associated with infrastructure and property damage are **Business operations and Infrastructure** (Figure 13 and Table 11). Potential indicators related to this signature are listed in Table 12.

[108] Royal Government of Bhutan, National Environment Commission, 2024. Annex 1: Country Partnership Strategy Bhutan 2024-2028. Thimphu: National Environment Commission, Royal Government of Bhutan

[109] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

[110] Asian Forest Cooperation Organization (AFoCO), n.d. Bhutan Country Profile.

[111] World Bank Group and Asian Development Bank, 2021. Climate Risk Country Profile: Bhutan. Washington, DC: World Bank Group and Asian Development Bank.

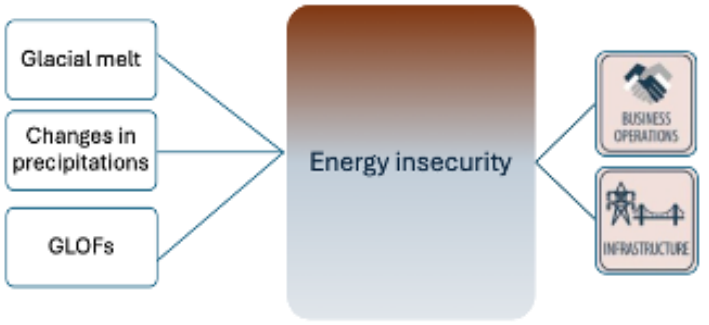

Figure 13. Diagram representing L&D signature 5.

Table 11. Reported observed and projected loss and damage for L&D signature 5.

Category	Reported observed and projected loss and damage
Business operations	■ Under climate change scenarios, Bhutan's hydroelectric capacity is projected to decrease by 3% between 2020-2059 before recovering post-2060 under Above 4°C scenarios.[112] ■ The International Energy Agency projects that the average hydropower capacity factor across the Himalayan sub-region is expected to decline by about 1.8–2.2 percent during the period 2020–2059, before stabilizing close to baseline levels between 2060 and 2099. In Bhutan, the most pronounced reduction is projected at around 3% during 2020–2059 under a scenario of warming above 4°C[113]. ■ Hydropower generation drops to below 20%[114] of installed capacity during winter months, forcing Bhutan to import electricity despite being a major exporter during summer.

[112] Samjhana, R. S., & Manan, S, 2025. Projected hydropower capacity under changing climate conditions and its implications in South and Southeast Asia. *American Journal of Climate Change*, *14*(2), 230-247.
[113]International Energy Agency, 2021. Climate Impacts on South and Southeast Asian Hydropower. Paris: IEA.
[114] Asian Development Bank. (2021). Renewable Energy for Climate Resilience Project: Sector assessment (summary): Energy (Project No. 54142-001).

	Bhutan pays Nu 4-4.5 per unit for winter imports while exporting summer electricity at Nu 3 per unit (Bhutan Trade Statistics, 2024). Therefore, decreasing power generation due to climatic changes in winter months would exacerbate the economic losses associated with this unfavourable trade dynamic. ■ In 2018, the Druk Green Power Corporation (DGPC) recorded the lowest electricity generation due to adverse hydrological conditions.[115] Hydropower debt accounts for 66.3% of Bhutan's external debt and 61.6% of GDP, a number that risk being worsened by changes in climatic conditions influencing hydropower production.[116] ■ The recent extreme rainfall, floods, and landslides events across Bhutan on 4-5th October 2025, temporarily disrupted operations.
Infrastructure	■ In 2023, a climate-related flash flood washed away sections of the 32-megawatt Yungichhu Hydro Power Project, killing 23 people and causing extensive infrastructure damage.[117] The DGPC spent around Nu 36 M (approx. USD 450,000) for flood mitigation work in the area post disaster.[118] ■ In 2020, flash flood event in Wangdue Phrodrang disrupted power lines causing absence of electricity in a village for two days.[119]

[115] Bhutan Ecological Society, *Renewable Energy*, Bhutan Ecological Society (Thimphu), 2025 [online].
[116] Department of Macro-Fiscal and Development Finance (DMDF), 2023. Public Debt Situation Report For the quarter ended 31st December 2023. Thimphu: Royal Government of Bhutan.
[117] SANDRP, 23 July 2023. *Bhutan Hydro Project Disaster – 23 Dead and Missing* [online].
[118] Bhutan Broadcasting Service, 13 August 2024. *Flood mitigation work along Newanchu stream in Oong-gar, Lhuentse*, BBS, [online].
[119] National Center for Hydrology and Meteorology (NCHM), 2022. Compendium of Climate and Hydrological Extremes in Bhutan (2017-2021). Thimphu: Royal Government of Bhutan.

	■ In 2020, flash flood events in Trongsa led to Mangdechhu Hydro Power Plant being shut down. ■ Powerlines, mini-hydropower houses have been damaged by heavy rains and flash floods on several instances including in 2012 (Gasa), 2017 (Lhuentse), and 2021 (Trongsa). ■ Insurance coverage limits the extent to which hydropower infrastructures assets can be insured under various climate scenarios and projections. The potential losses for uninsured assets are yet to be comprehensively estimated.

Table 12. Examples of indicators for L&D signature 5.

Measurement indicators	Costing indicators
■ Number of hydropower plant infrastructure affected	■ Cost of reparation and rehabilitation
■ Number of hydropower plants disrupted, and Kilowatts lost	■ Revenue loss; GDP loss
■ Number of households and days without electricity	■ Cost of alternative power source
■ Number of businesses affected by power disruption (manufacturing, production industries)	■ Revenue loss

4.7 L&D Signature 6: Impacts on cultural heritage due to glacier melt, floods, and forest fires

Bhutan's rich cultural heritage, embodied in its historic dzongs, monasteries, temples, and chortens, faces mounting risks from climate change. Many of these monuments are located along river valleys or on exposed ridges, leaving them

particularly vulnerable to floods, landslides, and forest fires. Recent decades have demonstrated the scale of this threat: major fires have destroyed or severely damaged iconic sites, including the 7th-century Paro Taktsang Monastery and the 16th-century Wangdue Phodrang Dzong. GLOFs events pose a significant risk. The Punakha Dzong, one of Bhutan's most significant religious and administrative centers, has been affected by flooding events in the 20th century, and remains at high risk from future GLOFs driven by accelerated glacier melt. Such events not only compromise the structural integrity of sacred sites but also endanger irreplaceable murals, manuscripts, and artifacts housed within them.

Climate change also has profound implications for Bhutan's intangible cultural heritage. Shifting climatic conditions are disrupting traditional agricultural calendars, seasonal rituals, and spiritual practices that are closely tied to local ecosystems. Indigenous knowledge systems, which have historically guided farming, resource use, and community resilience, are increasingly undermined by unpredictable rainfall, temperature anomalies, and glacial retreat. Studies have documented the erosion of traditional rituals associated with farming and land stewardship, raising concerns that the loss of both tangible and intangible cultural values could weaken cultural identity and community cohesion.

The most prevalent categories of loss and damage associated with impacts on cultural heritage are **Cultural heritage, Traditional knowledge, Societal and cultural identity** (Figure 14 and Table 13). Potential indicators related to this signature are listed in Table 14.

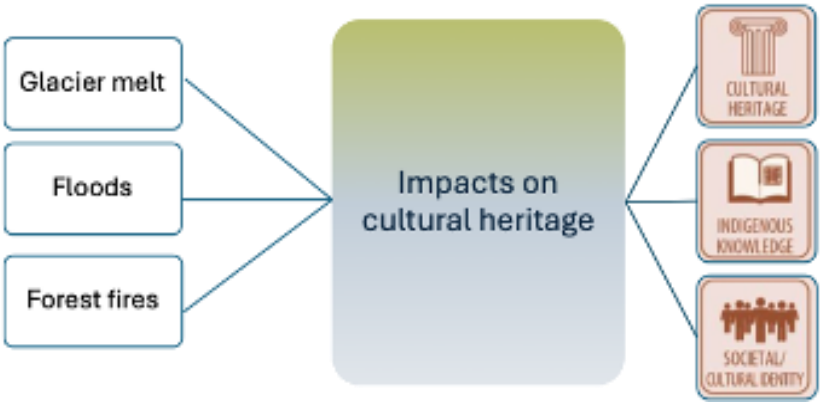

Figure 14. Diagram representing L&D signature 6.

Table 13. Reported observed and projected loss and damage for L&D signature 6.

Category	Reported observed and projected loss and damage
Cultural heritage	■ The 1994 GLOF event in Punakha valley led to the destruction of the eastern wall of a 500-year-old temple Dzongchhung Lhakhang, constructed by Dupthop Ngagi Rinchhen, and the disappearance of statues and religious objects of high cultural value[120]. ■ The recent extreme rainfall, floods, and landslides events across Bhutan on 4-5th October 2025, affected some cultural sites; assessments are still ongoing. ■ Increasing trend in forest fires exacerbated by changes in climate conditions puts cultural sites such as temples nested in the forest at risk[121]. ■ Mountain deities are believed to inhabit glaciated high peaks of the Himalayan mountains in Bhutan. Glacier melt associated with rising temperatures are threatening these sacred sites and related rituals[122].
Traditional knowledge	■ Glacier melt and decline have significant spiritual and cultural impacts on highland and mountain communities in Bhutan, threatening knowledge systems and ritual practices that are deeply intertwined with the proximate natural environment and that are currently assessed as at risk of disappearing.[123] These potentially profound losses have yet to be comprehensively documented.

[120] National Center for Hydrology and Meteorology (NCHM), n.d. Compendium of Climate and Hydrological Extremes in Bhutan since 1968 from Kuensel. Thimphu: Royal Government of Bhutan.
[121] IUCN, 27 June 2025. *Unprecedented fires fueled by climate change threaten iconic World Heritage forests*.
[122] Eden, p., 2025. Scientific Evidence and a Spiritual Plea from Bhutan's Glaciers: From Guardians to Vulnerable Icons, *Druk Journal*.
[123] Phanchung, Gyeltshen, N., Wangdi, T., & Yangzom, K., 2022. Resilience of Traditional Ritual Practices in Bhutanese Mountain Farming Systems Amid Climate Change and Anthropogenic Activities. *Mountain Research and Development*, 42(4), V11–V18.

Societal and cultural identity	■ Bhutanese societal and cultural identity is closely tied to the natural environment as illustrated in the biodiversity symbols of the country (e.g., national butterfly and bird). Negative impacts on ecosystems, biodiversity and especially loss of species indirectly threaten Bhutanese societal and cultural identity. ■ Similarly, as culture and heritage are enshrined as pillars of Bhutan's national identity, climate change impacts that threaten temples, oral traditions and folklore ultimately undermine the nation's social fabric and identity.

4.8

Table 14. Examples of indicators for L&D signature 6.

Measurement indicators	Costing indicators
■ Number of heritage sites/ monuments destroyed	■ Costs of reparation
■ Number of people lost access to heritage site/ monument	■ Cost of re-construction/restoration
■ Number of people unable to speak native/ local languages/ dialects	■ Cost of re-introduction of languages and training
■ Number of people unable to practise traditional knowledge and practice	■ Cost of support programmes for cultural preservation
■ Number of indigenous breeds or crop varieties lost	■ Cost of species breeding and re-introduction
■ Area in hectares where indigenous breeds or crop varieties are no longer tenable	■ Cost of restoration of traditional farming practices

■ No. of community conflicts increased due to climate-induced effects	■ Cost of mediation/resolution of increasing conflicts in communities

4.9 Quantifying the unquantifiable – Case studies of loss and damage in Bhutan

As part of this assessment, a joint field mission was conducted on 16th and 17th August 2024 by a team comprising the international consultant, national consultant, and representatives from UNDP and the Department of Environment and Climate Change (DECC). The team visited flood-affected areas in Dechencholing and Punakha to gather information on the impacts of recent climate-induced events. In Dechencholing, discussions were held with local extension officers and municipal representatives, while in Punakha, the team engaged with staff from the Early Warning System control room, who provided detailed presentations on flood impacts and system functionality. The first three case studies present the findings from these visits, illustrating the nature and complexity of loss and damage associated with climate-related hazards in Bhutan. A final case study presents a summary of initial findings of a rapid assessment of the series of extreme weather events on October 4-5, 2025, where rainfall, floods, and landslides occurred across the country.

Case study 1: Landslides and flash flood in Dechencholing – Cascading climate impacts and loss and damage in Bhutan's capital

The Dechencholing flood in Thimphu, on August 11, 2024, was caused primarily by a sudden, highly intense convective thunderstorm that triggered heavy rainfall, which in turn led to multiple landslides and flash flooding in the area (Figure 15). The Dechencholing Chhu and its tributary streams rapidly overflowed due to the combination of rain-fed catchments and landslide debris temporarily damming the main river channel, amplifying downstream flood impacts. Saturated soils and geological instability caused several landslides along the tributaries, which hurled boulders and logs into the main stream, creating temporary blockages (artificial dams).

The Dechencholing flood resulted in both economic and non-economic loss and damage, reflecting the multifaceted impacts of climate-induced disasters. Economic losses included the destruction of homes, shops, and public infrastructure such as

roads, drinking water pipelines, and electricity supply lines, alongside the submergence and loss of approximately 40 vehicles. Restoration efforts were carried out over the subsequent 12 days. The direct cost of flood relief and debris clearance alone amounted to Nu 10 million (approximately USD 117,647), excluding the unquantified costs of asset replacement, income disruption, and restoration of services.

Non-economic losses were equally significant. The flood led to the displacement of 84 families, the temporary closure of two schools, and the loss of one life[124], affecting community wellbeing, educational continuity, and social cohesion. The access road to a forest and temple was also blocked, preventing people from reaching the site. The psychological stress, disruption of daily life, and erosion of sense of security among affected residents further underscore the broader human dimensions of loss and damage, which are often not captured in financial cost assessments.

The severe impacts of the Dechencholing flood in Bhutan's capital, and the continued recovery challenges faced by affected communities more than a year later, highlight the significant strain such events place on national and local resources. Despite swift initial response efforts, many households continue to grapple with the long-term consequences of displacement, loss of livelihoods, and damaged infrastructure. This underscores the critical need for sustained financial and technical support to strengthen Bhutan's ability to respond to and recover from climate-induced loss and damage, particularly as such events are expected to increase in frequency and intensity.

Figure 15. Photo of flood site in Dechencholing, Thimphu, August 2024.

[124] National Center for Hydrology and Meteorology (NCHM) & Department of Geology and Mines (DGM), 2024. Site Assessment Report of Dechencholing Flash Flood Incident, 10 August 2024. Technical report submitted to the Ministry of Energy and Natural Resources, Royal Government of Bhutan, 14 August 2024.

Case study 2: Flash flood in Punakha district – The hidden costs of climate-induced loss and damage

The flash floods that struck Punakha between June and July 2025 were triggered by prolonged and intense monsoon rainfall, which caused riverbanks and unstable slopes along the Punakha-Gasa highway to collapse. Multiple sections of a highway, particularly between Damji and Tshachu Junction, were destroyed. The damages to the highway cut off Gasa from other regions for more than two weeks.

In the visited village in Punakha district, the farm road from Thinleygang to Renakha-Damchi Chewog was cut-off due to erosion of the riverbanks at Tendey-lum by a flash flood (Figure 16). Community members reported that while smaller floods had occurred in the past, they had not witnessed flooding of this magnitude in nearly four decades. The destruction of the bridge affected 42 households, cutting off access to essential services. During the disruption, individuals with chronic health conditions, such as diabetes and hypertension, were unable to access necessary medication, and students were transported by vehicle from the sub-district administration to ensure they could sit for their exams.

In many cases, when flood-related impacts are limited to moderate debris or sedimentation, the extension officer explained that community members mobilise to conduct clean-up activities themselves. This community-led response mechanism is commonly used for localized road maintenance, as many road sections are informally assigned to nearby villages or communities, who take responsibility for their upkeep. However, when the damage is more severe such as major blockages or infrastructure failure, local governments are requested to provide financial support. In such cases, budget constraints often delay the response, as there is no comprehensive funding framework or pre-allocated Gewog-level budget for emergency maintenance and reconstruction. Contributions from sub-district administrations are sometimes provided, but are typically insufficient, requiring communities to rely heavily on their own resources and labour. The bridge clearance alone took over three days with heavy machinery provided by local government, and it took two full weeks to restore basic connectivity. While some financial support was provided by the sub-district, the majority of the recovery work was carried out by local residents, underscoring gaps in institutional support for addressing loss and damage.

> *In the affected village, each household contributed two days of labour to help restore access, with approximately 50 households participating.* (Community representative)

The flash floods in Punakha exemplify the complex climate-induced losses and damages associated with extreme weather events that are expected to increase in frequency and intensity due to climate change as rainfall and precipitation patterns shift. Beyond economic damage to roads, irrigation channels, and other public infrastructure, the disruption to transportation also led to losses and damages such as loss of mobility, reduced access to food and health amenities, and education facilities. The estimated cost for reconstruction in

Punakha for the recorded climate-induced loss and damage in 2021 and 2025 is Nu. 46,332,767.58 (USD 545,091) (see Annex A.7). However, this does not account for the substantial direct and indirect losses and damages incurred, as the impacts on livelihoods, education, and health, remain largely unaccounted for.

The impacts of the Punakha floods revealed that the local communities actively participate in the recovery and rebuilding activities, contributing their own time, labour, and limited resources to restore access and rebuild essential infrastructure. This reliance on community-led responses underscores the urgent need for targeted support and financial mechanisms to ensure that the burden of climate-induced loss and damage does not fall disproportionately on Bhutan's most vulnerable communities.

Figure 16. Flood site at Tenndrel Lum, Toebesa in Punakha district, August 16, 2025.

Case study 3: Growing threat of Glacial Lake Outburst Floods – A case of severe projected loss and damage

Bhutan faces a growing and deeply concerning threat from Glacial Lake Outburst Floods (GLOFs) that are expected to cause substantial loss and damage in the country. Accelerated glacial melting driven by climate change increases the water volumes of glacial lakes, thus increasing the probability of GLOF events. There are currently seventeen lakes that are considered dangerous and require active monitoring and risk mitigation activities, including via excavation and drainage channels. Past GLOF events are frequently referenced, particularly the 1994 GLOF, which caused extensive damage to infrastructure and property, as well as loss of human life. These events represent single events with potentially devastating consequences that loom large in people's concerns about climate change.

The most prescient loss and damage issue is the impacts on hydropower dams in the country, given hydropower's critical role in the national economy. This is especially the case in the Punakha and Wangdue valleys, where the country's largest hydropower projects are located directly downstream of high-risk glacial lakes. The Punatsangchhu-II Hydroelectric Project, with a capacity to generate 1,020 megawatts of electricity, has begun generating electricity at full capacity and is in a highly vulnerable zone. Thorthormi glacial lake, situated within the Pho Chhu river basin upstream of the Punatsangchhu catchment, is considered one of Bhutan's most dangerous glacial lakes due to its rapidly expanding volume and unstable moraine dam formed by accumulations of debris.

A GLOF event could have devastating impacts on settlements, agriculture, infrastructure, and people's lives in downstream valleys and cause catastrophic damage to hydropower assets due to flooding, debris flows, and sedimentation impacting dams, intake structures, and turbines. This could lead to long operational downtimes, costly repairs, and disruptions in electricity generation, affecting both Bhutan's domestic power supply and export revenues. A GLOF would also endanger the Punakha Dzong (Pungthang Dewa chhenbi Phodrang) a historic monastery-fortress that houses both religious institutions and government offices, potentially resulting in irreversible harm to one of Bhutan's most treasured cultural heritage sites built in the 17th century. As demonstrated during the 1994 GLOF, the destruction of such heritage represents profound non-economic loss, with cultural and spiritual value that cannot be quantified.

> *Early Warning Systems in different river basins operate on different systems and are outdated. The systems need unification and updates. Six out of eighteen GLOF EWS sirens in the Phochhu and Mochhu basins are inactive. (Technicians at Wangdue NCHM department Control Room)*

While Bhutan has taken proactive steps to address this threat, such as the installation of an early warning system in the Punatsangchhu basin in 2011, several critical challenges were highlighted by NCHM staff during the visit (Figure 17). The system, which is primarily focused on flood detection, is outdated and requires upgrading and rehabilitation due to its

obsolescence resulting from a lack of spare parts and technological advancements. Gaps in real-time data collection, forecasting capacity, and the integration of GLOF risks into broader disaster management frameworks were highlighted as areas requiring urgent attention. Furthermore, the current system is not fully integrated with other early warning systems across the country, hindering effective coordination. To address these shortcomings, there is an urgent need for an updated, more robust early warning system that includes modern sensors and real-time data capabilities, as well as greater coordination across national and local levels.

Figure 17. Photo of visit of hydrometeorological station of Yebesa along Mochhu river in Punakha and Wangdue NCHM Early Warning System Control room, August 17, 2025.

Case Study 4: Rapid Assessment of Extreme Weather Events (rainfall in Bhutan, 4–5 October 2025

Between 4th and 5th October 2025, Bhutan experienced an unprecedented extreme weather event, characterised by heavy and intense rainfall that led to flash floods, landslides, river swells, as well as windstorms across several districts. The deluge caused widespread disruption – affecting critical infrastructure, crops, livestock, houses, cultural heritage sites, and hydropower operations – the death of one person, while two remain missing. The southern and western regions, particularly Samtse, Chukha, Haa, and Dagana were among the most severely affected. In response, government authorities undertook rapid assessments to evaluate the extent of loss and damage, initiate emergency response measures, and plan for long-term resilience (See Annex A.8).

Impact on Roads and Bridges

The Ministry of Works and the Department of Surface Transport reported extensive damage to road networks and bridges, particularly in the districts of Chhukha, Haa, Samtse, Bumthang, and Wangduephodrang. In total, 29 bridges were affected, comprising 17 Bailey bridges, six suspension bridges, three culvert bridges, and three wooden bridges. Of these, 22 bridges were completely washed away, while seven sustained varying degrees of damage, severely disrupting connectivity and transport. Notable bridges lost include:

- Denchukha Bailey Suspension Bridge on Denchukha Dzongkhag Road, Samtse
- Namchukhola Bailey Bridge on the Haa–Samtse Highway
- Jitti C Bailey Bridge on Samtse-Sipsoo Highway
- Tomichu Bailey Bridge on Ganglakha–Dungna Dzongkhag Road, Chukha
- Lubichu Bailey Bridge on Toktogom Farm Road under Bjachhog Gewog, Chukha
- Bjmichu Bailey Bridge on Baeyul Kinzang Farm Road under Darla Gewog, Chukha
- Shaychu Bailey Bridge on Sombaykha Dzongkhag Road, Haa

Assessment teams, comprising Ministry officials, Dzongkhag Administrations, local government representatives, and Members of Parliament from affected constituencies, have been deployed to evaluate additional bridge sites and overall road conditions. Beyond bridge destruction, heavy rainfall significantly deteriorated several road sections, further disrupting mobility and access to essential services.

Impact on Hydropower Infrastructure

The Ministry of Energy and Natural Resources initiated a rapid assessment of all major hydropower projects following the floods to ensure the safety of infrastructure, personnel, and surrounding communities. While no major structural damage to hydropower dams or powerhouses was reported, localized flooding and landslides affected access roads and temporarily disrupted operations at several sites. Key findings include:

- **Tala Hydropower Project:** River inflows surged dramatically, leading to dam overtopping. Two radial gates were partially opened, and the powerhouse operated at 1020 MW +10%. Staff were safely evacuated, and restoration efforts are ongoing.
- **Mangdechhu, Basohhu, Kurichhu Projects:** Currently operational with careful monitoring.
- **Nikachhu Project:** Minor road blockages reported; no structural damage.
- **Suchhu, Dagachhu, Punatsangchhu-II, Chhukha Projects:** Temporarily shut down as precautionary measures.
- **Punatsangchhu-I, Kholorchhu, and other under-construction projects:** No injuries or major damage reported; personnel accounted for, with high alert protocols in place.

Electricity and telephone services have been disrupted across many parts of the country. Power outages were reported in 28 locations. Restoration efforts are ongoing; however, several areas still remain without power or communication.

Impact on Agriculture and Livestock

The flash floods had severe repercussions for the agriculture and livestock sectors. Media reports indicate that a poultry farm in Denchukha, Dorokha of Samtse district, was completely destroyed. Floods caused damage to paddy fields, cardamom and Mandarin orchards, as well as vegetable gardens, affecting agricultural production in 13 districts. Additionally, approximately 300 livestock were lost, and about 370 acres of land damaged. These losses underline the vulnerability of rural livelihoods to extreme weather events and the importance of integrating disaster risk reduction measures into agricultural planning.

Response and Restoration

Emergency response teams have been mobilized to restore road connectivity. Efforts include clearing debris, repairing damaged sections, and constructing temporary crossings to re-establish access to affected communities. These interventions are crucial to ensure the movement of relief supplies and support the local population during the recovery phase. To

enhance resilience against future extreme weather events, the Department of Surface Transport is planning the construction of permanent, durable infrastructure. This approach aims to reduce vulnerability, ensuring that critical transport routes remain functional even under severe environmental stress.

Conclusion

The extreme weather events of 4–5 October 2025 in Bhutan caused significant loss and damage across the country. The rapid assessments and disaster response carried out by multiple government agencies provided critical insights, underscoring the urgent need for support and the importance of proactive disaster risk reduction as prevention for L&D. This experience also highlights existing good practices in assessing climate-induced loss and damage, which can be further strengthened and scaled up.

Lessons learned

These case studies highlight that:

- Estimating the range of direct and indirect losses and damages incurred by climate-induced events and processes requires the development of methodologies for valuation. Many interconnected losses and damages related to health, mobility, accessibility, and food security remain underreported due to lack of an overarching common reporting systems and standards of procedures.
- Critical infrastructure and housing will continue to suffer extensive damage from extreme weather events until they are replaced with more climate-resilient structures and even such structures will no longer be sufficient as extreme weather events become increasingly extreme.
- There is a need for clearly defined mandates, inter-agency coordination protocols, and efficient communication channels are essential to reduce delays and adequately support communities at risk of or recovering from climate-induced loss and damage.
- There is potential to mobilise local communities in early response and recovery to address losses and damages but these approaches must be accompanied by financial resources and support structures to avoid placing an unfair burden on affected populations.

- Sufficient and timely budgetary allocations for disaster risk reduction and immediate response, particularly at Gewog level, remain a priority for addressing loss and damage, including modernising and maintaining the early warning systems, risk assessments and mapping.

5 Towards a bottom-up, country-owned, and inclusive L&D Framework - Recommendations

5.1 Developing a national L&D framework and centralised data repository

Despite Bhutan's notable progress in integrating climate considerations into national planning, several challenges undermine the country's ability to systematically assess and report on climate-induced loss and damage (L&D). The present assessment reveals substantial data gaps and the absence of a comprehensive national system for collecting and integrating information on climate impacts, disaster events, and associated costs. Bhutan's unique national context, characterised by its topography, fragile mountain ecosystems, rich cultural heritage, and a largely subsistence-based rural economy, creates a distinct set of climate impacts and associated loss and damage. These characteristics call for a tailored, country-led L&D assessment system that reflects local realities while aligning with international frameworks.

The primary recommendation emerging from this assessment is, therefore, the establishment of a national Loss and Damage (L&D) Framework and a centralised data repository. Together, these mechanisms will enable Bhutan to systematically measure, monitor, and report the full spectrum of climate-induced losses and damages, both economic and non-economic. Specific recommendations, which should be understood as complementary measures that operationalise and strengthen this overarching goal, are outlined below.

1. *Conduct a review of data systems, indicators and ownership roles for all sectors and L&D signatures identified, to gain a comprehensive overview of sectoral disparities in data availability and measurements.*

The present assessment reveals that agriculture and infrastructure have relatively more structured datasets, while other critical domains, such as health, ecosystems, and cultural heritage, are underrepresented. This is not surprising as such sectors often require the use of indicators that track changes in conditions rather than quantify the magnitude of loss and damage and associated costs. Moving forward, indicators for degradation trends – for example, those used to track ecosystem services – will need to be harmonised and translated into indicators that track the loss of ecosystem services and their

associated costs. Moreover, it is crucial to distinguish between L&D data requirements and those of disaster database systems, which, although interconnected, are not synonymous. Disparities in sectoral data and indicators currently limit the ability to fully capture the interconnected nature of economic and non-economic losses, which in Bhutan are deeply intertwined.

2. *Develop an integrated indicator system to ensure consistent data collection and reporting with an emphasis on approaches to capture disparities between observed and projected loss and damage, as well as small-scale and localised events that are often overlooked.*

Existing reporting efforts remain fragmented across sectors and institutions, with a tendency for smaller-scale and localised events to go unreported. This is particularly concerning in Bhutan, where large-scale climate-related events (e.g., cyclones) are rare while recurrent hazards, including landslides, flash floods, and erratic precipitation patterns, engender cumulative impacts that can equal or surpass losses caused by major events. These aggregated losses, however, remain poorly documented and undervalued in national assessments. Moreover, the specificities of Bhutan's climate vulnerability underpin the presence of cases with significant potential and projected loss and damage. This is, for instance, illustrated with GLOF events, which are relatively low-probability but high-risk events that will have devastating consequences when they do occur. Similarly, the hydropower sector, which employs a small number of people in the country but contributes disproportionately to its economy, is a sector that will incur significant economic losses in the future as climate change accelerates.

3. *Consider the development and adoption of a wellbeing-centered L&D framework.*

Given the country's development philosophy of Gross National Happiness (GNH), intangible and non-economic losses, such as impacts on cultural assets, well-being, and community vitality, are strongly interlinked with tangible economic impacts. The proposed L&D framework could take as a central point of departure a wellbeing-centered framework, integrating specific L&D indicators that contribute to tracking the effects of climate impacts on individual and community wellbeing over time.

4. *Strengthen institutional coordination and policy alignment by adopting a collaborative and participatory approach to the L&D framework design and integrating L&D considerations in national climate policies.*

The L&D Framework development process should build on the newly established L&D Task Force and be complemented by the formation of technical working groups at both national and district levels focused on different dimensions of the framework. Equally important, the process must involve a wide range of stakeholders from government agencies, civil society, academia, and local communities through the organisation of capacity-building workshops and stakeholder consultations at the district level across the country. This approach would enable a diverse set of expertise and perspectives to be incorporated, particularly from vulnerable groups most affected by climate impacts. Integrating L&D considerations across key national climate policy instruments, including the National Adaptation Plan (NAP), Nationally Determined Contribution (NDC), Biennial Transparency Reports (BTRs) and related sectoral strategies, will be critical. Finally, strengthening institutional capacity by fostering partnerships with regional platforms, development partners, and particularly research institutions will be essential to ensuring methodological rigour, enhancing technical expertise, and aligning Bhutan's efforts with global best practices. Already identified institutions in the region include ICIMOD in Nepal, CDRI in India, and UNESCAP in Thailand.

5. *Develop a database that integrates data from existing systems and infrastructures on disasters, climate services, climate finance and transparency, as well as gross national happiness surveys.*

The design of this data repository should build on Bhutan's existing investments in its Risk and Resilience Portal, Climate Services Toolkit, Bhutan Climate Change MRV System, and the GNH survey framework, thereby ensuring continuity and national anchoring. By integrating these systems, Bhutan can avoid duplication, improve coordination among institutions, and strengthen the evidence base for both domestic decision-making and international reporting under the UNFCCC.

6. *Develop and institutionalise an inclusive and gender-responsive approach to the L&D Framework that enables and emphasises the representation and participation of vulnerable groups.*

The design and implementation of Bhutan's L&D Framework should be firmly anchored in inclusivity and gender-sensitive approaches, ensuring that the voices and experiences of diverse social groups are reflected. Climate-induced loss and damage disproportionately affect women, children, elderly people, persons with disabilities, and marginalised communities, particularly in rural areas with less access to public services. Bhutan already has strong institutional capacities on gender equality and social inclusion (GESI), as illustrated in its Vulnerability Baseline Assessment, which provides a sound basis for embedding these principles within the L&D Framework. To operationalise this, all stakeholders engaged in developing and applying the framework, including government agencies, local authorities, data managers, and enumerators, should receive targeted training on gender and social inclusion dimensions of L&D. This will be especially critical in managing sensitive data, such as impacts on health, livelihoods, or cultural heritage, where research and data management ethics are required.

To summarise, the development of a national L&D Framework and centralised data repository will fill critical information gaps and position Bhutan to respond more effectively to the accelerating impacts of the climate crisis. It will also enable the country to clearly articulate its needs in global policy debates on loss and damage and strengthen its case for international support.

5.2 Priority areas and interventions

Alongside efforts to consolidate and expand data systems to improve monitoring and evidence-based planning for climate-induced loss and damage through a national L&D Framework, the assessment highlights the need for the implementation of priority interventions. While climate-induced loss and damage evidently affect all sectors in Bhutan, constrained financial resources and capacities call for the identification of key priority areas and interventions. Targeted financing and measures, for instance, to **"nexus" areas, where multiple hazards, sectors, and losses and damages intersect, and where co-benefits can be maximized to prevent, minimize, and address climate-induced loss and damage**.

This section begins by outlining two examples of so-called nexus areas for intervention: *i) Nexus area 1: Agriculture, Health, and Ecosystem Services; and ii) Nexus area 2: Infrastructure, Human Settlements, and Energy*. These are

followed by an overview of proposed interventions, some of which were identified and prioritised (ranked 1 or 2) by stakeholders during the national workshop and consultation. Cross-sectoral and institutional interventions are first presented in Table 15, followed by interventions specific to each L&D signature summarised in Table 16 that provide actionable guidance for strategic and targeted financing and coordinated action. It is important to note that interventions to prevent or minimise loss and damage could equally be qualified as adaptation measures, and vice-versa.

Nexus area 1: Agriculture, Health, and Ecosystem Services

Agriculture, health, and ecosystem services are closely interlinked and represent a critical priority area for addressing loss and damage in Bhutan, given their centrality to livelihoods, wellbeing, and ecological stability. Agriculture, which employs 41.7% of the population directly, is highly climate-sensitive, with rising temperatures, erratic precipitation, and increasing incidence of droughts, - pests and diseases already leading to crop failures, reduced yields, and heightened food insecurity. These shocks directly impact human health, contributing to malnutrition, water- and vector-borne diseases, and psychosocial stress associated with recurrent livelihood losses. Simultaneously, climate stressors are undermining vital ecosystem services, such as water regulation, soil fertility, forest resources, and pollination, which sustain agricultural productivity and rural livelihoods. Biodiversity loss further compounds these risks: as species distributions shift and habitats degrade, communities lose access to medicinal plants, wild foods, and genetic resources critical for resilience. The IPCC identifies mountain ecosystems and their biodiversity as highly vulnerable to cascading risks where ecological degradation directly exacerbates impacts on food systems and health outcomes. Addressing this nexus through holistic and integrated interventions, can therefore offer significant co-benefits by reducing cascading and cumulative economic and non-economic losses.

Nexus area 2: Infrastructure, Human Settlements, and Energy

Infrastructure, human settlements, and energy constitute another priority nexus where multiple climate hazards converge, undermining Bhutan's development priorities. Landslides, flash floods, and Glacial Lake Outburst Floods (GLOFs) that can have particularly devastating consequences, threaten and repeatedly

damage critical infrastructure, including roads, bridges, and hydropower facilities, disrupting connectivity, access to services, and national revenue generation. Human settlements, particularly those located in hazard-prone valleys and along river systems, face recurrent small- and medium-scale events that erode household assets, displace populations, and weaken social cohesion. Bhutan's energy sector, dominated by hydropower, is increasingly exposed to altered hydrological regimes, glacial retreat, and sedimentation, threatening both generation capacity and long-term sustainability. Modernised Early warning systems for floods, GLOFs, and landslides offer substantial co-benefits in this nexus, providing communities with critical lead time to reduce casualties and damages, while also protecting vital infrastructure and energy facilities. Importantly, these systems can contribute to protecting Bhutan's cultural heritage sites that are integral to the country's societal and cultural identity. Prioritising this nexus through investments in early warning systems, resilient infrastructure design, hazard-informed settlement planning, and diversification of energy sources will minimise cascading climate-induced loss and damage, contributing to protecting both tangible and intangible assets.

Table 15. Identified L&D interventions at the cross-sectoral and institutional level.

Cross-sectoral and institutional	Examples of intervention
Data governance	■ Formalise institutional coordination mechanism for responding to loss and damage ■ Develop formal Memorandums of Understanding (MoUs) or data-sharing agreements among stakeholders ■ Develop standardised formats, classifications, and protocols for loss and damage, particularly costing methodologies

	■ Strengthen Bhutan's disaster risk portal (specifically a loss and damage module) ■ Develop an L&D specific inclusivity framework based on Bhutan's approach to GESI ■ Strengthen research capacities and collaborations ■ Capacity development on L&D at all levels
Finance	■ Streamline Public Financial Management (PFM) processes to fund for L&D ■ Explore diverse financing mechanisms for L&D- contingency fund and insurance. ■ Set up Gewog level contingency fund to respond to immediate L&D events and other disaster events

Table 16. Identified interventions for each of the L&D signatures.

*Effective adaptation contributes to preventing and/or minimising loss and damage. Therefore, in many cases, preventive measures for loss and damage also constitute adaptation measures.

L&D Signature	Examples of L&D interventions
Signature 1: Food and water insecurity due to changes in temperatures, erratic precipitation, windstorms, droughts, and land degradation.	***Prevention and minimisation***
	■ Promote climate-smart and resilient crop and livestock practices to address rising pest and disease outbreaks ■ Strengthen monitoring and forecasting system ■ Nature-based solutions such as watershed management, slope stabilisation and rainwater harvesting
	Recovery, reconstruction, rehabilitation

	■ Restoration and regeneration of rangeland resources ■ Reparation and reconstruction of agricultural facilities post-event ■ Rehabilitation of water provision ■ Control and removal of invasive/pest species ■ Compensation scheme for crop loss
Signature 2: Impacts on human health and wellbeing due to heatwaves, forest fires, landslides, and floods.	***Prevention and minimisation***
	■ Comprehensive survey of climate effects on health, especially water-borne and vector-borne diseases ■ Strengthen early warning and evacuation systems for landslides and floods
	Recovery, reconstruction, rehabilitation
	■ Relocation measures post-displacement ■ Reparation and rehabilitation of contaminated water sources ■ Integrate climate risks into public health systems, including surveillance and rapid response measures for climate-sensitive diseases and mental health support after disaster events
Signature 3: Infrastructure and property damage due to floods, GLOFs, windstorms, and landslides.	***Prevention and minimisation***
	■ Review, expand, and modernise Early Warning Systems for GLOFs and other floods ■ Review and update emergency response plans ■ Strengthening of infrastructure resilience through climate-proofing and disaster risk reduction measures
	Recovery, reconstruction, rehabilitation
	■ Development and testing of compensation/insurance scheme for property damages

	■ Strengthening of rapid assessments, reconstruction and reparation programmes for infrastructures
Signature 4: Impacts on terrestrial and freshwater ecosystems due to changes in temperatures, glacial retreat, and forest fires.	***Prevention and minimisation***
	■ Holistic Management of human-wildlife conflicts - Habitat management such as rehabilitation, chain-link/electric/coral fencing, crop and livestock insurance scheme ■ Comprehensive survey on the pests and diseases for both domestic and wild species, including forests ■ Community-based conservation: engaging local farmers, leveraging traditional knowledge to maintain the native breeds ■ Monitoring of pure breeds using genomic tools and identifying important traits best suited for climate-resilient husbandry/ agriculture ■ Procurement of advanced firefighting equipment ■ Capacity building training for frontline and communities ■ Enhance institutional synergy for firefighting ■ Early warning/detection systems using AI and technology ■ Community-led Forest Fire Management ■ Scientific Forest Management (Fuel Load Management)
	Recovery, reconstruction, rehabilitation
	■ Gene banking and maintenance of viable population in their natural habitat ■ Soil remediation/restoration measures ■ Control and removal of invasive/pest species ■ Restoration, replanting, and re-introduction of native species ■ Rapid post-fire wildlife impact assessments and long-term monitoring of wildlife return post-event

	■ Erosion control measures post-fire event (e.g., log barriers, straw wattles)
Signature 5: Energy insecurity due to glacial retreat, changes in precipitation, and GLOFs.	***Prevention and minimisation***
	■ Assess rainfall intensity, enhance sediment monitoring and modelling capability ■ Implement long-term hydrological forecasting systems ■ Detailed climate vulnerability assessments ■ Energy diversification, reservoir & water management, demand-side management
	Recovery, reconstruction, rehabilitation
	■ Reparation after sediment build-up damage ■ Contingency funds and rapid response to access alternative power source
Signature 6: Impacts on cultural heritage due to glacial retreat, floods, and forest fires.	***Prevention and minimisation***
	■ Mapping and documentation of cultural heritage at risk ■ Integration of traditional knowledge and practices in relocation and rehabilitation plans and approaches ■ Community-led cultural preservation programs ■ Protective infrastructure and landscape management around critical sites ■ Develop emergency response and post-event restoration protocols
	Recovery, reconstruction, rehabilitation
	■ Reconstruction and restoration programmes for affected heritage sites ■ Memorialisation measures ■ Support programmes for cultural preservation

5.3 Financing needs

A critical component of enhancing Bhutan's capacity to address climate-induced loss and damage (L&D) is the mobilisation of adequate and sustained financing at scale. This financing is required to improve the measurement and accounting of L&D and to support interventions that prevent, minimise, and address economic and non-economic losses and damages.

At present, Bhutan faces significant constraints in estimating financing needs. The lack of systematic reporting on losses and damages, coupled with limited post-event cost assessments, precludes the development of a comprehensive, evidence-based financing plan. Recurrent small-scale hazards, cumulative impacts, and non-economic losses such as damage to ecosystems, livelihoods, and cultural heritage are often unquantified, leaving substantial gaps in the estimation of required resources.

Despite these limitations, proxy estimates can provide a preliminary understanding of financing needs. For example, expenditure estimates from Bhutan's National Adaptation Plan (NAP) and sectoral climate risk assessments can be used as indicative benchmarks for planning investments in L&D interventions.

6 Conclusion

This report represents Bhutan's first national assessment of climate-induced Loss and Damage (L&D), providing a critical foundation for advancing evidence-based policy and planning in this emerging area. While Bhutan is internationally recognized as a leader in environmental conservation and climate action, its unique geographical and topographical conditions expose the country to a wide spectrum of extreme and slow-onset climate-related hazards that are deeply affecting its people, culture, environment, and economy.

As part of this assessment and to localize global frameworks on L&D and ensure a country-led, inclusive, and nationally owned approach, Bhutan convened a national stakeholder workshop and a series of consultations. These dialogues engaged participants from diverse sectors and districts across the country and led to the proposal and adoption of Bhutan's L&D definition, L&D Signatures, and a new L&D Taskforce. This inclusive and participatory process demonstrates Bhutan's commitment to ensuring its engagement and work on Loss and Damage moving forward reflects national priorities, local realities, and the voices of vulnerable groups most affected by climate impacts.

The assessment identifies six distinct L&D "signatures" that characterize Bhutan's experience: (i) Food and water insecurity due to changes in temperature, erratic precipitation, windstorms, droughts, and land degradation; (ii) Impacts on human health and wellbeing due to heatwaves, forest fires, landslides, and floods; (iii) Infrastructure and property damage due to floods, GLOFs, windstorms, and landslides; (iv) Impacts on terrestrial and freshwater ecosystems due to changes in temperatures, glacier melt, and forest fires; (v) Energy insecurity due to glacier melt, changes in precipitation, and GLOFs; and (vi) Impacts on cultural heritage due to glacier melt, floods, and forest fires. These signatures reflect the interlinked and cascading nature of L&D in Bhutan, underscoring the need for holistic approaches that address both economic and non-economic dimensions.

The findings reveal that Bhutan is already experiencing significant climate-induced L&D across all sectors of society. Catastrophic events such as GLOFs represent an archetypal case of severe projected loss and damage requiring urgent preventive measures. The country also faces recurrent and localized hazards including landslides, flash floods, and erratic precipitation that

cumulatively impose damages comparable to major extreme events. Yet, these aggregated impacts often go unreported and undervalued in current disaster assessments, obscuring their true scale and implications in the context of climate change. Additionally, significant data gaps currently hinder a complete sector-wise analysis.

The assessment also demonstrates that financing needs for L&D in Bhutan extend across the full spectrum of approaches: from ex-post measures such as recovery, reconstruction, and rehabilitation to preventive interventions that minimize risks, address cumulative and pervasive effects, and prepare for projected impacts. Addressing these needs requires systematic monitoring, reporting, and valuation of losses and damages, supported by a dedicated national L&D Framework and centralized data repository. Bhutan can build on its existing institutional arrangements, including its new Risk and Resilience Portal, Climate Services Toolkit, Climate Change MRV System and Gross National Happiness survey framework, to operationalize such a system.

Moving forward, the challenge for Bhutan lies not only in establishing robust institutional and data systems but also in securing financing at the scale required. The country cannot face escalating climate-induced losses and damages alone. International solidarity and support will be indispensable to safeguard Bhutan's development gains, protect its communities, and uphold its global role as an environmental leader and carbon neutral country. By undertaking this assessment, Bhutan has taken an important step towards articulating its L&D needs and priorities, while contributing valuable insights to the global discourse on how climate change is reshaping societies.

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8 Annexes

8.1 A.1. List of participating agencies, departments, and organisations at the national workshop

	Agency	Number of representatives
1	Bhutan Chamber for Commerce and Industries / Association of Bhutanese Industries	1
2	Department of Environment & Climate Change, MoENR	7
3	Department of Geology and Mines, MoENR	1
4	Department of Human Settlements, MoIT	1
5	Department of Local Governance and Disaster Management, MoHA	3
6	Department of Macro-fiscal and Development Finance , MoF	1
7	Department of Agriculture, MoAL	1
8	Department of Energy , MoENR	1
9	Department of Forests and Park Services , MoENR	1
10	Department of Industries , MoICE	1
11	Department of Infrastructure Development , MoIT	1
12	Department of Livestock , MoAL	1
13	Department of Surface TransportST, MoIT	1
14	Department of Tourism, MoICE	1
15	Department of Water, MoENR	1
16	Department of Planning and Budget and Performance , MoF	1
17	Department of Education Programmes,MoESD	1
18	Department of Public Health, MoH	1
19	National Biodiversity Centre, MoAL	1
20	National Center for Hydrology and Meteorology	2
21	National Commission for Women and Children	1
22	District Disaster Management Officers	6
23	District Environment Officers	20
24	Thromdes Environment Officers	4

25	National Statistics Bureau	1
26	Druk Green Power Corporation	1
27	Bhutan Ecological Society	1
28	Tarayana Foundation	1
29	Disabled People's Organization of Bhutan	1
30	Bhutan Trust Fund for Environmental Conservation	1
31	UNDP Bhutan	6
	TOTAL	66

8.2 A.2. Agenda for National Stakeholder Consultation Workshop on Climate-Induced Loss and Damage

Agenda and Program for Stakeholder Workshop and Consultation on Loss and Damage,
13-15 August, 2025.

Day 1 – Conceptual and Analytical Foundations			
Time	**Session**	**Title & Focus**	**Format**
9:00-9:30	Registration		
9:30-9:45	Welcome & Opening Session	Welcome Remarks by -DECC Director Remarks by -UNDP	
09:45 – 10:40	Session 1	Overview of workshop L&D – An introduction & Key Concepts: Definitions: Loss, Damage, Vulnerability, Justice	Presentation & Q&A
10:40 – 11:00	Photo Session & Tea/Coffee Break		
11:00-13:00	Session 1 Exercise	Hands-On Exercise 1: L&D signatures Bhutan's definition of L&D	Group exercise
13:00-14:00	Lunch		
14:00 – 15:00	Session 2	Accounting and Measuring L&D – Methods Overview: Data systems, indicators, global frameworks	Presentation
15:00-16:00	Session 2 Exercise	Hands-On Exercise 2: Selecting L&D Indicators for assessment	Group exercise
16:00 – 16:20	Break		
16:20_17:00	Wrap-Up	Reflections and group synthesis	Plenary

Day 2 – Policy Integration and Institutional Anchoring			
Time	**Session**	**Title & Focus**	**Activities / Format**
09:00 – 09:15	Reflection on day 1	What is L&D	Menti
09:15 – 10:15	Session 3	L&D Policy Integration – Beyond DRR: Bridging DRR, NDCs, and L&D Planning	Presentation
10:15 – 10:30	Tea/Coffee Break		
10:30 – 11:30	Session 3 Exercise	Policy & Institutional Mapping: Agencies, mandates, gaps, overlaps, and entry points for integrating L&D	Group Exercise
11:30-12:30	Group presentation	Group output	Plenary (10 mins each)
13:00-14:00	Lunch		
14:00-15:00	Session 4	FRLD and SNLD – Global Decisions and Modalities: Role of networks and funding instruments	Presentation + curated Q&A
15:00-16:00	*Session 5*	*DRM portal (MHRDSS) demo - 30 mins* *Discussion on Enhancement needs for L&D: 40 mins*	*DLGDM*
16:00-16:20	Tea/Coffee Break		
16:20-17:20	Session 6	Relook at the proposed country-specific L&D definition *Sector-based data issues and data compilation/scheduling* • *DoFPS* • *DOA* • *DOL* • *DoST* • *Thromdes* • *NBC*	Open dialogue *Sector wise*

		• *DoE* • *DLGDM (DM and LG)* • *DoW* • *NCHM*	

Day 3 – Advancing Bhutan's Loss and Damage Assessment: Grounding Perspectives and Priorities			
Time	**Session**	**Title & Focus**	**Activities / Format**
09:00–10:00	Session 7	Finalizing Bhutan's L&D definition	Interactive group exercise
10:00–10:30	Session 8	Task force for L&D	Plenary discussion
10:30–11:00	Tea Break		
11:00–13:00	Session 9 Exercise	Breakout Session: Identifying Priority Issues, Interventions and sectors	Thematic group discussions & exercise
13:00–14:00	Lunch Break		
14:00–15:30	Session 10	Presentation (10 mins each) and discussion	Plenary
15:00-15:30	Tea Break		
16:00–17:00	Session 11	Overall prioritization Missing elements	
17:00-17:15	Session 12	Feedback on the workshop/Closing and way forward	Menti/Remarks

8.4 A.3. List of documents reviewed

Agency	Documents shared
Department of Agriculture	Crop damage report data (2016-2017; 2018-2019; 2021)
	Crop-and-livestock-damage-and-loss-assessment-methodology
	Disaster Report Oct 2021
	Extreme Weather Events Records, 2022
	Food and Nutrition Security Policy, 2023
	Fruit Crop Loss by Hailstone at Tsirang Dzongkhag, 2024
	Land Conversion Data
	Potato crop damages report of Bumthang, 2024
Department of Forests, and Park Services	DoFPS, Draft of National Forest Fire Prevention and Response Strategy (2024)
Department of Environment and Climate Change	Agrifood Sector Roadmap For Implementing Bhutan's NAP
	Energy Sector Roadmap For Implementing Bhutan's NAP
	Water Sector Roadmap, For Implementing Bhutan's NAP
	National Adaptation Plan (NAP), of the Kingdom of Bhutan, 2023
	First Biennial Update Report to the UNCCC, 2022
	First Biennial Transparency Report to the UNFCCC, 2024
	Second Nationally Determined Contribution, 2021 Bhutan Country Analysis for green growth, 2024
	Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (LTS), 2023
	Assessment of Climate Risks on Agriculture for National Adaptation (NAP) Formulation Process in Bhutan

	Assessment of Climate Risks on Health for National Adaptation (NAP) Formulation Process in Bhutan
	Assessment of Climate Risks on Forests and Biodiversity for National Adaptation (NAP) Formulation Process in Bhutan
	Assessment of climate risks on water resources for the National Adaptation Plan (NAP) in Bhutan, Priority risks and recommendations for adaptation, 2021
	Third National Communication (TNC) of Bhutan, 2020
	Climate Change Vulnerability Analysis for National Adaptation (NAP) Formulation Process in Bhutan
Department of Water	Assessment and Mapping of Water Sources in Bhutan (A comprehensive inventory and status of water sources used by Bhutanese communities), 2021
	List of existing Springshed Management areas and Payment for Ecosystem Services
Department of Surface Transport	Monsoon Restoration Expenditure Reports, 2022-2023; 2023-2024; 2024-2025
	Slope Failure Mitigation Cost and Programs
	SOPs for reporting and management of roadblocks
	Guidelines on Design, Construction and Maintenance of Road Infrastructure incorporating Climate-resilient Features, (December 2019)
	Low Emission Development Strategy (LEDS) - Surface Transport, 2021
	SOP for monsoon damages restorations, 2020
	Road Blocks data, 2023-2025
	Road Networks data, 2023-2025
Department of Local Government and Disaster Management	Site Assessment Report of Dechencholing Flash Flood Incident 10 August 2024, Thimphu
Department of Livestock	Livestock Population 2006-2025 (Source_ NSB 2006-2025)

	Tsamdro (Rangeland) data Surveyed under 11 Dzongkhags
National Biodiversity Centre	Paper on Indigenous Animal Genetic Resources of Bhutan
	A Swirling Offering: Climate Change Impacts on Incense and Other Useful Alpine Plants of Bhutan, 2025=
	Himalayan Alpine Vegetation, Climate Change and Mitigation, 2014
	Dendroclimatic Reconstruction of Mean Annual Temperatures over Treeline Regions of Northern Bhutan Himalayas, 2022
	Evolutionary Plant Breeding as a Response to the Complexity of Climate Change, 2020
	Spatial Surveillance of Invasion by Alien Species in a Heterogeneous Ecological Landscape, 2019
	National-Paper-on-Biodiversity-and-Climate-Change- Bhutan, 2011
	Immunological tolerance of Bhutanese native chicken to Infectious Bursal Disease Virus infection, 2016
	Species Vulnerability red list data
National Center for Hydrology and Meteorology	Analysis of Historical Climate and Climate Change Projection, 2019
	Bhutan Climate Projection Report, 2024
	Compendium of Climate and Hydrological Extremes in Bhutan since 1968 from Kuensel
	Compendium of Climate and Hydrological Extremes in Bhutan (2017-2021)
	Extreme Weather Events in Bhutan, 2018
	Record of Extreme Weather Events in Bhutan, 2020
	Record of Extreme Weather Events in Bhutan, 2022
	Hydro Met Policy of the Kingdom of Bhutan 2023
	Site Assessment Report of Dechencholing Flash Flood Incident 10 August 2024, Thimphu
	State of Climate Report 2024

Punakha Dzongkhag	Disaster Estimate & Report Nalanda
	Estimate for Disaster Damaged of Irrigation Toepisa
	Estimate-Tshachuphu Irrigation Channel
	Site Report of Menchuna-Bagona Farm Road
	Site Report of Tendey Lum
	Yield loss assessment of paddy, Punakha, 2021

8.6 A.4. List of L&D Task Force Members

No	Name	Designation	Agency/Organization
1	Langa Dorji	Deputy Chief Environment Officer	DECC, MoENR
2	Dechen Dorji	Assistant Environment Officer	
3	Dr. Norbu Wangdi	Director	Bhutan Ecological Society
4	Karma Chorten Dendup	Sr. Forestry Officer	DoFPS, MoENR
5	Sonam Chophel	Forestry Officer	DoW, MoENR
6	Beejai Darjee	Biodiversity Officer	NBC, MoAL
7	Dr. Om Katel	Lecturer	CNR, RUB
8	Wangchuk Zangmo	Dy. Chief Program Officer	NCWC
9	Yeshi Nidup	Sr. GIS Officer	DHS, MoIT
10	Tshering Choden	Program Coordinator	DMDF, MoF
11	Nima Chenzom	Asst. Planning Officer	
12	Wangmo	Assistant Engineer	DoE, MoENR
13	Gyembo Tsheten	Sr. Livestock Production Officer	DoL, MoAL
14	Deki Lhamo	Dy. Chief Agriculture Officer	DoA, MoAL
15	Ugyen Chophel	Dy. Chief Statistical Officer	NCHM
16	Sonam Tshewang	Principal Engineer/GIS Officer	DLGDM
17	Sonam Rabgye	Planning and Partnership specialistist	UNDP

8.7 A.5. List of climate-induced events and loss and damage shared by key informants

Source: Various Government sources & Publications (NCHM/DLGDM/Research Institutions/MoAL/DoFPS/Social Media)					
Year	**Event**	**Dzongkhag**	**Village/ Gewog**	**Reported damage**	**Category (ELD/ NELD/ Both)**
1968	Flood	Punakha		Punakha valley: several houses washed away, including Bajo Lakhang; Old traditional bridge of Wangdue Phodrang and a house with 12 people washed away;	Both
1968	Thimphu Flood	Thimphu	All gewogs	About 75 houses and shops in Thimphu have been washed away by the flood waters; bridges swept away; seven persons have lost their lives and property worth several lakhs have been damaged or washed away	Both
1968	3 days continuous rain caused Paro flood	Paro	Shaba and Wangthanka, Dobshari and Juka-thang	Stocks of rice and wheat, other food stuff, cloth and other merchandise worth lakhs, kept in the shops have been spoiled. Hydel Bridge, Dzong bridge and Bongdi bridge have been washed away. Ten	Both

				persons were swept away in the flood. heavy damage to paddy land. Landslide. The Government Agriculture Farm at Bongde has been hit badly. loss is estimated to be worth Rs. 2.5 lakhs	
1968	Phochu and mochu flood	Sarpang	Kalikhola	Swept away many shops and 10 persons.	Both
1968	Phochu and mochu flood	Chirang		16 lives were lost and many others injured.	NELD
1982	Thungti Flood	Trashigang	Thungti	Washed away shops and houses of four families. The flood eroded dry lands and damaged paddy fields.it was revealed that gold and silver ornaments, old silver coins and many valuable things were washed away in the flood	ELD
1987	Mochu Flood	Punakha	Punakha market area	Two shops were carried away, and three damaged by boulders, other drift material, and flood water	ELD
1990	Mithidang Flood	Trashigang	Trashigang town	Heavy flooding in town. Few temporary toilets are missing and some huts with	ELD

				minor damages. no casualties	
1990	Flash Flood	Chukha	Phuntsholing town	Destroying fields and houses, and disrupting the water line for Phuntsholing. Destroyed Norgay bridge. flooding two shacks. The worst hit area was the Bhutan Oil Distributors, located opposite the Chukha colony, where the flood broke a portion of the wall and entered the pump, sweeping away many oil drums. gabion walls washed away.	ELD
1991	Flash Flood	Trahsigang	Ramjar village under Bartham gewog	2 school girls washed away age 7 and 6. Their house also washed away	Both
1991	Haa chu Flood	Haa	Lukha village	The wooden bridge near the Haa Junior High School washed away. The embankment and vegetable field flowed.	ELD
1991	Duti khola flood	Chukha		The water supply pipes at the Duti Khola source in Phuntsholing have been washed away by heavy rainfall. The small huts around the colony were all swept away and the diesel generator	ELD

1992	Flood	Samdrup Jongkhar	s/jongkhar town below vegetable market	Culling houses below the vegetable market were swept away. Six people were killed. Road between s/j and Deothang was blocked by landslide	Both
1993	Flashflood	Trashigang	Rangjung	Carried away 7 cows. The bridge washed away. Road closed to traffic.	ELD
1993	Flash flood	Chukha	Genju	2 people were washed away by the landslide. Several others were injured.	NELD
1993	Flash flood	Samtse	Pagli, Chengmari	Damage to the Penden Cement Authority Ltd factory is estimated at about Nu. 30.00 million. 2 other buildings were washed away by the landslide. Gomtu school closed and the Pagli checkpost washed away. Betelnut orchards and agricultural field damage. 4 irrigational channels washed away.	ELD
1993	Flash flood	Paro	Damchna, Kenphu	4 bodies swept and 2 bullocks. 2 huts completely washed away	Both
1994	Flash flood	Trashigang	Trashigang town	14 buildings were damaged, 11 of them irreparably. Bridge half washed away. Bridge at Rongthang washed away	ELD

1994	GLOF	Punakha		17 people were missing. The eastern wall of the 500-year old Dzongchhung Lhakhang, constructed by Dupthop Ngagi Rinchhen, was affected after the retaining wall fell under the force of the river. Some statues and religious objects are reported missing but the main images of the “Jhou” and Dupthop Ngagi Rinchhen are still intact. The flood partially damaged the police complex at Dzong Phakha, the dzong’s solar bathing house, the renovation camp of the dzong, the Phochhu suspension bridge, Glacial flood hits Punakha forest plantations opposite the dzong, and paddy field along the river banks. The flood washed away 12 houses and left nearly 1,800 acres of pasture and agricultural land covered in sand and silt. Yaks, grain, bridges, water mills, chortens, and even a	Both

				few human lives, were other casualties of the flood which swept down river, along the Phochhu, into Punakha.	
1994	GLOF	Gasa	Lunana	Affected 91 households. Twelve houses were damaged and 964.74 acres of pasture lands covered with sand and silt or washed away together with 816 acres of dry land. Yaks, grains, bridges, water mills, chortens and a temple were part of the toll.	ELD
1995	Obstruction of the stream causes flash floods.	Lhuentse	Changzam village in Dungkhar gewog	Three irrigation channels were washed away and several acres of wet and dry land and three houses damaged.	ELD
1996	Flashflood caused landslide	Sarpang	Sarpang town, kharkhola village.	Massive floods and landslides claimed the lives of at least 14 people, damaged crops and property, killed livestock, and washed away roads	Both

				to all other parts of the country.	
1996	Flash flood	Trashigang	Bartsham	A man was buried and killed on the spot when his hut collapsed under a landslide.	Both
1996	Flash flood	Chukha	Pasakha	After a flash flood washed away more than Nu 30 million worth of raw material and landslides damaged parts of the factory complex, the Bhutan Ferro Alloys Ltd. (BFAL). Washed away bridge	ELD
1999	Setey kherey flood	Sarpang	Gelephu and Lodrai	Substantial paddy land washed away.	ELD
1999	Stream catchment flood	Trashiyangtse		Five people died. washed away one house and two huts, some cattle and destroyed about 11 acres of land.	Both
2000	Flash flood	Chukha	Phuntsholing	17 huts were washed away in the vegetable market. while the BOD fuel station, a private sawmill, the city corporation water supply office were submerged, automobile workshop and the city corporation's staff quarters were severely damaged	ELD

2000	Flash flood	Samtse	Noonpani village	5 people died. The Jitti bailey bridge, Daina bridge, the suspension bridge in Chengmari, the Kuchi-Daina bridge, the Jogitar suspension and the Namchu suspension bridge - were also washed away. Water pipes and electric poles were damaged.	Both
2000	Flash flood	Trashigang	Wamrong dungkhag, Nanong geog	One man was killed and four houses washed away.	Both
2000	Flash flood	Mongar	Kengkhar	Two persons were killed. 15 houses destroyed.	Both
2003	Bareykha river caused flash flood	Trahsiyangtse	Bumdeling	Damaged about 25 acres of fields.	ELD
2004	Flash flood and landslides	Eastern Dzongkhag	Melphey, Wamrong, Resirbo	Eleven lives have been lost to floods in the eastern dzongkhags, 29 houses have been totally washed away, about 26 have collapsed, and 107 were partially damaged.	Both
2004	Flash flood	Trashigang	Phongmey Lower Secondary School	Two students killed and two missing.	NELD
2005	Flooding	Chukha	Phuntsholing	A settlement of about a dozen makeshift shops upstream, washing	ELD

				away two measuring gauges installed along the riverbank. Damaged dried land.	
2005	Flooding	Trashiyangtse	Bumdeling	Washed away more than three acres of paddy fields. Affected the roosting grounds of Black Necked Crane	ELD
2007	Flash flood	Trashiyangtse	Toetso	Destroyed the paddy cultivated land. Washed away 59 metres of the Kesheri irrigation canal and destroyed the Samthang irrigation canal.	ELD
2008	Flooding	Haa	Damthang	Washes away four cows. Water entered the traditional houses and filled with debris.	ELD
2008	Flooding	Chukha	Phuntsholing	A part of the gabion wall, along the left bank, built by Phuentsholing city corporation (PCC), was washed away.	ELD
2008	Landslide and flooding	Samtse	Sakrutey	Five households residing near the river lost more than half their paddy fields	ELD
2009	Heavy rainfall and flood (Aila cyclone)	Thimphu	Semtokha and Hongtsho	Two students washed away	NELD
2009	Flooding (Aila cyclone)	Haa	Haa town	Washed away four labour camps and a workshop. Flooding	ELD

				the town and forcing residents to evacuate their homes	
2009	Heavy rainfall and flood (Aila cyclone)	Dagana		Washed away the Dagachu bridge. washed away 20 m of the DaganaSunkosh road.	ELD
2009	Heavy rainfall and flood (Aila cyclone)		Wangkha, Tanalum, Tshimasham, Taktikoth	One Dantak labourer was killed while clearing a landslide area. Road block on Thimphu-phuntsholing highway	Both
2009	Heavy rainfall and flood (Aila cyclone)	S/jongkhar		One person killed	NELD
2009	Landslide and snow avalanche cyclone Aila	Gasa	Laya	Two hundred and thirteen yaks, 45 horses, 19 mules and one cow are believed to have been washed away	ELD
2009	Flooding	Thimphu	Zamtong and Tshochekha	Washed away about 2.3 km of the 4.350 km long farm road. Destroyed irrigation channels and a suspension bridge in the village. Bridges washed away	ELD
2010	Flood water	Chukha	Pasakha (SIngye)	Three people have been killed and five others were injured and lost all their belongings.	Both

2010	Flash flood	Thimphu	Namseling, Mewang	Washed away culverts and damaged crops and houses along the stream flowing beneath the sharp bend near a small automobile workshop.	ELD
2010	Flash flood	Sarpang	Sarpang town	Washed away five huts and damaged nine others. Heavy rainfall also damaged roads between Sarpang and Gelephu at numerous points	ELD
2012	Flash flood	Gasa	Damji	Damaged paddy fields, irrigation channels, farm roads, drinking water supply schemes and crops, three bridges and roads. A cowshed was reportedly washed away, along with a cow, at Damji. Powerline disrupted	ELD
2012	Flash flood	P/Gatshel	Chengkari	Two shops (makeshift houses) were already washed away. Underground electric cable was also washed away by rainfall in Dungsam. NganglamGyalpoizhing highway was washed away	ELD

2012	Heavy rain cause flash flood	Sarpang	Around Gelephu town, Pelrithang	Affected the land with full of debris. The rain water has also entered the Pelrithang jail and family quarters. Overflowing water from the adjacent drainage has entered the cottage structures. Stopped vehicle movement between Sarpang and Gelephu.	ELD
2012	Flooding	Sarpang	Near Gelephu	One Van and Toyota vehicle washed away while crossing the road.	ELD
2013	Flash flood and landslides	Punakha	Kabjisa Geog	Flash flood damages 6 acres including paddy field. Caused a block at Punakha-Gasa road, after a small culvert bridge got washed away. Several farm roads in the villages have also been damaged	ELD
2013	Flooding	Trashigang	Phongmey and Sakteng	The flooded river has washed away both road and ropeway	ELD
2014	Flash flood	Trashiyangtse	Toetsho geog	Three suspension bridges and two irrigation channels were washed away. Destroyed between 600 and 700 acres of paddy fields	ELD

2015	Flood and GLOF	Gasa	Laya leading to Punakha-Wangdue valley	Washed away six wooden bridges (bazams). The two drinking water pipes connecting Bajo town were washed away. Around 300 cordyceps collectors are also stranded on the other side of the lake. Some livestock were lost.	ELD
2015	Flash flood	Chukha	Bangay bazaar in Phuntsholing	Seven families lost their makeshift houses and shops. It also flooded a brick factory and workshop. Submerged two excavators and three school buses downstream.	ELD
2015	Flash flood	Dagana		No major damages were found except some walls along the rivers are washed away	ELD
2015	Flash flood	Wangdue	Nahi geog	Washed away one suspension and two motorable bridges, and two vegetable sheds in Nahi gewog. Nahi primary school and Nabisa chiwog have been cut off. Drinking water sources for Rinchengang and other BPC staff and PHPA staff's residence was	ELD

				washed away. Washed away several irrigation sources for Nahi, Rinchengang and Gaselo.	
2015	Flash flood	Sarpang	Gelephu	Flooded the road while also triggering landslides to block the road at Box cutting. Water gushed into houses. It also affected the land.	ELD
2015	Flash flood	S/jongkhar	S/jongkhar	Broke the retaining walls, damaged the parking lot and carried the truck away.	ELD
2016	Flash flood	Sarpang	Sarpang town	Washed away all the 52 shops in sarpang town. It cuts off vehicular movement and people.	ELD
2016	Flash flood	Chukha	Phuntsholing	Flooded workshops and warehouses located along its banks.	ELD
2016	Flash flood	Sarpang	Gelephu (Pelrithang)	The occupants of 22 houses were evacuated to higher ground. Threaten lives and property. Floodwater swept muck and debris into their homes. It also washed away the walls of one of the houses. The water treatment plant was submerged under	ELD

				water and covered with sand and debris.	
2016	Monsoon rainfall	Whole country	Whole country	The road at Sorchen was washed away. The Tsirang-Sarpang highway has been cutoff and a bridge near Sarpang checkpoint was washed away. Dzongkhalum near Trongsa was damaged. Buduney bridge in Samtse has been damaged. Workshops in Phuntsoling and makeshift shops in Sarpang were damaged. Some of the GR(gewog road) all over Bhutan was also washed away.	ELD
2016	Flash flood	Punakha and Wangdue		The PHPA II coffer dam and main dam construction site was flooded. Submerged an area used for mining sand in the basin. Washed away embankment walls at Kamichu. 11-year-old boy was washed away by the Sukti river in Gomtu	Both

2016	Flash flood	Sarpang	Gelephu geog, Ghaden Chewog	16 households in Gelephu Geowg were partially submerged under swollen Setikharay. The culvert between Gelephu-Pelrithang highways was completely washed away. More than 60 acres of cultivated paddy land and 500m long wall belonging to 30 households of Gaden Chewog was damaged by Taklai river. 2 acres of cardamom field was eroded in Jmcholing.gewog. More than 100 metres of the Gelephu-Zhemgang highway near Chisopani bridge were washed away. More than 100m of road foundation at Jamcholing was washed away. Gelephu dzongkhag was cut off from the rest of the Dzongkhags.	ELD
2017	Flash flood	Gasa	Tashithang	A section of the road at Tashithang along the Punakha-Gasa highway was washed away.	ELD

2017	Flash flood	Trashigang	Bartsham Gewog	Damaged farm roads and washed away crops in four of the five chiwogs. Debris and boulders that washed down the slope where Bartsham Central School is located covered the multipurpose hall and partially damaged a hostel after the rain flooded the hostel.	ELD
2017	Nakpola and Kuktur-gang streams caused a flash flood	Trash-Yangtse	Bumdeling	Washed away three RCC bridges, two wooden bridges, and an excavator in the gewog and destroyed paddy fields, irrigation water sources, and fallow lands belonging to 16 households.	ELD
2017	Swollen streams caused flooding	Lhuentse	Shawa in Gangzur	Around 20 households lost at least 17 acres of crops. Washed away a few domestic animals, an electric pole, irrigation canals, and a mini hydropower supply water	ELD
2017	Flashflood	Trongsa	Thruepang	Flooded Thruepang Palace compound. Destroyed the town's drinking water source.	ELD
2017	Heavy rain	Wangdue	Lopokha	The bridge was washed away, and	ELD

	caused flash flood			crops were damaged.	
2017	Heavy rain caused flash flood	Lhuentse	Kilung	Damaged a suspension bridge affecting about 50 households and students of Thimyul Lower Secondary School in Lhuntse.	ELD
2017	Flash flood	Gelephu	Gelephu	Rainwater that flooded the border gate area soon dried up, not requiring evacuation. Further up around eight kilometers away at the Aie-slip, a major landslide blocked traffic flow until late afternoon.	NELD
2017	Heavy rain caused flooding	Gelephu	Jampheling	Gelephu Thromde evacuated at least three families from the low-lying areas in Jampheling Demkhong after their makeshift huts were flooded with rainwater.	ELD
2017	Small flashflood	Thimphu	Cheri	Had no major impact.	ELD
2017	Flood	Punakha	PHPA II	The dam site was filled with water and debris from the flooding the Punatsangchhu spilled over the cofferdam.	ELD
2017	Flash flood	Gelephu	Gelephu	Washed away 100 meters of the temporarily reinstated Gelephu-	ELD

				Assam highway which was washed away on August 25 by the overflow from the reservoir below the airport.	
2017	Heavy Rainfall caused flood	Sarpang	Serzhong	Washed away more than 200 meters of Serzhong Gewog Centre road. Also washed away drinking water sources about two kilometers away from the Shershong gewog centre which benefited the people of Norbuling and Chuzargang gewog.	ELD
2017	Flood	Mongar	Tsakaling	Damaged crops, more than 250 orange trees were also washed away.	ELD
2018	Flash flood	Lhuentse	Slilibe in Maedtsho Gewog	Washed away a labor camp consisting of 13 temporary sheds and a motorbike, affecting some portions of the gewog road and farm roads. Also damaged was the under-construction RCC bridge that connects a native cattle-breeding centre of Sertsham to the grazing area located on the other side of the river.	ELD

2018	Flash flood	Trashigang	Rangshikhar	Although no major damages were reported, the meat shop and the ground floor of the vegetable market including two huts and the children's park were completely covered in muck. Four vehicles including two trucks were also stuck. Drinking water sources for the town and water pipelines in three different locations were also washed away.	ELD
2018	Flash flood	Trashigang	Rangjung	About 12.5 km from Trashigang towards Rangjung, the flood completely washed away the road along the stretch. A farmer lost 1.7 acres of his paddy field to the flood.	ELD
			Dramang	Washed away a semi-commercial poultry farm including the road in the area. Also washed away three wooden structures including rice and corn mills. Around 400 pullets were also killed in the incident.	ELD

2019	Flash flood	Lhuentse	Na-key-thang	Damaged the water sources that catered to residents living near a car automobile workshop at Jabin, an open- air gym at Nakeythang, and the ECCD centre.	ELD
2019	Heavy Rain	Gelephu	Gelephu	The reinforced concrete cement bridge (10 meters) near the domestic airport was completely washed away. A mini-tripper truck belonging to Sashastra Seems Bal (SSB) was also washed away.	ELD
2019	Flash flood	Lhuentse	Gangzor gewog	Two women; a mother and a daughter were washed away by the flashflood.	NELD
2019	Flash flood	Chukha	Baunijhora P/ling	Sediments submerged the new Baunijhora bridge	ELD
2020	Flood	Gelephu	Maochu Gelephu	16 people were stranded near the water treatment plant who were rescued the next morning. Four soldiers lost their lives. The flooding has also caused minor damage to the paddy plantation located near the riverbank. However,	Both

				the damages to the water treatment plant could not be assessed yet.	
2019	Flood	Punakha	Jarogang	Four workers of PHPA II went missing after the vehicle they were travelling in was washed away by the swollen river. Also damaged a house in Jarogang. About 700ms of the highway was completely submerged under the water.	ELD
2020	Flash Flood	Trongsa	Bjeezam	Swept away belongings of six families near Bjeezam leaving them homeless. A shop, two huts, and the bridge to Nubi Gewog Centre were washed away. An artificial dam has been formed at the Mangdechu River due to the flash flood debris. AWLS/AWS and manual gauge stations at Bjizam are submerged due to the backflow from the dam formation and are not operational. The Mangdechhu	ELD

				Hydro Power remains shut down	
2020	Flash flood	Wangdue Phrodrang	Ruecheykha, Ruebisa Gewog	Damaged more than three acres of rice paddy belonging to 11 households. Damaged farm roads to Jala village. Ruecheykha village didn't have electricity for two days as the flash flood disrupted power lines.	ELD
2021	Flash Flood	Trongsa	Chendebji village, Tangsibji Gewog	Damaged bridges, Mini Hydro-power houses, cow sheds, and timber logs in the nearby area but there are no casualties according to local people. People's access route was made difficult as they had to cross the other side of the river to do daily farming work."	ELD
2021	Flash flood and landslide	Gasa	Laya	10 people died and 5 others were injured.	NELD
2021	Flash Flood	Trashi-Yangtse	Serkang stream	3 Human casualties reported	NELD

2021	Flash Flood	Gasa	Gasa Taschu	Four concrete structures including one shop were washed away. There was no report of human casualties. All seven hot spring ponds and bridges damaged	ELD
2021	Flood	Sarpang	Gelephu	Breached a gabion wall constructed along the Shetikhari stream in Gelephu. Washed away temporary boulder wall connecting the reinforced concrete wall at the confluence. Stranded more than 20 people	ELD
2023	Flash Flood	Lhuentse		At least 6 people were killed and 17 others are still missing. A section of the Yungichhu Hydro Power Project was also damaged.	Both
2024	Flash Flood	Thimphu	Dechencholing	49 households have been severely impacted. Damaged 10 buildings in the area including 4 under construction. One car was washed away, eight remain in good condition, and the rest are damaged. 84 households in the	ELD

				RBG campus have also been impacted. Sixty-four students were affected. The flood also affected 62 foreign workers from 6 construction sites in the Dechencholing town	

8.8 A.6. Preliminary data on forest fires from draft of National Forest Fire Prevention and Response Strategy (2024) DoFPS

Table 1. Number of fire incidents by Dzongkhags (district)

Dzongkhags name	2023	2024	2025	Total
Bumthang		3	4	7
Chukha	7	4	6	17
Dagana	5	7		12
Gasa			2	2
Haa	5	1	3	9
Lhuntse	2	6	3	11
Mongar	12	13	6	31
Paro	6	8	8	22
Pemagatshel	5	1	3	9
Punakha	12	5	4	21
Samdrup Jongkhar	1	2	4	7
Samtse		2		2
Sarpang			1	1
Thimphu	13	12	9	34
Trashigang	11	18	6	35
Trashiyangtse	2	8	1	11
Trongsa	3	5	1	9
Tsirang	4	3	2	9
Wangdue Phodrang	7	6	6	19
Zhemgang	1	4	1	6
Total	**96**	**108**	**70**	**274**

Table 2. Forest fire suppression staff 2023-2025

Forest fire suppression staff numbers	2023	2024	2025	Total (#)
Civil Servants	59	197	164	420
Desuung volunteers	919	1223	1825	3967
Forestry Officials	657	921	1287	2865
Others (Specify)	277	540	463	1280

Public/Community	1914	3273	2361	7548
RBA	857	611	1474	2942
RBP	279	907	718	1904
Other volunteers	224	224	231	679
Total	**5186**	**7896**	**8523**	**21605**

Table 3. Costs of fire suppression efforts 2023-2025

2023 Cost in USD	**2024 Cost in USD**	**2025 Cost in USD**	**Total cost (USD)**
518	2624	2600	5741
15565	17529	144359	177453
11729	19282	127612	158624
2582	4812	12712	20106
35665	65906	103635	205206
7465	6218	142335	156018
4759	12229	43571	60559
7500	5582	8476	21559
85782	134182	585300	805265
Total	**2268365**	**1170600**	**1610529**

Table 4. Types of forest burnt in hectares

Types of forest burnt (Ha)	**2023**	**2024**	**2025**	**Grand Total**
Alpine Forest		16.84		16.84
Blue pine Forest	1051.41	193.99	2559.04	3804.44
Chir pine Forest	8971.58	10742.34	2797.96	22511.88
Cool Broadleaved Forest	9.76	58.96	39.85	108.57
Fir Forest			331.43	331.43
Hemlock Forest		0.54		0.54
Juniper Rhododendron Scrub		12.14		12.14
Non-Forest (agriculture, built up, barren, etc)	5.37	147.63		153

Spruce Forest		0.82	25.42	26.24
Subtropical Forest	1.42	41.06	88.39	130.87
Warm Broad-leaved Forest	40.48	26.8	6.68	73.96
Total	**10080.02**	**11241.12**	**5848.77**	**27169.91**

A.7. Climate events and damages in Punakha Dzongkhag in 2021 and 2025

*It is important to note that these data are partial. Many events, losses and damages remain unrecorded.

Events	Date	Main impacts, losses, and damages	Location	Cost (Nu)	Cost (USD)	Data source
Continuous rainfall	19-24 October, 2021	Loss of harvested paddy 664 Households affected; 383.29 acres off the cultivated 1181.28 acres affected (32%); Farmers lost 412.53MT of paddy worth Nu. Nu. 16.91M	11 gewogs of Punakha	16910000	198,941.18	Dzongkhag Agri
Heavy Rainfall	23 June 2025	Damage to Irrigation Channels access Roads and River Protections works Including Re-construction of Retaining wall at Nalandra Shedra	Toepisa, Puakha	14,477,888.55	170328.10	Dzonghag engineering
Flashflood	23 June 2025	Damage to irrigation channel	Lemjakha, Thinlegang, Toepisa, Punakha (Okalum source)-Tsirigang	293,439.38	3452.23	Dzonghag engineering
Flashflood	23 June 2025	Damage to irrigation channel	Gyemkha-Mendeygang, Toepisa, Punakha	160,409.40	1887.17	Dzonghag engineering

Flashflood	23 June 2025	Damage to irrigation channel	Siluna, Toepisa, Punakha	119,645.42	1407.59	Dzonghag engineering
Flashflood	23 June 2025	Damage to Mahilum Irrigation Channel at Source	Thinleygang-Lemjekha, Toepisa, Punakha	182,224.14	2143.81	Dzonghag engineering
Flashflood	23 June 2025	Damage to Lumina Irrigation Channel at Source	Toepisa, Punakha	111,548.50	1312.34	Dzonghag engineering
Flashflood	23 June 2025	Damage to Gantey Irrigation Channel at Source	Toepisa, Punakha	383,669.16	4513.75	Dzonghag engineering
Flashflood	23 June 2025	Damage to Lumitsawa Irrigation Channel at Source	Toepisa, Punakha	83,669.16	984.34	Dzonghag engineering
Flashflood	23 June 2025	Damage to road at tendel zam due to Flash-flood debris and Levelling of River Basin	Toepisa, Punakha	4,294,317.62	50521.38	Dzonghag engineering
Flashflood	23 June 2025	Mitigation Works Along Menchuna to Bagona Farm Road	Chura Jango, Toepisa, Punakha	435,034.87	5118.06	Dzonghag engineering
Flashflood	23 June 2025		Along tohogang farm road, Toepisa, Punakha	246,007.40	2894.20	Dzonghag engineering
Flashflood	23 June 2025		Angzoling and Jangochen (Tahogang Farm Road), Toepisa, Punakha	8,919.68	104.94	Dzonghag engineering

Flashflood	23 June 2025		Angochen landslide (Below the road at the horizontal curve), Toepisa, Punakha	1,049,211.53	12343.67	Dzonghag engineering
Flashflood	2 July 2025	Damage of retention wall	Nalanddra, Toebesa, Punakha	6,002,792.30	70621.09	Dzonghag engineering
Flashflood	2 July 2025	Damage to Tshachuphu Irrigation Channel	Teowang, Punakha	830,297.69	9768.21	Dzonghag engineering
TOTAL				**45,589,074.80**	**536,342.06**	

A.8 Rapid assessment preliminary report of extreme weather events of 4-5 October 2025

Updates on the damages of flood disasters of 4th &5th October 2025

as of 4:10 PM, 9 October 2025

Continuous and intense rainfall across the country on 4th and 5th October 2025 triggered a series of localized floods, flash floods, landslides, swollen rivers, and windstorms across multiple Dzongkhags. These events caused extensive damage to bridges, roads, farm infrastructure, and residential structures.

While no major human casualties have been confirmed, two persons were reported missing in Haa Dzongkhag due to flash floods in Sertena, Gakiling Gewog. The southern and western regions, particularly Samtse, Chukha, Haa, and Dagana were among the most severely affected.

A. Transport infrastructure damages

The deluge caused extensive damage and disruption to highways, farm roads, and bridges rendering them either impassable or completely washed away.

1. Damages to Bridges:

Multiple bridges either sustained structural damages or have been completely washed away. 29 bridges (17 bailey bridges, six suspension bridges, three culvert bridges, and three wooden bridges). The summary below categorizes the affected bridges based on their type and the extent of damage sustained.

SN	Bridge	Gewog	Dzongkhag	Remarks
1	Jitey Khola Bailey bridge (1)	Sangnagcholing	Samtse	Washed away
2	Jiti Khola Culvert bridge	Sangnagcholing,	Samtse	Washed away
3	Jiti khola Bailey bridge (2)	Sangnagcholing,	Samtse	Damaged

4	Denchukha Bailey bridge	Denchukha	Samtse	Washed away
5	Damji-Denchukha Suspension bridge	Denchukha	Samtse	Washed away
6	Namchu Bailey bridge	Dumtey	Samtse	Washed away
7	Ngangladrang Suspension bridge	Norbugang	Samtse	Washed away
8	Kuchi-Diana Bailey bridge	Ugyentse	Samtse	Damaged
9	Somchu Wooden bridge	Gakiling	Haa	Washed away
10	Amochu Bailey bridge	Gakiling	Haa	Washed away
11	Somchu Bailey bridge	Gakiling	Haa	Washed away
12	Sherchu Bailey bridge	Gakiling	Haa	Washed away
13	Babuna Culvert bridge	Gakiling	Haa	Washed away
14	Somchu Suspension bridge (near Thangdokha)	Gakiling	Haa	Washed away
15	Sertena Suspension bridge	Gakiling	Haa	Washed away
16	Lamjeygang Wooden bridge	Samar	Haa	Washed away
17	Getanachu Bailey bridge	Bongo	Chukha	Washed away
18	Toktogom Bailey bridge	Bongo	Chukha	Damaged
19	Pachu-Lingdhen Bailey bridge	Phuntsholing	Chukha	Washed away

20	Nyechu Bailey bridge	Phuntsholing	Chhukha	Damaged
21	Jigmechu-Pipping Suspension bridge	Darla	Chhukha	Damaged
22	Chiyuel-Pangserla Bailey bridge	Getena	Chhukha	Washed away
23	Tomichu Bailey bridge	Logchina	Chhukha	Washed away
24	Hatigar Bailey bridge	Logchina	Chhukha	Washed away
25	Menlungpa Bailey bridge	Metakha	Chhukha	Washed away
26	Wooden Bridge in Ekerwog	Gangtey	Wangduephodrang	Damaged
27	Ula Bailey bridge	Rubisa	Wangduephodrang	Washed away
28	Menchugang Suspension bridge	Chokhor	Bumthang	Damaged
29	Jakar crematorium culvert bridge	Chokhor	Bumthang	Washed away

2. Status of highways and dzongkhag roads:

While concerned agencies have since managed to restore connectivity on most highways, many of the major highways remain closed to vehicular movement today. Details are provided below:

SN	Name of the Road	Location	Status
1	Dorokha-Phutsena SNH	Multiple roadblocks at Namchukhola due to washing away of bridge and RCC Culvert	Closed
2	Lhamoizingkha-Dagapela SNH	Multiple roadblocks including at chainage 46.1(Samarchu) due to wash out of road base width	Closed
3	Haa-Samtse SNH	Multiple roadblocks Between the stretch	Closed
4	Khamana-Sombayama DR	Roadblocks along the stretch	Closed
5	Somhaykha Dungkhag-Gakidling DR(Haa Dz	Multiple roadblocks Between the stretch	Closed
6	Tshangkha DR (Dagana Dz)	Roadblock at the stretch. Expected to opened at 5 PM	Closed
7	Getena DR (Chukha Dz.)	Multiple road block along the stretch	Closed
8	Ganglakha- Dungna DR (Chukha Dz)	Multiple road block due to washing away of Tomichu bridge and Malamchu bridge with multiple blocks	Closed
9	Denchukha DR (Samtse Dz.)	Road blocks due to washing of Denchukha bailey suspension bridge	Closed
10	Thimphu-Phuntsholing AH (Damchu-Chukha bypass)	Multiple road blocks reported along the stretch	Closed
11	Trongsa- Gelephu PNH	Roadblock at chainage 15km from Gelephug(boxcut) Expected to be cleared by 12.00 PM tomorrow	Closed

B. Damages to electricity and telephone connectivity

Electricity and telephone services have been disrupted across many parts of the country. Restoration efforts are ongoing; however, several areas still remain without power or communication. Power outages were reported in 28 locations. BPC personnel have managed to restore electricity fully in 18 locations, partially in six, while four other locations remain under blackout. Details of the affected locations are provided below:

1. Places where electricity supply was disrupted

Sl.#	ESD	Outage Location	Status Update
1	Paro	Soe and Lingzhi Gewog (33kV Drugyel- Lingzhi fdr)	Partly restored
		Lower Tsendona (11kV Tsendona feeder)	Supply restored
		Jashina and Pangkha	Supply restored
2	Punakha	Laya	Partly restored
3	Gelephu	Lodari near Army colony for Esd Gelephu (Reported Power outage as on 5.10.25 at 1:00 pm.)	Supply restored
		Sasbotey (Rural) under ESSD Sarpang (Reported as on 05.10.2025, 8:30:00 AM)	Supply restored
4	Wangduephodrang	Taksha Silli, Adha, Jalla, Ulla	Supply restored
5	Haa	Sombeykha and Gakeling	Still under blackout
6	Trongsa	Nikachu	Supply restored
		Langthel feeder:Villages affected Jangbe-143, Baling-75 under Langthel gewog. Nimshong-103, Korphu-105, Nabji 89 under Korphu gewog.	Supply restored

7	Dagana	Dagana, Gesarling, Drujeygang, Lajab feeder, S.F feeder	Supply restored
		Part of Lhamoizingkha and Karmaling Gewog	Supply restored
8	Pemagatshel	Mekuri, Telung, Tshobaly, Gongdu Daksa, Durungri	Supply restored
9	Samtse	Dorokha, Tendruk and Norgaygang, rural areas in Samtse and Gomtu	Partly restored, Denchukha still in blackout
		11kV Tendruk Norgaygang Feeder (Tendruk and Norgaygang Gewog)	Supply restored
10	Tsirang	33kV Tsholingkhar feeder (Towards Gosarling Gewog and Part of Semjong)	Partly restored
		33kV Dunglagang Feeder (Kherithang)	Supply restored.
		33kV Rangthangling Feeder	Supply restored
13	Mongar	11kV Chali Feeder (Chali gewog, Tsakaling gewog, Tsamang Gewog and part of Saling gewog)	Supply restored
16	Phuentsholing	Toorsa (11kV Trading feeder)	Still under blackout
		Metakha and Dungna (33 kV Serina Bosokha feeder)	Still under blackout
17	Gedu	Gurungdara II, 33kV Feeder	Partly restored
		Chungkha Feeder	Partly restored
19	Zhemgang	33kV Zhemgang Feeder	Supply restored
		33kV Dakpai Feeder	Supply restored
20	Wangdue	Feeder 3 (Basochhu)	Supply restored
21	Tashichhoeling	11kV Tendruk Norgaygang Feeder (Tendruk and Norgaygang Gewog)	Supply restored
22	Thimphu	11kV Tsheluna feeder	Still under blackout

Telephone connectivity has been restored in many areas out of the 236 sites that were initially reported without service. As of the latest update, only 34 Bhutan Telecom (BT) sites and 11 TashiCell (TCell) sites remain without connectivity. Details of the affected sites are provided below:

2. Places where Bhutan telecom connectivity hasn't been restored:

No.	Region/Dzongkhag	Site Name	Count
1	Thimphu	Jangthodrubegang, Bjadodosagang, Sey, Sogaygochungmo, Lingzhi Chukana, Lingzhi Exchange	6
2	Chukha/ Phuentsholing	Toorsa	1
3	Samtse	Mipdupoktor, Gibjee, Setipakha, Nimanong, Kirney Top	5
4	Haa	Moochu1, Anakha Goenpa, Sertena, Pungthra, Nakha, Suchu, Gakiling	7
5	Dagana	Tanabji, Susigang	2
6	Gasa	Laya Tokto	1
		Total	**22**

3. Places where TashiCell connectivity has not been restored

No	Region/Dzongkhag	Site Name
1	Haa	Yangtshena
2	Haa	Suchhu
3	Samtse	Khempatop
4	Samtse	Denchukha
5	Samtse	Gebji
6	Samtse	Pungthra
7	Sarpang	Burgangchu
8	Laya	Malateng_
9	Lhuentse	Singye Dzong

C. Agriculture and livestock damages:

Beyond infrastructure, the floods also inflicted severe damage on agricultural and livestock in several parts of the country, destroying standing crops and affecting local food security.

1. Damages to livestock

Livestock losses, including the death of pigs, poultry, and cows as well as damage to fishery ponds were reported in several Dzongkhags. Details are provided below:

Sl. #	Dzongkhag	Livestock Casualty
1	**Dagana**	2 Oxen dead
2	**Samtse**	65 pigs & 15 cows, 167-layer birds, 14 goats, 50 local poultry
3	**Tsirang**	3 fishery ponds destroyed
4	**Haa**	1 calf dead
5	**Chhukha**	1 fishery pond & 2 bee hives damaged, and 7 goats dead

2. Damages to agriculture

Floods caused damage to paddy fields, cardamom and orange orchards, as well as vegetable gardens, affecting agricultural production in several areas. Following are the details of agricultural damages:

No	Dzongkhag	Crops Damages (in acres)							
		Maize	Paddy	Cardamom	Oranges	Mangoes	Buckwheat/ millet	Asparagus	Crops
1	Dagana	0.05	8.27	20.45	1.12				
2	Chukha	4.65	5.74	6.50	0.72 + 70 trees	1.0	0.82		2.47
3	Tsirang	0.40	1.00	0.20					
4	Bumthang						1.2		
5	Samtse		2.50						
6	Wangduephodrang		1.91		8 trees				0.5
7	Zhemgang	14.98					0.3		
8	Paro		0.30					0.35	
	Total	20.08	19.72	27.15	1.84 + 78 trees	1.0	2.32	0.35	2.97

D. Damages to houses and other structures

Recent rainfall across dzongkhags has caused structural damage affecting houses, public facilities, and cultural heritage sites. Details of these damages are given below:

No	Dzongkhag	Structure damages	Location	
			Village	Gewog
1	Samtse	One house washed away	Kyidsa	Norbugang
		Drinking water source of Norbugang Higher Secondary School damaged	Norbugang	Norbugang
2	Chukha	One-storied house damaged	Dungna	Dungna
		One-storied house damaged	Logchina	Logchina
3	Haa	2 mining camps washed away	Sertena	Gakiling
		One Bungalow completely damaged	Anakha	Sangbay
4	Bumthang	Toilet and bedroom of one house damaged	Jambay Lhakhang	Choekhor
		Kitchen partially damaged	Norbugang	Choekhor
5	Punakha	Retaining wall of farm road washed away	Zobesa	Kabjisa
6	Wangduephodrang	Irrigation Channel and RWSS washed away	Bjena	Bjena
		RWSS source washed away	Beldrog	Kazhi
7	Tsirang	Roof of dining hall blown off	Patshaling PS	Patshaling
		Kitchen roof damaged	Neymedsa	Rangthangling
		One kitchen collapsed	Tsholingkhartoed	Tsholingkhar
8	Zhemgang	Roof of one house blown off	Phangkhar	Phangkhar

		Dzongdag's residence partially damaged	Zhemgang town	Trong
9	Dagana	Drinking water source for Daga Throm & Dzong area completely washed away	Daga town	Tseza
		One house collapsed	Lhaling	Kana
		One retaining wall damaged & one house rooftop blown off	Norbuling	Tashidhing
		One house damaged	Akhochen	Khebisa
		Retaining wall of a house damaged	Gangzur	Tsendagang
10	Paro	Protection wall collapsed	Ringpung Dzong	Hungrel
		Retaining wall collapsed	Eutok Goenpa	Shaba
		Boundary wall collapsed & major cracks on main entrance gate	Gewog Office	Naja
		Approximately 500 meters of Irrigation Channel were destroyed	Jeebji-Loonchena,	Dotey
		River protection wall and concrete foot path with railing were affected	Phakilo	Hungrel
		Steps leading towards the Lhakhang entrance have collapsed	Gomdralo Gonpa	Shaba
		Inundation of ECCD structures and chain-link boundary fencing at one side completely damaged	Tsendona	Lango
		Debris caused	Jazhina,	Naja

		the collapse of a private structure (Hut)	Singoen	
11	Phuntsholing Thromde	56 stockyards damaged	Amochu	Phuntsholing Throm

E. Damages of machineries, plants and equipment

Losses of machinery were also reported, including damage to crusher plants, trucks, cranes, payloaders, and rollers. Below are the details of the machineries and equipment affected:

S/no	Vehicles/Machine/equipment	Numbers
1	Excavator	15
2	Trucks	30
3	Small vehicles	10
4	Motor bikes	9
5	Crusher plants	5

F. Human casualty

Tragically, two lives have been confirmed lost and one is reported missing and one injured. Details are given below:

Sl. #	Dzongkhag	Human Casualty
1	Haa	1 dead and 1 missing. 1 body recovered on 6-Oct-2025 from Cooch Bihar
2	Wangduephodrang	1 washed away by swollen stream in Kazhi
3	Bumthang	1 injured by fallen plank

G. Relief Measures

Families residing in the National Workforce Centre and temporary quarantine housing have been relocated in Kidu housing colony. Authorities in other affected Dzongkhags are also providing relief measures; details are yet to be received.

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