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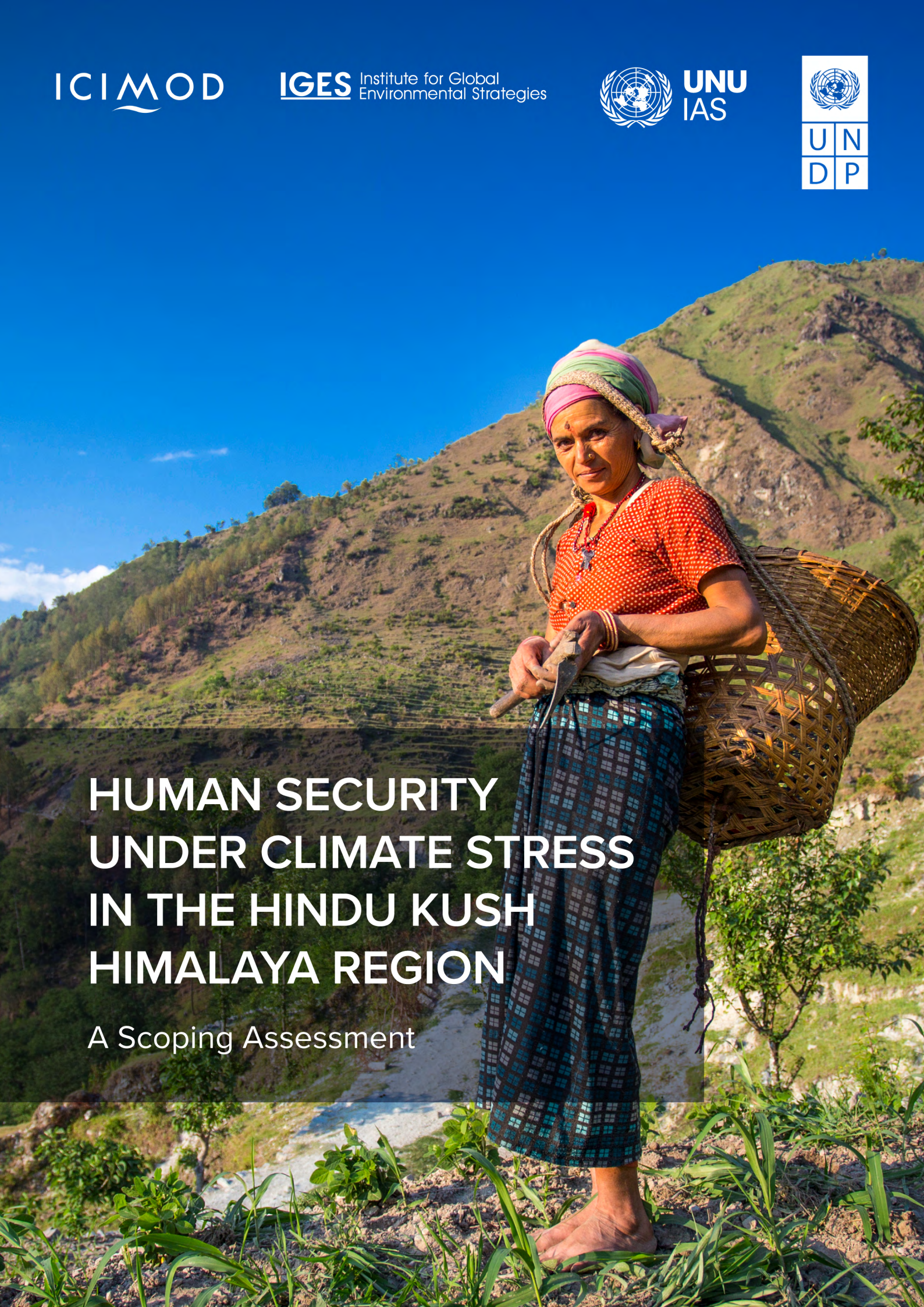

HUMAN SECURITY UNDER CLIMATE STRESS IN THE HINDU KUSH HIMALAYA REGION

A Scoping Assessment

Notes

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In this report, the notion of human security is used in the broad, people-centred definition that has emerged through the work of the United Nations Development Programme and Commission on Human Security, rather than the more conventional understanding of security that is defined in terms of sovereignty, border protection, state institutions, conflict, and armed forces. Here, it is an overarching lens for examining how multiple dimensions of human wellbeing, including access to food, water, health services, secure livelihoods, and freedom from pervasive fear and want, are affected by climatic and socio-economic changes. In this usage, the emphasis on protecting the "vital core" of people's lives is closely linked to the expansion of substantive freedoms and capabilities, and to the conditions under which individuals and communities can exercise agency in responding to climate and environmental stress.

The IPCC's Fifth and Sixth Assessment Reports converge on a similar analytical treatment, in which human security is understood as the cumulative outcome of interactions between climate hazards and societal factors that shape exposure, sensitivity, and adaptive capacities. Within this framing, climate change operates as a "threat multiplier" that heightens existing risks to human development and social stability primarily by eroding wellbeing, undermining livelihoods, and disrupting access to essential services. This approach of human security allows the assessment to foreground how climate stress reconfigures the opportunity sets, constraints, and coping strategies of people living in Afghanistan, India, Nepal, and Pakistan, and to analyse these dynamics in relation to broader questions of equity and climate justice.

Acknowledgements

This Scoping Assessment Report on “Human Security under Climate Stress in the Hindu Kush Himalaya Region” has been jointly prepared by the United Nations Development Programme (UNDP), the International Centre for Integrated Mountain Development (ICIMOD), the Institute for Global Environmental Strategies (IGES), and United Nations University (UNU). This joint effort demonstrates a shared commitment to addressing the complex nexus of climate change and human security in the Hindu Kush Himalaya (HKH) region.

The collaborating institutions acknowledge with gratitude the contributions of the experts, researchers, and practitioners from across the HKH countries whose technical inputs, field experiences, and analytical perspectives have enriched this report. We are immensely grateful to the government officials, civil society organizations, and community representatives who participated in the Country Consultation Workshops and focus group discussions (FGDs) in the four focus countries (Afghanistan, India, Nepal, and Pakistan) for their engagement and valuable feedback during the assessment process. Their willingness to share local realities, traditional knowledge, and ground-level data provided invaluable depth and context. We are sincerely thankful to the UNDP Country Offices, The Council on Energy, Environment and Water (CEEW) in India, and Sustainable Development Policy Institute in Pakistan for facilitating the conduct of the workshops and providing us with detailed transcripts of the discussions.

Special appreciation goes to the experts from the focus countries who have spared their valuable time and knowledge on the subject by participating in virtual interview sessions. We acknowledge valuable inputs provided by Padmashree Dr. Eklabya Sharma, Strategic Advisor and Senior Fellow at Ashoka Trust for Research in Ecology and the Environment (ATREE); Mr. Lokendra Thakkar, Chief Scientific Officer, Environmental Planning & Coordination Organization (EPCO), Government of Madhya Pradesh; Mr Supongnukshi (IFS), Chief Conservator of Forests (CCF), Department of Environment, Forest & Climate Change, Government of Nagaland; Mr. Mihin Dollo, Senior Manager (Natural Resources), North Eastern Region Community Resource Management Society (NERCORMS) Shillong, Meghalaya; Mr. R. R. Rashmi, Distinguished Fellow, The Energy and Resources Institute (TERI), New Delhi; Dr. Indu K. Murthy, Sector Head - Climate, Environment and Sustainability, Center for Study of Science, Technology and Policy (CSTEP); Mr. Rehmat Ali, Sustainable Development Policy Institute (SDPI); and a Gilgit Resident, Pakistan, Ms. Zunaira Fayyaz, environmentalist and lawyer. Their experiences and perspectives were instrumental in contextualizing climate stress and human security aspects of this assessment.

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We gratefully acknowledge the financial contributions and administrative support that made this regional assessment possible. This work was primarily supported by UNDP. The authors also acknowledge the financial support from ICIMOD as well as the Ministry of Foreign Affairs, Japan, under the research project “Analysis of the transformation of the security environment triggered by climate change and Japan’s diplomatic and security approach” (2023–2025), to carry out part of this research work.

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- Authors

Executive Summary

Human security in the Hindu Kush Himalaya (HKH) region confronts unprecedented challenges as climate change fundamentally alters the environmental foundations upon which nearly two billion people depend. The study area, spanned four countries of the HKH region, namely Afghanistan, India, Nepal, and Pakistan, which provide water resources through ten major river basins and harbour some of the world's most climate-vulnerable populations. This assessment examines human security challenges across the four focus countries which represent diverse vulnerabilities and adaptive capacities. The assessment applied an integrated framework developed to analyse how climate impacts cascade across interconnected food, water, and energy systems to create compound threats exceeding individual sectoral impacts.

The Hindu Kush Himalaya has warmed by 1.8°C compared to 1.1°C globally, with glaciers disappearing 65% faster in the 2010s than in previous decades. The effects of warming create escalating threats - the 682 glacial lake outburst flood (GLOF) events documented between 1833-2022 killed 6,907 people, while the unprecedented frequency of 2025 events, three major GLOFs within months, shocked experts accustomed to historical occurrence rates of once every 5-10 years. Projections indicate potential loss of 30-80% of current glacial mass by 2100 under various emission scenarios, fundamentally transforming the region's hydrological systems. Snow cover is declining rapidly, with earlier snowmelt creating mismatches in the timing of water availability and agricultural demand. The 2025 season marked the region's lowest snow persistence in 23 years. Compound climate extremes are intensifying: the 2022 pre-monsoon heat wave affected 1 billion South Asians; the 2022 Pakistan floods affected 33 million people and caused USD 30 billion in damages; and Afghanistan experienced its third consecutive drought year with annual droughts becoming the norm across large areas. These accelerating changes exceed historical bounds, challenging traditional agricultural knowledge systems and adaptation strategies developed over centuries.

On the basis of these climatic trends, this report integrates human security concepts with systems thinking to address how climate impacts propagate through interconnected systems. The Food-Water-Energy (FWE) nexus underpins human wellbeing, with water emerging as the central organizing principle in mountain regions. The Indus, Ganges, and Brahmaputra depend fundamentally on glacier-fed flows which are experiencing rapid changes. Existing water treaties, negotiated on twentieth-century hydrological baselines, fail to reflect accelerating glacier retreat and changing seasonality. Livelihood security mediates between environmental changes and human wellbeing outcomes, the concept encompassing natural, physical, human, financial and social capitals which determine adaptive capacity. Climate change disrupts both resource systems and traditional knowledge, creating conditions where established coping mechanisms prove insufficient. Agricultural livelihoods demonstrate complex pathways where climate impacts extend beyond direct production effects to disrupt traditional indicators, seasonal labour patterns, and market relationships. Women face particular vulnerabilities through their roles in water collection, agricultural production, and resource management, although their currently limited land ownership and access to adaptation resources, hinder their capacity to respond to the direct effects of a changing climate on livelihood. Migration operates simultaneously as an adaptation strategy and indicator of system breakdown. It covers a spectrum from seasonal labour migration integrated into livelihoods, to situations of permanent displacement reflecting adaptation failure. The assessment framework distinguishes climate-induced migration, employed as an adaptive response to gradual change, from climate-driven displacement as a crisis-driven involuntary movement. Projections suggest that 62 million South Asians will migrate due to climate disasters by 2050, with Nepal alone expecting 1.3 million climate migrants by 2050, more than three times 2006-2020 baseline rates. Threshold analysis enables identification of critical tipping points where incremental adaptation proves insufficient and systemic transformation becomes necessary. Glacier systems in multiple regions approach irreversible retreat, regardless of future emissions. Groundwater systems in several urban areas face depletion, threatening traditional patterns of use. Agricultural systems confront conditions where traditional varieties and practices become unviable, requiring fundamental livelihood transformations.

Through the analytical framework, country-specific case studies provide a snapshot of the broader regional vulnerabilities.

Nepal exemplifies concentrated vulnerabilities of small mountain nations, with 90% glacial water dependency and 47 potentially dangerous glacial lakes (42 in the high-risk Koshi basin). Agriculture employs 61.2% of the population, generating 25-27% of GDP while facing unprecedented variability exceeding historical bounds. Kathmandu Valley's water demand of 360 million litres daily far exceeds the current supply of 90-140 million litres, with the 2021 Melamchi Water Supply Project disaster demonstrating how extreme events can destroy adaptation investments. Nepal derives 87% of electricity from hydropower, creating a vulnerability to single-point failure, despite its significant clean energy potential. Climate-driven migration of approximately 500,000 Nepalis annually generates remittances totalling NPR 879.3 billion (22.7% of GDP), providing crucial household buffers while potentially reducing adaptation investment incentives. Gender dimensions are particularly pronounced as women face increased workloads, with water collection time increasing from 30 minutes to over 3 hours during dry seasons, while they own only 19.7% of agricultural land, and control 5% of total land area. Current climate finance flows of USD 48.52 million annually represent a small fraction of the estimated USD 2.3 billion annual adaptation needs, leaving finance gaps exceeding 95%.

Afghanistan exemplifies compound vulnerabilities where climate change intersects with conflict, institutional fragility, and international isolation. The country ranks 15th globally on the Climate Risk Index with 15.3 million people food insecure (40% of population) and 5 million displaced as of the first quarter of 2025. Approximately 70% of water resources derive from glacial and snowmelt sources which are experiencing rapid changes, with the third consecutive drought year indicating that annual droughts may become normative. Conflict has severely disrupted agricultural infrastructure and irrigation systems while weakening traditional water management institutions. The intersection of climate and conflict creates adaptive challenges where insecurity prevents the implementation of climate measures while climate impacts exacerbate resource competition fuelling local conflicts. Afghanistan's current political context has created significant challenges for directly accessing multilateral climate finance mechanisms, despite the country's minimal greenhouse gas contributions and very high climate vulnerability. At the same time, ongoing UN- and partner-supported initiatives demonstrate that regional and intermediary channels can still help deliver climate-relevant support to communities in ways that are consistent with evolving international engagement frameworks. The challenges faced by women in terms of mobility, education, and economic participation have reduced their ability to access formal adaptation resources, even as they continue to be directly exposed to climate impacts through their roles in agriculture, water management, and caregiving.

Pakistan demonstrates challenges of managing climate risks in large, populous countries with significant economic constraints and transboundary dependencies. The country ranks 8th on the Climate Risk Index, with 35.2 million at risk and annual economic losses of 1.9% of GDP. Approximately 72% of water resources derive from glacial and snowmelt sources, with the Indus basin depending on glacier melt for up to 90% of summer flows. The catastrophic 2022 floods affecting 33 million people and causing USD 30 billion damages, demonstrated how single extreme events overwhelm national response capacity and create long-lasting development setbacks. Agriculture employs 38% of population and contributes 23% of GDP, but is facing multiple stresses including temperature increases, changing precipitation patterns, and a frequency of extreme weather events exceeding traditional system design parameters. Energy security faces challenges from both hydropower vulnerability to hydrological variability (27% of electricity from hydro) and operational constraints on water-cooled thermal plants during low-flow periods. Climate-induced displacement operates at massive scales, with the 2022 floods alone displacing 8 million people internally, while urban areas experience rapid population growth reflecting both the search for economic opportunities and climate-driven rural displacement. Pakistan's estimated climate finance needs of USD 30-60 billion by 2030 vastly exceed current resources, while significant debt burdens constrain fiscal space for adaptation investments.

India illustrates the complexity of addressing climate adaptation in diverse federal systems with substantial technical capacity but massive scale challenges. The country ranks 7th on the Climate Risk Index with 175.8 million people at risk in the Himalayan regions alone, encompassing 13 Indian States/Union Territories with diverse vulnerabilities. India contains 55 potentially dangerous glacial lakes posing GLOF risks to downstream communities; the 2021 Uttarakhand flood killed over 200 and destroyed the Tapovan Dam, demonstrating the threat of potentially catastrophic events. Water security affects both mountain communities and hundreds

of millions in the densely populated Indo-Gangetic Plain, with groundwater systems facing unprecedented extraction pressures as surface water becomes less reliable. India achieved historic renewable energy growth, adding a record 29.52 GW in FY 2024-25 to reach 220.10 GW total (world's 4th largest producer), yet hydropower vulnerability creates risks when extreme events damage infrastructure designed for historical climate conditions. Agricultural challenges vary across diverse Himalayan regions, with consultation findings emphasizing the lack of inter-departmental coordination and an absence of integrated policy addressing these challenges. Social strictures significantly shape adaptive capacity, with caste and gender determining water access and resource rights, while indigenous innovations, including the 'ice stupas' of Ladakh, represent significant potential lacking government recognition.

Faced with these challenges, effective response requires institutional transformation addressing the systemic and interconnected nature of climate impacts. Elements of this transformation may include basin-level resource councils with cross-sectoral mandates which could coordinate water allocation, hydropower development, and agricultural planning while incorporating climate projections into decisions. Early warning systems must integrate across hazard types and jurisdictional boundaries, combining technical monitoring with community-based observation networks. Gender-responsive planning must recognize women as adaptation agents rather than vulnerable beneficiaries, ensuring participation in resource allocation decisions while addressing structural barriers limiting their access to adaptation resources and a decision-making voice. Climate finance mechanisms require fundamental transformation to address the massive gaps between available resources and adaptation needs. Direct access modalities should enable sub-national governments and community organizations to access international funds without multiple intermediaries. Innovative instruments, including green bonds, climate-linked sovereign debt, and risk-sharing mechanisms, can mobilize private resources. Loss and damage finance mechanisms addressing climate impacts exceeding adaptation capacity require development - as demonstrated by the amounts needed for Pakistan's 2022 flood reconstruction vastly exceeding available assistance. Technology transfer must address both hardware and software dimensions, including physical technologies, technical knowledge, institutional capacities, and social arrangements enabling effective implementation. Renewable energy technologies require adaptation for mountain contexts with small-scale distributed systems appropriate for remote areas. Water technologies, including efficient irrigation, storage systems, and treatment facilities appropriate for mountain communities, need deployment at scale. Agricultural technologies including climate-resilient varieties and soil conservation practices should reach farmers through participatory approaches. Indigenous innovation, its documentation and scaling, together represent critical but often-overlooked potential.

Regional cooperation emerges as an imperative given transboundary climate impacts on shared rivers, and through migration flows and economic linkages. Existing water treaties require fundamental transformation to address climate-altered hydrological conditions. Enhanced cooperation on climate-induced migration could facilitate safe labour mobility supporting adaptation in both origin and destination areas. Technology and knowledge sharing through South-South cooperation could scale successful practices across the region. Regional climate finance coordination could enhance access to international funds while supporting shared adaptation priorities.

The Hindu Kush Himalaya confronts unprecedented climate-induced transformations requiring systemic rather than incremental responses. The region's accelerating changes exceed global averages, with warming levels, glacier retreat, and the frequency of extreme events approaching and crossing critical thresholds beyond which adaptation becomes enormously more difficult and costly. What is required is systemic transformation, integrating climate adaptation across all development dimensions, building resilience at multiple scales, addressing the root causes of vulnerability including poverty and inequality, enabling transformative institutional and technological change, and recognizing adaptation as continuous adaptive management rather than discrete projects. The knowledge, technologies, and resources exist to support managed adaptation preserving human security and dignity, but mobilizing them requires political will, institutional innovation, and international solidarity at scales not yet demonstrated. The imperative is clear: climate security in the Hindu Kush Himalaya requires urgent, integrated regional action with international support commensurate with both vulnerability and climate justice imperatives.

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1. Introduction

Urban floods in the Kathmandu Valley October, 2024.
Photo: Jitendra Raj Bajracharya/ICIMOD.

Human security in the twenty-first century confronts unprecedented challenges as climate change fundamentally alters the environmental foundations upon which billions of people depend for their survival and wellbeing. The Hindu Kush Himalaya (HKH) region, encompassing Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan, represents a critical laboratory for understanding how climate impacts propagate through complex socio-ecological systems to create cascading threats to human security. This mountain system, often designated as the "Third Pole" due to its extensive ice coverage outside the polar regions, provides water resources that support nearly two billion people across Asia while harbouring some of the world's most climate-vulnerable populations.[1] This assessment focuses on four countries representing diverse climate vulnerabilities and adaptive capacities across the Hindu Kush Himalaya region: Afghanistan, India Nepal, and Pakistan.

The conceptualization of human security has evolved significantly since its introduction in the 1994 United Nations Development Programme (UNDP) Human Development Report, which defined it as protection of "the vital core of all human lives in ways that enhance human freedoms and human fulfilment",[2] and represented a fundamental reorientation of security discourse from territorially bounded state protection to individual and community-level vulnerabilities and capabilities. Such a shift, that ensures the focus on people rather than states, is especially critical in the context of climate change, where environmental stressors transcend political boundaries. The Commission on Human Security (CHS) established by the UN Secretary General in 2001 further refined this concept to emphasize both protection from critical and pervasive threats and empowerment of people to take charge of their own lives. However, climate change introduces novel forms of systemic disruption that challenge existing human security frameworks, requiring new analytical approaches that can address the interconnected nature of climate impacts across multiple domains of human wellbeing. Subsequent reports (HDRs 2007/8, 2023/24) recognize climate change as central to human security challenges but apply, rather than reframe, the 1994 definition, treating climate as a cross-cutting threat that exacerbates economic, food, health, environmental, and other security dimensions without narrowing human security exclusively to climate concerns.

Contemporary research establishes that human security faces unprecedented challenges from climate change. For instance, the UNDP Human Development Report 2023-24 projects that 40-190 million people are expected to die because of higher temperatures under moderate to high emissions scenarios by the end of the century,[3] with impacts projected to be highly unequal. Regions such as South Asia are expected to see sharp increases in mortality rates while developed regions may experience net reductions. This spatial inequality reflects the fundamental injustice of climate change, where those least responsible for emissions face the greatest threats to their security and wellbeing.

1 ICIMOD (2019). The Hindu Kush Himalaya Assessment Report. International Centre for Integrated Mountain Development.

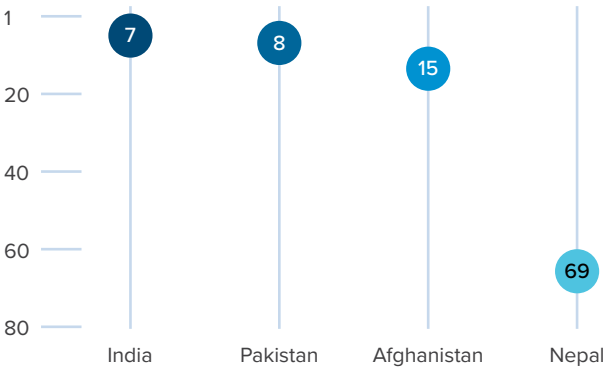
2 United Nations Development Programme. (1994). Human Development Report 1994. https://www.undp.org/publications/human-development-report-1994

3 United Nations Development Programme. (2024, March 14). Human Development Report 2023/24. UNDP Nepal. https://www.undp.org/nepal/publications/human-development-report-2023-24

Table 1: Climate Vulnerability Indicators for Countries in Study Area

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA
Population at Risk	8.5 million *(World Bank 2021)*	15 million *(IOM 2024)*	35.2 million *(NDMA 2023)*	175.8 million *(IPCC AR6 2022)*
Annual Economic Loss	2.8 % GDP *(Germanwatch 2025 and World Bank 2022)*	6.1 % GDP *(World Bank and FAO 2020-23)*	1.9 % GDP *(World Bank 2022)*	0.8 % GDP *(CEEW 2023)*
Climate Displacement	1.3 million by 2050 *(World Bank 2022)*	5 million (Q1 2025) *(IOM 2024)*	8 million in 2022 *(World Bank 2022)*	Variable *(IDMC)*
Glacier Dependence	90% *(ICIMOD 2019)*	70% *(FAO 2020)*	72% *(IWMI 2023)*	45% *(IPCC AR6 2022)*

Climate Risk Index Rank (2025)



Source: Germanwatch 2025

The Hindu Kush Himalaya region exemplifies the challenges of the impacts of climate change to human security with multiple climate vulnerabilities creating compound risks exceeding the capacity of institutional arrangements based on traditional risk management approaches.[4] The Indus, Ganges, Brahmaputra, and other major rivers originating in the Hindu Kush Himalaya provide water resources for agricultural systems supporting over 1.5 billion people.[5] Changes in seasonal flow patterns, reduced dry season availability, and increased variability create water security challenges that propagate through agricultural systems, urban water supplies, and hydroelectric generation across multiple countries. These transboundary impacts require regional coordination mechanisms that can address shared vulnerabilities while respecting national sovereignty and diverse institutional arrangements.

Although the countries in the HKH region face similar challenges, the challenges confronted by each differ based on the underlying geographical and institutional structures. Nepal represents a high-altitude nation with extreme dependence on glacial water resources and limited adaptive capacity. Afghanistan exemplifies compound vulnerabilities where climate change intersects with conflict, institutional fragility, and international isolation. Pakistan demonstrates the challenges of managing climate risks in a large, populous country with significant economic constraints and transboundary water dependencies. India illustrates the complexity of addressing climate adaptation in a diverse federal system with substantial technical capacity but massive scale challenges.

The theoretical framework developed for this analysis integrates human security concepts with systems thinking approaches to create a comprehensive understanding of climate-induced vulnerabilities and adaptive responses. The framework recognizes four interconnected dimensions that determine human security outcomes under climate stress, namely (1) the Food-Water-Energy (FWE) nexus that provides the material components for human wellbeing, (2) livelihood systems that mediate between resource availability and welfare outcomes, (3) systemic resilience mechanisms that determine adaptive capacity, and (4) migration dynamics that represent both adaptation strategies and system breakdown indicators.

This human security analysis also draws on findings from UNDP's climate mobility projections[6] produced using the INCLUDE model, a spatial modelling framework designed to examine how climate change and development trajectories shape internal migration over time. The model compares population patterns under development-only futures with those that also incorporate climate impacts on water availability, agriculture, and ecosystems, allowing it to identify where climate change is likely to influence movement, concentration, or immobility within countries. By exploring multiple plausible futures that combine different socioeconomic pathways and emissions trajectories, the analysis highlights how mobility outcomes vary depending on policy choices, economic conditions, and exposure to climate stress. Integrating these projections into the human security report provides a forward-looking perspective on where pressures on livelihoods, urban systems, and regional stability may intensify, complementing current vulnerability and governance assessments with anticipatory evidence to support planning, prevention, and risk-informed responses.

4 Mishra, A., Appadurai, A. N., Choudhury, D., Regmi, B. R., Kelkar, U., Alam, M., ... & Sharma, U. (2019). Adaptation to climate change in the Hindu Kush Himalaya: Stronger action urgently needed. In The Hindu Kush Himalaya assessment: Mountains, climate change, sustainability and people (pp. 457-490). Cham: Springer International Publishing.

5 Sharma, A., & Manhas, N. S. (2025). Environmental Security Complex in the Hindu-Kush Himalayas: A Regional Perspective. Strategic Analysis, 49(1), 34–46. https://doi.org/10.1080/09700161.2025.2511432

6 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

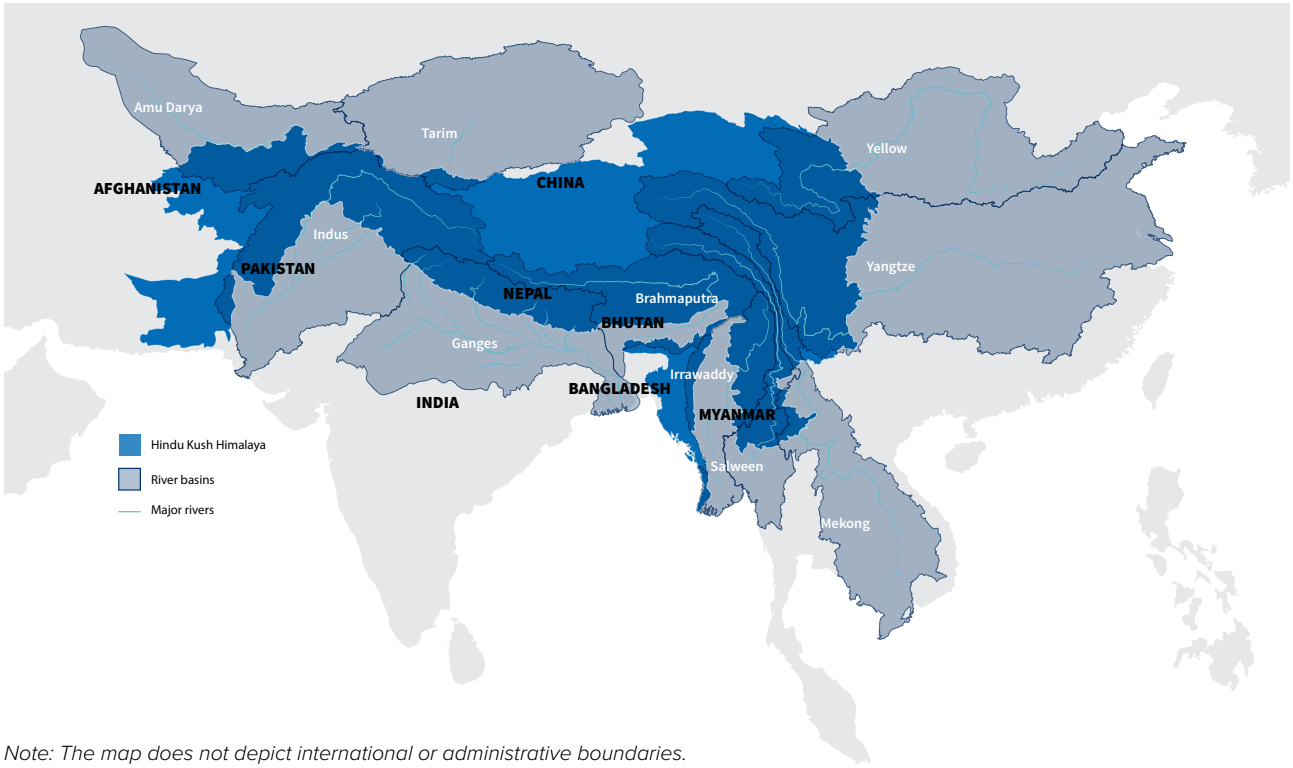
2. Environmental Context and Climate Projections for the HKH

Mahakali flood, Darchula district, in Nepal's far west, bordering India. Photo: Jitendra Raj Bajracahrya/ICIMOD

2.1 Environmental Setting and Climate Trends

The Hindu Kush Himalaya region encompasses over 4.3 million square kilometres of some of Earth's most complex and climatically sensitive terrain, containing approximately 54,000 glaciers that store more ice and snow than anywhere outside the polar regions.[7] This vast mountain system extends across eight countries and feeds ten major river basins that provide water resources supporting nearly two billion people across Asia, making regional climatic stability crucial for continental-scale human security. The region's designation as the "Third Pole" reflects both its massive ice reserves and its critical importance for global climate regulation and regional water cycles.

Map 1: The ten major river systems and their basin boundaries in the Hindu Kush Himalaya



Note: The map does not depict international or administrative boundaries.
Source: ICIMOD

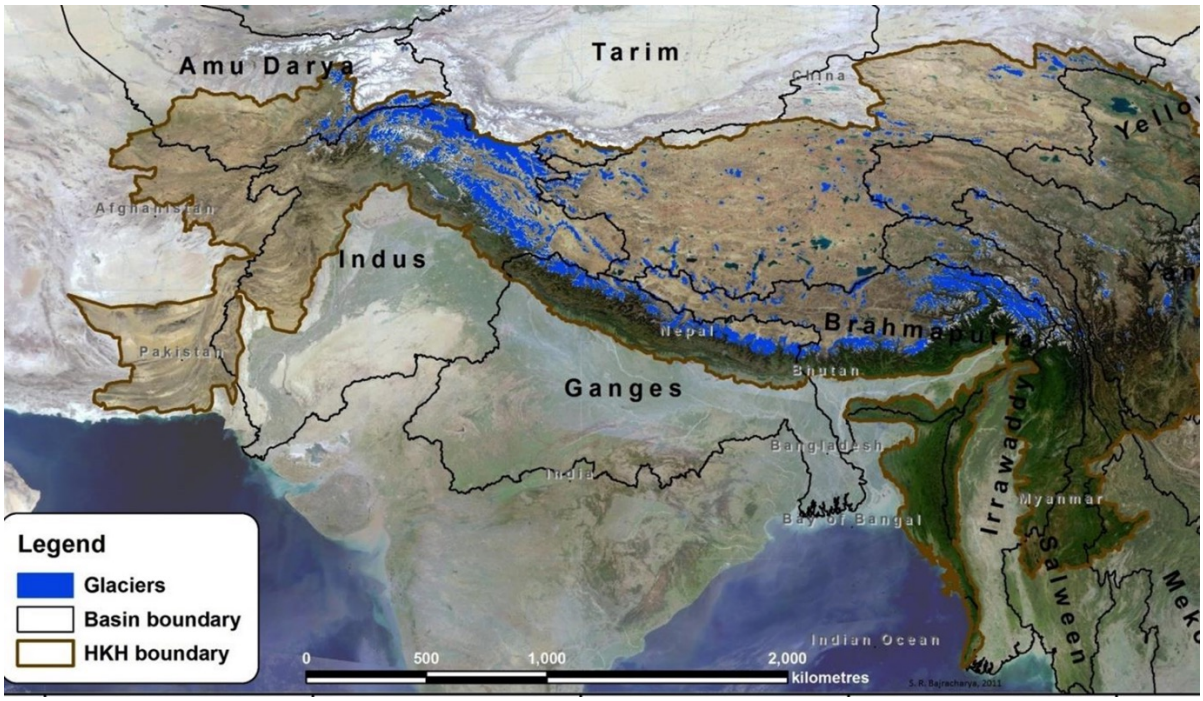
Historical climate observations reveal that the Hindu Kush Himalaya has experienced warming rates significantly above global averages, with temperatures increasing by 1.8°C over the past half-century compared to 1.1°C globally.[8] This enhanced warming reflects elevation-dependent warming effects common in mountain regions, where high-altitude areas experience more rapid temperature increases due to reduced atmospheric density, changes in surface albedo as snow and ice retreat, and altered atmospheric circulation patterns. Analysis of temperature trends in the HKH across elevation gradients demonstrates that warming rates increase with altitude, with high-altitude stations experiencing warming rates 0.2-0.3°C per decade higher than valley locations.[9] The warming trend shows no signs of abating, with recent decades experiencing some of the most rapid temperature increases on record. The elevation-dependent nature of this warming means that high-altitude areas critical for glacier formation and snow accumulation are experiencing the most rapid temperature increases, creating conditions that favour accelerated ice loss and reduced seasonal water storage capacity.

7 ICIMOD (2019). The Hindu Kush Himalaya Assessment Report. International Centre for Integrated Mountain Development.

8 Singh, SP; Bassignana-Khadka, I; Karky, BS; Sharma, E. (2011). Climate change in the Hindu Kush-Himalayas: The state of current knowledge. Kathmandu: ICIMOD

9 Sabin, T.P. *et al.* (2020). Climate Change Over the Himalayas. In: Krishnan, R., Sanjay, J., Gnanaseelan, C., Mujumdar, M., Kulkarni, A., Chakraborty, S. (eds) Assessment of Climate Change over the Indian Region. Springer, Singapore. https://doi.org/10.1007/978-981-15-4327-2_11

Map 2: Distribution of glaciers in the ten major river basins of the Hindu Kush Himalaya



Note: The map does not depict international or administrative boundaries.
Source: ICIMOD

Temperature projections for the HKH indicate continued warming well above global averages, with potentially catastrophic implications for cryosphere stability and water security. Even under scenarios that successfully limit global warming to 1.5°C consistent with Paris Agreement targets, the HKH is projected to experience warming of at least 2.1°C, with northwestern regions including the Karakoram experiencing warming of 2.7°C or higher.[10] Under higher emission scenarios, regional warming could reach 4-5°C by century's end, which would fundamentally transform the region's hydrological systems and render many current adaptive strategies obsolete.[11] The enhanced high-altitude warming has direct implications for glacier mass balance, snow cover persistence, and the timing of seasonal snowmelt that feeds major river systems across the region.

Precipitation patterns across the HKH exhibit high spatial variability and complex temporal trends that reflect the region's diverse topographic and climatic conditions. The region receives moisture from multiple sources including the Indian summer monsoon, Mediterranean westerlies, and local convective systems that interact with complex topography to create highly variable precipitation patterns. Summer monsoon precipitation dominates in eastern and southern parts of the region, while winter westerlies provide crucial snowfall in western and northwestern areas. Climate change is altering these precipitation patterns in ways that have profound implications for water security and agricultural systems across the region. Monsoon precipitation is becoming more variable in timing and intensity, with delayed onset, increased intra-seasonal variability, and more frequent extreme precipitation events that can cause flooding and erosion rather than contributing to groundwater recharge.[12] Winter precipitation patterns are shifting toward more rainfall and less snow at middle elevations, reducing seasonal water storage and increasing immediate runoff that can contribute to flood risks during winter months.[13] The implications of these climatic changes for water security are already becoming apparent across the region. River flow regimes are shifting toward earlier peak flows as snowmelt occurs sooner

10 Krishnan, R., Shrestha, A. B., Ren, G., Rajbhandari, R., Saeed, S., Sanjay, J., & et al. (2019). Unravelling Climate Change in the Hindu Kush Himalaya: Rapid Warming in the Mountains and Increasing Extremes. Springer.

11 International Centre for Integrated Mountain Development (ICIMOD). (2019). Hindu Kush Himalaya Assessment: Climate Change, Sustainability and People. Kathmandu, Nepal.

12 Ullah, W., Haberlandt, U., Ptak, M., & Bruy, M. (2023). "An increasing trend in daily monsoon precipitation extremes in South Asia attributed to increased atmospheric forcing." Frontiers in Environmental Science, 11, 1228817. https://doi.org/10.3389/fenvs.2023.1228817

13 Carbon Impacts. (2025). "Rising Heat and Shifting Western Disturbances Fuel Extreme Weather in Himalayas." Retrieved from https://carbonimpacts.info

in the year, reducing water availability during traditional dry seasons when demand is highest.[14] Springs that have provided reliable water sources for mountain communities for generations are drying up as groundwater recharge patterns change and underground flow systems are disrupted by temperature increases.[15] Urban areas throughout the region are experiencing water shortages as traditional supply sources become unreliable and demand increases with population growth and economic development.

Extreme weather events are becoming more frequent and intense across the HKH, with particular increases in heat waves, intense precipitation events, and drought conditions that exceed historical variability. The World Meteorological Organization's State of the Climate in Asia 2024 report identifies the region as experiencing unprecedented combinations of extreme weather including record-breaking temperatures, intense flooding, and prolonged drought conditions that affect millions of people across multiple countries.[16] Western and southwestern Afghanistan saw more frequent sand and dust storms than average, possibly linked to long-term drought conditions.

These environmental changes directly undermine human security by destabilizing the resource foundations, especially water availability, agricultural production systems, and energy generation, upon which over 1.5 billion people depend. The magnitude and pace of change increasingly exceed the adaptive capacity of institutions designed for stable environmental conditions, creating conditions where climate stress translates into governance challenges, resource competition, and potential displacement.

2.2 Cryosphere Changes and Water Security Implications

The cryosphere represents the most climate-sensitive component of the HKH system, with glaciers, snow cover, and permafrost experiencing rapid changes that have immediate and long-term implications for regional water security. Recent research demonstrates that glacial retreat has accelerated dramatically, with Hindu Kush Himalayan glaciers disappearing 65% faster in the 2010s compared to previous decades.[17] Field, satellite, and weather records confirm that 9% of ice area present in the early 1970s had disappeared by the early 2000s, with accelerating loss rates in recent years indicating that the pace of change is increasing.[18] Glacial mass balance measurements across the region reveal predominantly negative trends, with most glaciers experiencing net ice loss over multi-year periods. The rate of mass loss varies significantly across different sub-regions, with eastern Himalayan glaciers generally experiencing more rapid retreat than western Karakoram glaciers. The western Karakoram region has historically exhibited an exceptional pattern wherein glaciers have remained stable or have even gained mass, normally termed as the Karakoram Anomaly. This anomaly was sustained due to concentrated snowfall in high-altitude conditions, combined with protective debris cover that reduced melt rates.[19] However, recent evidence indicates that this anomaly is now reversing, as between 2018-2023, the majority of Karakoram glaciers started retreating and experienced sudden mass deficits, falling into the overall regional trend that indicates accelerating ice loss.[20]

14 Khanal, S., Lutz, A. F., Kraaijenbrink, P. D. A., van den Hurk, B., Yao, T., & Immerzeel, W. W. (2021). "Variable 21st century climate change response for rivers in High Mountain Asia at seasonal to decadal time scales." Water Resources Research, 57, e2020WR029266. https://doi.org/10.1029/2020WR029266

15 Thapa, B., et al. (2023). "Drying of Springs in the Himalayan Region of Nepal." Mountain Research and Development, 43(4), 1-10. https://doi.org/10.1659/mrd.2023.00007

16 World Meteorological Organization (WMO). *State of the Climate in Asia 2024* (WMO-No. 1373). Geneva, 2025.

17 ICIMOD. (2023). *Water, ice, society, and ecosystems in the Hindu Kush Himalaya: An outlook.* (P. Wester, S. Chaudhary, N. Chettri, M. Jackson, A. Maharjan, S. Nepal, & J. F. Steiner [Eds.]). ICIMOD. https://doi.org/10.53055/ICIMOD.1028

18 ibid

19 Wang, J., Xu, B., Li, Z., Nasir, J., Farhan, S. B., Wang, M., et al. (2025). The interpretation of Karakoram anomaly by high Karakoram ice core record. *Journal of Geophysical Research: Atmospheres*, 130, e2023JD040235. https://doi.org/10.1029/2023JD040235

20 Zhou, S., Sun, Z., Abowarda, A. S., Aletoum, E., Huang, Q., Lin, X., & Liu, G. (2025). Has the Karakoram anomaly persisted over the past two decades? *GIScience & Remote Sensing, 62*(1). https://doi.org/10.1080/15481603.2025.2548059

Projections of future glacial change under different emission scenarios paint an alarming picture of continued and accelerating ice loss throughout the 21st century. Even under optimistic scenarios limiting global warming to 1.5°C, the region could lose 30% of its current glacial mass by 2100, while under high emission scenarios, losses could reach 70-80% of current ice volume.[21] Such massive glacial retreat would fundamentally alter regional hydrology, with implications for seasonal water availability, flood hazards, and water quality that extend far beyond mountain areas to affect downstream populations across multiple countries. Snow cover patterns are also changing rapidly across the HKH, with significant implications for seasonal water storage and agricultural systems that depend on snowmelt-fed irrigation. Satellite observations reveal declining snow cover extent and earlier snowmelt timing across most of the region, with particularly pronounced changes at middle elevations where temperature increases are causing more precipitation to fall as rain rather than snow. The 2025 observations indicate the region experienced its lowest snow persistence in 23 years, marking the third consecutive year of below-normal seasonal snow accumulation.[22]

The timing of snowmelt is shifting earlier in the year across much of the region, with peak snowmelt occurring 1-2 weeks earlier than historical averages in many watersheds.[23] This earlier timing creates mismatches between water availability and agricultural demand, as traditional planting schedules assume later snowmelt timing that provided irrigation water during critical growing periods. Earlier snowmelt also increases the risk of water scarcity during late summer and autumn months when agricultural water demand remains high, but natural water sources are reduced.

Permafrost degradation represents an additional component of cryosphere change that affects slope stability, infrastructure integrity, and hydrological processes across high-altitude areas of the HKH. Warming temperatures are causing permafrost to thaw at increasing depths and across wider areas, leading to increased landslide risks, infrastructure damage, and changes in subsurface water flow patterns. Permafrost thaw can also release stored carbon and contribute to greenhouse gas emissions that further accelerate climate change through positive feedback effects.

The hydrological implications of cryosphere change extend far beyond immediate water availability to affect water quality, sediment transport, and ecosystem services across major river basins. Glacial retreat increases sediment loads in rivers as newly exposed moraines and rock surfaces become available for erosion. Changing snowmelt timing affects river temperature regimes and dissolved oxygen levels that influence aquatic ecosystems and the requirements for treatment of water for human consumption. These changes create additional challenges for water management systems that must adapt to both changed water quantity and quality conditions, particularly in transboundary river basins where water allocation frameworks are increasingly inadequate for climate-altered realities. The Indus Waters Treaty (1960) and Ganges Waters Treaty (1996) were both negotiated based on 20th-century hydrological baselines that do not reflect accelerating glacier retreat and changing seasonality. The Indus basin depends on glacier melt for up to 90% of summer flows, and eastern river basins see accelerated mass loss on lower-altitude glaciers that will substantially reduce availability after mid-century. This would fundamentally disrupt the fixed allocation percentages upon which decades of regional cooperation depend.[24] The cascading impacts of earlier snowmelt peaks, intensified sediment loads from newly exposed moraines, altered river temperatures affecting water treatment, and extreme precipitation events now challenge the bilateral coordination mechanisms that were designed for stable, predictable flows.

21 ICIMOD. (2023). *Water, ice, society, and ecosystems in the Hindu Kush Himalaya: An outlook.* (P. Wester, S. Chaudhary, N. Chettri, M. Jackson, A. Maharjan, S. Nepal, & J. F. Steiner [Eds.]). ICIMOD. https://doi.org/10.53055/ICIMOD.1028

22 Muhammad, S. (2025). HKH Snow Update 2025. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. https://doi.org/10.53055/ICIMOD.1087

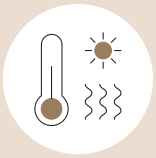
23 Wang, H., Wang, B. B., Cui, P., Ma, Y. M., Wang, Y., Hao, J. S., ... & Li, C. Y. (2024). Disaster effects of climate change in High Mountain Asia: State of art and scientific challenges. *Advances in Climate Change Research, 15*(3), 367-389.

24 Gain, A. K., Immerzeel, W. W., & Ludwig, F. (2017). "Implications of climate change for water resources of transboundary river basins in South Asia." Water Resources Management, 31, 4565-4580.

The destabilization of cryosphere-dependent water systems has direct implications for regional stability and human security. Transboundary river systems originating in the HKH support populations across multiple countries, meaning that upstream glacial retreat creates downstream water insecurity that can exacerbate existing resource allocation tensions and challenge cooperative frameworks designed for predictable hydrological conditions. As water scarcity intensifies, the potential for resource competition, both within and across borders, escalates, particularly where institutional mechanisms for water sharing lack adaptive capacity.

2.3 Extreme Weather Events and Compound Risks

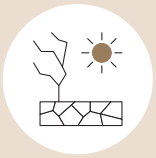
Compound risks impacting human security in the HKH region



Heat waves

2022 pre-monsoon heat wave:

affected over 1 billion people across South Asia, with temperatures above 45 °C, straining power, crops, and health systems.



Drought

2023 Afghanistan droughts:

third consecutive year of drought-like conditions, compounding existing vulnerabilities related to conflict, weak institutions, and limited adaptive capacity.

Extreme precipitation

2022 Pakistan floods:

affected over 33 million people, causing more than $30 billion in damage and overwhelming national response capacity.

Glacial lake outburst floods

High Mountain Asia GLOFs:

682 events recorded since 1833, with a recent acceleration alarming scientists and hazard managers.

The HKH region is experiencing increased frequency and intensity of extreme weather events that create compound risks exceeding the impacts of individual hazards. Heat waves are becoming more frequent, intense, and longer-lasting across the region, with particularly severe impacts in lower-elevation areas where population densities are higher and cooling resources are limited. The 2022 pre-monsoon heat wave affected over 1 billion people across South Asia, with temperatures exceeding 45°C across multiple countries and creating conditions that stressed power grids, reduced agricultural productivity, and increased health risks for vulnerable populations.[25]

Extreme precipitation events are also increasing in frequency and intensity, creating flood risks that exceed the design capacity of existing infrastructure systems and emergency response mechanisms. The 2022 floods in Pakistan affected over 33 million people and caused damages exceeding USD 30 billion, demonstrating the potential for single extreme events to overwhelm national response capacity and create long-lasting impacts on development progress.[26] Similar events have affected multiple countries across the region, with flood damages increasing due to combinations of more intense precipitation, inadequate drainage infrastructure, and increasing exposure of populations and assets in flood-prone areas. Drought conditions are becoming more frequent and severe across many parts of the Hindu Kush Himalaya, with particularly severe impacts

25 Bal, S.K., Prasad, J.V.N.S and Singh, V.K. (2022). Heat wave 2022 Causes, impacts and way forward for Indian Agriculture. Technical Bulletin No. ICAR/ CRIDA/ TB/01/2022, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana, India, p50.

26 Cui, P., Bazai, N.A., Qiang, Z. *et al.* Flood risk assessment with machine learning: insights from the 2022 Pakistan mega-flood and climate adaptation strategies. npj Nat. Hazards 2, 42 (2025). https://doi.org/10.1038/s44304-025-00096-1

in rain-fed agricultural areas and regions dependent on groundwater resources. Afghanistan experienced its third consecutive year of drought-like conditions in 2023, with annual droughts expected to become the norm across large areas. These drought conditions compound existing vulnerabilities related to conflict, institutional fragility, and limited adaptive capacity, creating conditions where climate impacts have disproportionate effects on human wellbeing.[27] The combination of extreme heat and drought creates particularly severe compound risks that can overwhelm adaptive capacity even when individual hazards remain manageable. Heat-drought combinations stress both human and natural systems simultaneously, reducing agricultural productivity while increasing cooling demands that strain energy systems and reduce water availability for multiple uses. These compound events are becoming more frequent and severe across the region, creating conditions that exceed the design assumptions of existing infrastructure and emergency response systems.

Glacial lake outburst floods (GLOFs) represent a unique category of extreme event that is increasing in frequency and impact as glacial retreat creates larger and more unstable glacial lakes. The comprehensive documentation of GLOFs in High Mountain Asia reveals 682 individual events between 1833-2022, with a recent acceleration in event frequency that has alarmed scientists and hazard management experts.[28] Nepal has identified 21 potentially dangerous glacial lakes, while northern Pakistan has 33 glacial lakes at risk of catastrophic failure. These lakes can release millions of cubic meters of water suddenly, causing devastating floods that destroy infrastructure and displace communities hundreds of kilometres downstream. Traditional GLOF risk assessment approaches based on lake size and dam characteristics may be inadequate under rapidly changing conditions when small, newly formed lakes can pose significant risks. Recent events have been caused by supraglacial lakes that form rapidly on glacier surfaces and may be too small to detect using standard satellite monitoring systems. This evolution in hazard characteristics requires adaptive monitoring and risk management approaches that can respond to changing conditions rather than assuming stable hazard patterns based on historical experience.

The broader regional climate context includes air pollution effects that accelerate glacial melting through deposition of black carbon and other light-absorbing particles on snow and ice surfaces. The Indo-Gangetic Plain, one of the world's most polluted regions, regularly exports aerosols to the HKH that reduce surface albedo and enhance warming effects. This pollution feedback represents an additional stressor that compounds greenhouse gas-driven warming and creates regional climate impacts that persist even if global emissions are reduced. Climate projections indicate that current trends will intensify over the coming decades, with particularly severe implications for the four focus countries of this analysis. Afghanistan faces projections of continued temperature increases above global averages, with annual maximum and minimum temperatures rising faster than mean temperatures. Pakistan's northern regions, which depend heavily on glacier and snow melt for water supplies, face projections of 50% reductions in wheat yields in some areas by 2050 without adaptation measures.[29] Nepal's middle hills are experiencing changes in crop suitability zones as traditional varieties become unviable at historical growing elevations.[30] India's Himalayan regions face increasing risks of glacial lake outburst floods and water scarcity as glacial water sources diminish.

27 United Nations Office for the Coordination of Humanitarian Affairs. (2025, January 9). *Afghanistan: Humanitarian Update, November 2024.* https://www.unocha.org/publications/report/afghanistan/afghanistan-humanitarian-update-november-2024

28 Shrestha, F., Steiner, J. F., Shrestha, R., Dhungel, Y., Joshi, S. P., Inglis, S., Ashraf, A., Wali, S., Walizada, K. M., and Zhang, T.: A comprehensive and version-controlled database of glacial lake outburst floods in High Mountain Asia, Earth Syst. Sci. Data, 15, 3941–3961, https://doi.org/10.5194/essd-15-3941-2023, 2023.

29 Khan, Fahad. (2025). Pakistan's Climate Change Crisis: Climate-Induced Events, Cloud Burst, Glacial Lake Outburst Floods and Critical Responses. Journal of Environment, Climate, and Ecology. 2. 10.69739/jece.v2i2.986.

30 Subedi, A., Raut, N., & Gurung, S. (2023). How Himalayan communities are changing cultivation practices in the context of climate change. *Regional Sustainability, 4(*4), 378-389.

These environmental changes occur within the context of existing vulnerabilities that amplify climate impacts. The region's mountain populations often depend on climate-sensitive livelihoods including rain-fed agriculture, pastoralism, and forest-based activities that have limited buffering capacity against environmental variability. Infrastructure systems including roads, bridges, and buildings are frequently inadequate to withstand extreme weather events that are becoming more frequent and intense. Limited institutional capacity for disaster preparedness and response means that climate impacts often overwhelm local coping mechanisms and require external assistance that may not be readily available.

The increasing frequency and intensity of extreme weather events directly threaten human security by overwhelming institutional response capacity and displacing vulnerable populations. Compound events, such as simultaneous heat stress and water scarcity, create cascading failures that propagate across food systems, energy infrastructure, and urban services, generating conditions where emergency responses prove inadequate and populations face choices between remaining in degraded environments or undertaking risky migration. These dynamics illustrate how biophysical changes could translate into governance crises and into potential conflicts over diminishing resources.

2.4 Regional Research on Hindu Kush Himalaya Climate Impacts

The International Centre for Integrated Mountain Development (ICIMOD) has produced extensive research on climate change impacts in the Hindu Kush Himalaya region, including the comprehensive Hindu Kush Himalaya Assessment Report that provides authoritative analysis of climate trends, impacts, and adaptation needs across the region. The assessment demonstrates that the Hindu Kush Himalaya has experienced temperature increases of 0.28°C per decade since the 1950s, significantly above global averages, with projections indicating continued warming of at least 2.1°C even under optimistic global warming scenarios.[31]

ICIMOD's cryosphere research reveals that Hindu Kush Himalayan glaciers disappeared 65% faster in the 2010s compared to previous decades, with 9% of ice area present in the early 1970s having disappeared by the early 2000s. Projections suggest that 70-80% of current glacier volume will disappear by 2100 under high emission scenarios, while even under optimistic scenarios limiting global warming to 1.5°C, the region could lose 30% of its glacial mass.[32] This glacial retreat has immediate implications for seasonal water availability and longer-term consequences for water security across major river basins supporting nearly two billion people.

Research on glacial lake outburst floods demonstrates that the Hindu Kush Himalaya faces increasing GLOF risks as warming temperatures destabilize moraine-dammed lakes formed by glacial retreat. The comprehensive High Mountain Asia GLOF reveals that 20% of documented GLOFs were recurring events from just three ephemeral ice-dammed lakes, indicating that some glacial systems pose repeated risks that require ongoing monitoring and preparedness measures.[33]

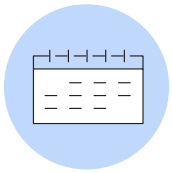
31 ICIMOD (2019). The Hindu Kush Himalaya Assessment Report. International Centre for Integrated Mountain Development.

32 ICIMOD. (2023). *Water, ice, society, and ecosystems in the Hindu Kush Himalaya: An outlook.* (P. Wester, S. Chaudhary, N. Chettri, M. Jackson, A. Maharjan, S. Nepal, & J. F. Steiner [Eds.]). ICIMOD. https://doi.org/10.53055/ICIMOD.1028

33 Shrestha, F., Steiner, J. F., Shrestha, R., Dhungel, Y., Joshi, S. P., Inglis, S., Ashraf, A., Wali, S., Walizada, K. M., and Zhang, T.: A comprehensive and version-controlled database of glacial lake outburst floods in High Mountain Asia, Earth Syst. Sci. Data, 15, 3941–3961, https://doi.org/10.5194/essd-15-3941-2023, 2023.

Table 2: Glacial Lake Outburst Flood Statistics in the Study Region

(Source: ICIMOD[34])

	 Documented GLOFs (1833-2022)	 Potentially Dangerous Glacial Lakes	 Fatalities (Historical)	 Population at Risk	 Recent Major Events
NEPAL	89	21	487	2.1 million	2024 Thyanbo
PAKISTAN	156	33	890	7.2 million	2022 Hunza
INDIA	78	15	623	1.8 million	2023 Sikkim
AFGHANISTAN	23	8	156	0.9 million	2020 Panjshir
CHINA	201	134	3891	15.3 million	2020 Jinwuco
TOTAL (HKH)	682	211	6907	27.3 million	2025 Multiple

34 https://rds.icimod.org/Home/DataDetail?metadataId=1973283

Recent ICIMOD analysis indicates an alarming acceleration in GLOF events, with scientists expressing deep concern over the rapid rise in glacial-origin flood events across the region. The back-to-back floods in Nepal's Rasuwa and Upper Mustang districts within 24 hours in 2025 shocked hazard experts who described such frequency as "completely unprecedented".[35] Historically, GLOFs occurred once every 5-10 years in the region, but this pattern has changed dramatically with May-August 2025 alone witnessing three separate glacial-origin floods affecting Nepal, Afghanistan, and Pakistan.[36] ICIMOD research reports emphasize that lake size is no longer a reliable indicator of GLOF threat, with recent events caused by small, newly formed supraglacial lakes that may be too small to detect using freely available satellite imagery. The organization's 2020 assessment identified potentially dangerous glacial lakes based on size criteria of 0.02 km^2, but recent events involving smaller lakes suggest that risk assessment methodologies require updating to account for rapidly changing conditions under accelerated climate change.[37]

The organization's work on climate services demonstrates that mountain regions require specialized approaches to climate information and early warning systems due to complex topographic effects on weather patterns, limited observational networks, and high spatial variability in climate conditions. ICIMOD's regional cooperation initiatives demonstrate both the potential for transboundary collaboration on mountain development and the challenges of implementing coordinated responses across multiple countries with different political systems, development priorities, and institutional capacities. Research conducted through the Mountain Partnership and other regional networks demonstrates that mountain communities possess extensive traditional knowledge for managing environmental variability, but climate change introduces conditions that exceed the bounds of historical experience. The Five Years of Action for the Development of Mountain Regions (2023-2027) and its framework[38] for mountain regions, as announced by the United Nations General Assembly, recognizes that climate change acts as a risk multiplier that interacts with other pressures including population growth, economic development, and globalization to influence mountain landscape security. The framework emphasizes the generation of evidence on human mobility in mountain contexts while increasing dialogue and cooperation among mountain communities sharing common ranges.

The pace of environmental change documented by regional research demonstrates that climate impacts are outpacing both scientific projections and institutional adaptation capacity. The accelerating glacial retreat and unprecedented frequency of recent GLOF events, coupled with changing monsoon patterns, indicate that the HKH region is entering a period and conditions without recent precedent, leading to circumstances where traditional risk management approaches may prove inadequate and human security will depend on institutional innovation and regional cooperation that can address compound, transboundary risks.

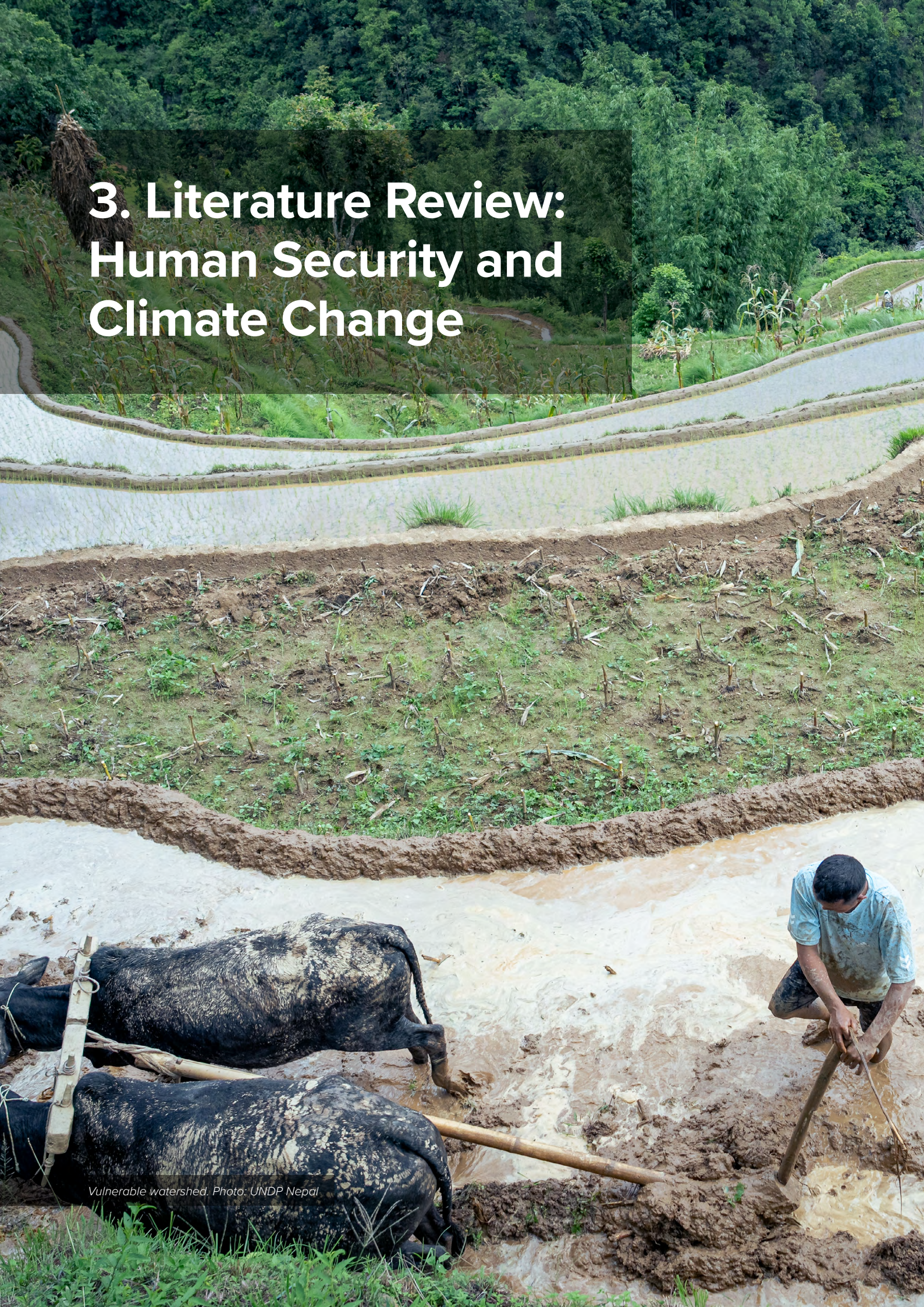
35 https://www.spotlightnepal.com/2025/07/11/icimods-researchers-say-nepal-being-hit-by-two-floods-within-24-hours-completely-unprecedented-researchers-say/

36 https://thehimalayantimes.com/environment/scientists-alarmed-by-surge-in-glacial-lake-floods-across-the-himalayas

37 Bajracharya, S.R., Maharjan, S.B., Shrestha, F., Sherpa, T.C., Wagle, N., Shrestha, A.B. (2020). Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali River Basins of Nepal, the Tibet Autonomous Region of China, and India. Research Report. ICIMOD and UNDP.

38 Food and Agriculture Organization of the United Nations. (2023). Global Framework for the Five Years of Action for the Development of Mountain Regions 2023–2027. FAO. https://openknowledge.fao.org/server/api/core/bitstreams/409a6e90-ec6a-4a1b-8251-69834f43a063/content

3. Literature Review: Human Security and Climate Change



Vulnerable watershed. Photo: UNDP Nepal

Approaches to human security under climate stress require fundamental reconceptualization beyond the traditional frameworks that emerged in the post-Cold War security discourse. The Commission on Human Security's foundational definition of protecting "the vital core of all human lives in ways that enhance human freedoms and human fulfilment" assumes particular complexity in climate-vulnerable mountain regions where environmental degradation directly undermines the basic means for human existence. Climate change transforms the actual and conceptual landscapes by introducing what can be characterized as "systemic stressors" that operate across temporal and spatial scales, creating conditions where traditional distinctions between emergency response and development planning become obsolete.[39] O'Brien and Leichenko's (2000) analysis of human security under climate stress, argues that climate change represents "an unprecedented threat to human security" due to its capacity (through rapid change and increasing uncertainty) to undermine the development of human capabilities.[40] Their work establishes important conceptual foundations for understanding vulnerability to climate change as influenced by multiple processes of global change that interact with local conditions to create complex patterns of risk and opportunity.

The human security paradigm's emphasis on "freedom from fear and freedom from want" acquires heightened relevance in the Hindu Kush Himalaya context, where climate-induced environmental changes simultaneously threaten physical safety through increased disaster risks and economic security through disrupted livelihood systems. However, the standard seven-dimensional framework of human security, which encompasses economic, food, health, environmental, personal, community, and political security, requires integration with systems thinking that recognizes the dynamic interdependencies among these domains under climate stress. The conventional approach of treating these dimensions as discrete analytical categories fails to capture how climate change generates cascading effects that propagate across all domains simultaneously.

Figure 1: Human Security Aspects[41]

39 Collier, S. J., & Lakoff, A. (2021). *The government of emergency: Vital systems, expertise, and the politics of security.* Princeton University Press.

40 O'Brien, K. & Leichenko, R. (2000). Double exposure: assessing the impacts of climate change within the context of economic globalization. Global Environmental Change, 10(3), 221-232.

41 Koundouri, P., Aslanidis, PS., Dellis, K. *et al.* Mapping human security strategies to sustainable development goals: a machine learning approach. *Discov Sustain 6,* 96 (2025). https://doi.org/10.1007/s43621-025-00883-w

Contemporary research on cascading climate risks provides crucial insights for refining how we conceptualize human security in mountain regions. Cascading risks emerge when climate hazards trigger "a sequence of secondary, causally connected events" that propagate beyond the initial impact zone, potentially amplifying disruptions across interconnected systems.[42] In the HKH, such cascading effects manifest when glacier retreat reduces downstream water availability, forcing agricultural communities to exhaust groundwater resources, which in turn degrades soil productivity and triggers out-migration that destabilizes urban labour markets in destination areas. These cascading impacts operate across multiple temporal scales; immediate hazard cascades occur through extreme events such as earthquakes, avalanches and GLOFs which trigger secondary hazards such as landslides and debris flows that, in turn, threaten settlements and infrastructure leading to displacement. On the other hand, slower, multi-decade cascades as a result of climate-driven environmental degradation, transform entire livelihood systems through water depletion, soil loss and forced migration. These interconnected disruptions cannot be adequately addressed through sectoral interventions that fail to account for systemic interdependencies. The integration of threshold analysis into human security frameworks also represents a critical methodological advancement for climate-vulnerable regions. Traditional resilience concepts[43] assume that systems can absorb disturbances and return to previous states, but climate change introduces conditions where such return may neither be possible nor desirable. Instead, human security in climate-stressed environments requires recognition of "critical thresholds" beyond which system transformations become irreversible.[44] These thresholds operate at multiple scales: individual households may cross poverty thresholds that permanently alter their adaptive capacity; community water systems may experience depletion levels that cannot support traditional livelihoods; and regional glacier systems may reach tipping points where ice loss accelerates regardless of global mitigation efforts.

The methodological implications of threshold-based human security analysis extend beyond conceptual refinement to operational practice. Effective interventions require the capability to distinguish between "risks" that remain within a system's absorption capacity and "threats" that exceed resilience thresholds and trigger system-wide transformations.[45] This distinction has profound implications for intervention design and resource allocation , as risk management strategies focus on strengthening system buffers and adaptive capacity, while threat response requires emergency intervention and system transformation. The failure to make this distinction often results in inadequate responses that attempt to apply incremental adaptations to situations requiring fundamental system reorganization.

The empowerment dimension of human security assumes particular importance in climate-vulnerable mountain communities where traditional coping mechanisms may become obsolete under changing environmental conditions. The Commission on Human Security's emphasis on "strategies that enable people to develop their resilience to difficult situations" must account for the reality that climate change can render traditional resilience strategies ineffective. Indigenous communities in the HKH possess extensive knowledge systems for managing environmental variability, but rapid climate change introduces conditions that exceed the bounds of historical experience.[46] Human security approaches must therefore balance respect for traditional knowledge with recognition that novel climatic conditions may require entirely new adaptive strategies. Such challenges necessitate that global scientific advances and new best practices on climate action inform, and are integrated appropriately into, tailored local interventions in order to best respond to climate change. The spatial dimensions of human security under climate change require particular attention in transboundary regions like the Hindu Kush Himalaya. Climate impacts routinely cross political boundaries, impacting shared water systems, migration flows and economic linkages, and creating situations where national human security policies may be insufficient to

42 Lawrence, J., Blackett, P., & Cradock-Henry, N. A. (2020). Cascading climate change impacts and implications. *Climate Risk Management, 29*, 100234.

43 Joakim, E. P., Mortsch, L., & Oulahen, G. (2015). Using vulnerability and resilience concepts to advance climate change adaptation. *Environmental Hazards, 14*(2), 137-155.

44 Werners, S. E., Pfenninger, S., van Slobbe, E., Haasnoot, M., Kwakkel, J. H., & Swart, R. J. (2013). Thresholds, tipping and turning points for sustainability under climate change. *Current opinion in environmental sustainability, 5*(3-4), 334-340.

45 Naylor, A., Ford, J., Pearce, T., & Van Alstine, J. (2020). Conceptualizing climate vulnerability in complex adaptive systems. *One Earth, 2*(5), 444-454.

46 Poornima, R., Ramakrishnan, S., Priyatharshini, S., Poornachandhra, C., John, J. E., Ramya, A., & Dhevagi, P. (2024). Climate change implications in the Himalayas. In *The Himalayas in the Anthropocene: Environment and development* (pp. 237-277). Cham: Springer Nature Switzerland.

address transnational challenges.[47] The 2022 floods in Pakistan demonstrated how extreme weather events in mountainous regions can displace millions of people and disrupt regional supply chains, affecting human security conditions far beyond the immediate impact zone through multiple pathways.[48] The floods led to agricultural supply-chain disruptions affecting food-supply agreements with Afghanistan, generated infrastructure damage to shared hydropower systems, creating energy security risks - and population displacement and regional insecurity.[49] Such transboundary effects, operating across economic, demographic and sociological linkages, necessitate regional approaches to human security that can coordinate responses across multiple jurisdictions and institutional frameworks.

The intersection of climate change and human security has emerged as a critical area of scholarly inquiry, with substantial theoretical and empirical contributions from leading international organizations and research institutions. The conceptual foundations for understanding climate-human security linkages draw upon diverse disciplinary perspectives including environmental security studies, development economics, political ecology, and resilience theory. Building upon the review, this section also organizes the findings and approaches of international institutions such as the UNDP, the Intergovernmental Panel on Climate Change (IPCC) and the International Organization on Migration (IOM), to demonstrate how different international frameworks have conceptualized and operationalized human security in relation to climate change, providing comparative perspectives on definitions, analytical approaches, and implementation strategies that inform the integrated framework developed for this analysis.

3.1 UNDP Human Security Framework and Climate Applications

The United Nations Development Programme (UNDP) has played a crucial role in developing and operationalizing human security approaches to climate change through both conceptual work and practical implementation projects. UNDP's human security framework emphasizes the protection of individuals and communities from critical and pervasive threats while simultaneously empowering people to take charge of their own development and security needs.[50] This dual emphasis on protection and empowerment provides important guidance for climate adaptation strategies that must address both immediate vulnerabilities and longer-term capacity building needs.

UNDP's Adaptation Policy Frameworks (APF) for Climate Change[51] establish four major principles that provide foundations for climate-informed human security interventions. First, adaptation to short-term climate variability serves as a basis for longer-term adaptation to climate change, recognizing that building resilience to current weather variability provides essential foundations for managing future climate risks. Second, adaptation assessment and planning must occur within developmental contexts, ensuring that climate responses contribute to broader development objectives rather than competing with them. Third, adaptation needs must be addressed at multiple scales including local community levels, recognizing that effective responses require coordination across household, community, national, and international scales. Fourth, equal emphasis must be placed on both adaptation strategies and implementation processes, acknowledging that good strategies are insufficient without institutional mechanisms capable of effective implementation.

47 Michel, D., Eriksson, M., & Klimes, M. (2021). Climate change and (in) security in transboundary river basins. In *Handbook of Security and the Environment* (pp. 62-75). Edward Elgar Publishing.

48 Higgs, K. (2024). A Great Disaster: The Floods of 2022 in Pakistan. In *Climate Change and Global Health: Primary, Secondary and Tertiary Effects* (pp. 178-185). GB: CABI.

49 https://www.wri.org/insights/pakistan-floods-threaten-global-security

50 UNDP. 2006. The Human Security Framework and National Human Development Reports: Thematic Guidance Note. New York.

51 Lim, B and E. Spanger-Siegfried (eds.). 2004. Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. New York: United Nations Development Programme:http://ncsp.undp.org/document/adaptation-policy-frameworks-climate-change-developing-strategies-policies-and-measures

Contemporary frameworks for analysing climate-security-human security linkages have advanced significantly beyond the 1994 UNDP definition, with UNEP's Weathering Risk methodology providing systematic climate security risk assessment, the UN Climate Security Mechanism Toolbox operationalizing integrated climate-peace-security analysis, and UNDP's 2023 Re-envisioning initiative establishing that adaptation must simultaneously address resilience and peace outcomes. These frameworks recognize that in mountain regions like the HKH, climate impacts cascade through interconnected natural resource systems and governance institutions in ways that can simultaneously threaten human security across all seven UNDP dimensions (economic, food, water, health, environmental, personal, and political) while potentially exacerbating existing conflicts over resource allocation unless adaptation is explicitly designed as a peacebuilding intervention. The assessment therefore applies this integrated framework, examining how climate stressors affect human security in Afghanistan, India, Nepal, and Pakistan while identifying where adaptation measures can deliver both resilience and peace co-benefits across transboundary systems.

Box Item 1: UNDP Nepal Project

The practical application of UNDP's human security framework to climate adaptation has been demonstrated through projects such as the "Enhancing Human Security through Local Climate Actions" initiative implemented in Nepal's Karnali Province. This project, funded by the Government of Japan with a budget of approximately USD 2.3 million over 2023-2024, demonstrates integrated approaches to building resilience across multiple human security dimensions through community-led adaptation strategies. The project addresses adaptive agriculture, renewable energy, early warning systems, community infrastructure, and capacity building implemented through participatory approaches that prioritize community leadership and local knowledge integration.

Project outcomes include improved human security for over 40,000 people through early warning systems, support for 3,000 households with clean cooking solutions, training for over 1,100 community members and officials on resilience building, creation of 200 green jobs, and green infrastructure benefits for 500 households. The project's emphasis on gender and social inclusion ensures that climate adaptation interventions address the differentiated vulnerabilities and capacities of women, men, and marginalized groups within mountain communities. The project's participatory approach prioritizes community leadership and local knowledge integration while building adaptive capacity across multiple human security dimensions.[52]

UNDP's Human Development Report 2023-24 provides important insights into the relationship between climate change and human development, demonstrating that unmanaged climate interdependencies affect both wellbeing and agency dimensions of human security. The report shows that progress toward Sustainable Development Goals has stalled or reversed for 30% of targets, with climate change serving as a major driver of regression on key goals including climate action, biodiversity loss, food security, poverty reduction, inequality, and gender equality.[53] This regression demonstrates that climate impacts threaten not only immediate human welfare but also the longer-term development trajectory of vulnerable countries and communities. The report's analysis of climate migration projects that forced displacement could affect 216 million people by 2050 under current emission trajectories, with South Asia identified as one of the most affected regions. However, the report emphasizes that migration outcomes depend significantly on policy responses and adaptation investments that can either facilitate managed mobility as an adaptation strategy or reduce displacement pressures through building resilience in-situ. This provides important opportunities for human security approaches that can address migration, both in terms of the protection needed for displaced populations, and as an empowerment strategy that expands livelihood opportunities.

52 https://www.undp.org/nepal/projects/enhancing-human-security-through-local-climate-actions

53 UNDP. (2024, March 14). *Human Development Report 2023/24*. UNDP Nepal. https://www.undp.org/nepal/publications/human-development-report-2023-24

3.2 IPCC Assessment Reports on Climate Impacts and Human Systems

The Intergovernmental Panel on Climate Change's (IPCC) treatment of human security has evolved significantly across successive assessment reports, reflecting growing understanding of climate-security linkages and improved analytical frameworks. The Fifth Assessment Report included the first systematic assessment of climate impacts on human security.[54,55] The 'threat multiplier' concept has become central to climate security analysis, recognizing that climate change rarely causes security problems directly but instead exacerbates existing vulnerabilities and tensions. The threat multiplier framework helps explain why climate impacts vary dramatically across different social and geographic contexts, with some communities demonstrating remarkable resilience while others experience rapid deterioration in security conditions under similar climate stresses.

The IPCC's Sixth Assessment Report significantly advances understanding of climate-human security linkages by introducing more sophisticated analysis of cascading risks and compound events. The report demonstrates that risks are developing sooner than previously assessed, with observed losses and damages already causing "dangerous and widespread disruption" affecting billions of people despite adaptation efforts.[56] Working Group II identifies 127 global and regional key risks, including loss of lives and assets, economic disruption, livelihood failure, and reduced habitability that collectively threaten human security across multiple scales.[57] The concept of compound risks represents a significant advancement in climate risk analysis, recognizing that climate hazards increasingly occur in combinations that can overwhelm adaptive capacity even when individual hazards remain manageable.

The Working Group II, "Summary for Policymakers", demonstrates that "risks to human systems are increasing with every increment of global warming" and that adaptation limits are being reached in multiple regions and sectors. This acceleration of risks becoming manifest has important implications for human security planning, requiring adaptive management approaches that can respond to rapidly changing conditions rather than assuming gradual, predictable change patterns.[58] Chapter 6 of the Working Group II report, "Climate Change and Cities," provides important insights into how climate impacts affect urban populations, which are also recipients of climate-induced migrants from rural areas.[59] The chapter demonstrates that urban areas face particular vulnerabilities from compound climate risks including heat stress, flooding, water scarcity, and air quality degradation that can overwhelm urban infrastructure systems and disproportionately affect vulnerable populations including the recent migrants. The urbanization of climate risk has important implications for human security as cities become focal points for both climate impacts and adaptation responses.

54 IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

55 Adger, W.N., J.M. Pulhin, J. Barnett, G.D. Dabelko, G.K. Hovelsrud, M. Levy, Ú. Oswald Spring, and C.H. Vogel, 2014: Human security. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 755-791.

56 IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 pp., doi: 10.59327/IPCC/AR6-9789291691647.

57 New, M., D. Reckien, D. Viner, C. Adler, S.-M. Cheong, C. Conde, A. Constable, E. Coughlan de Perez, A. Lammel, R. Mechler, B. Orlove, and W. Solecki, 2022: Decision-Making Options for Managing Risk. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2539–2654, doi:10.1017/9781009325844.026.

58 IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-33, doi:10.1017/9781009325844.001.

59 Dodman, D., B. Hayward, M. Pelling, V. Castan Broto, W. Chow, E. Chu, R. Dawson, L. Khirfan, T. McPhearson, A. Prakash, Y. Zheng, and G. Ziervogel, 2022: Cities, Settlements and Key Infrastructure. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 907–1040, doi:10.1017/9781009325844.008.

The treatment of human security in the Working Group II report represents a significant advance from previous assessments through more systematic analysis of cascading risks and threshold effects. The report recognizes that "human security will be progressively threatened as the climate changes" through multiple pathways that interact across different spatial and temporal scales. Economic security faces threats from climate impacts on agricultural productivity, infrastructure damage, and disrupted supply chains. Food security confronts challenges from changing precipitation patterns, temperature stress on crops, and increased pest and disease pressure. Health security encounters risks from heat stress, vector-borne diseases, water and sanitation challenges, and mental health impacts from displacement and livelihood loss. Chapter 2 of the Working Group II report provides detailed analysis of terrestrial and freshwater ecosystems, demonstrating that mountain regions face particularly severe climate impacts due to temperature sensitivity, limited adaptation options, and high exposure to extreme events.[60] The chapter establishes that mountain glaciers are retreating rapidly worldwide, with implications for seasonal water availability, flood hazards, and ecosystem services that support mountain livelihoods. High-altitude species are experiencing habitat loss as climate zones shift upslope faster than many species can migrate, creating biodiversity losses that affect ecosystem services including water regulation, soil protection, and pollination.

The Special Report on Ocean and Cryosphere in a Changing Climate (SROCC) provides specific analysis of mountain regions, demonstrating that "snow, glaciers and permafrost are declining and will continue to decline in almost all regions throughout the 21st century".[61] The report establishes that changes in mountain cryosphere affect water resources through multiple pathways including altered seasonal timing of water availability, increased variability in water supplies, and greater risk of water scarcity during warm and dry periods. These changes have cascading implications for agriculture, energy generation, urban water supplies, and ecosystem services across large geographic areas downstream from mountain regions.

Working Group II Chapter 7 on "Health, Wellbeing and the Changing Structure of Communities" provides comprehensive analysis of climate impacts on migration and displacement, establishing that "climate change is affecting human mobility through slow-onset changes and extreme weather events".[62] The chapter demonstrates that climate migration operates through complex causal pathways involving environmental degradation, economic disruption, social instability, and conflict that interact to influence mobility decisions. The chapter's analysis shows that migration can serve as an effective adaptation strategy when it is planned and supported by appropriate policies but becomes a source of vulnerability when it occurs as forced displacement without adequate support systems. The chapter establishes that climate migration is not uniform across populations, with factors including education, income, social networks, and legal status determining who has the capacity to migrate successfully and who becomes trapped in degraded environments. This differentiation has important implications for human security interventions, which must address both the needs of those who migrate and those who remain in climate-affected areas. The chapter also demonstrates that migration can have positive effects for both origin and destination areas through remittances, skill transfer, and reduced pressure on resources, but only when it occurs within supportive policy frameworks.

60 Parmesan, C., M.D. Morecroft, Y. Trisurat, R. Adrian, G.Z. Anshari, A. Arneth, Q. Gao, P. Gonzalez, R. Harris, J. Price, N. Stevens, and G.H. Talukdarr, 2022: Terrestrial and Freshwater Ecosystems and Their Services. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 197–377, doi:10.1017/9781009325844.004.

61 Bindoff, N.L., W.W.L. Cheung, J.G. Kairo, J. Arístegui, V.A. Guinder, R. Hallberg, N. Hilmi, N. Jiao, M.S. Karim, L. Levin, S. O'Donoghue, S.R. Purca Cuicapusa, B. Rinkevich, T. Suga, A. Tagliabue, and P. Williamson, 2019: Changing Ocean, Marine Ecosystems, and Dependent Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 447-587. https://doi.org/10.1017/9781009157964.007.

62 Cissé, G., R. McLeman, H. Adams, P. Aldunce, K. Bowen, D. Campbell-Lendrum, S. Clayton, K.L. Ebi, J. Hess, C. Huang, Q. Liu, G. McGregor, J. Semenza, and M.C. Tirado, 2022: Health, Wellbeing, and the Changing Structure of Communities. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1041–1170, doi:10.1017/9781009325844.009.

3.3 IOM: Environmental Migration and Climate Mobility Research

The International Organization for Migration (IOM) has emerged as a leading institution for research and policy development on climate-induced human mobility, developing comprehensive frameworks for understanding environmental migration and implementing programs to address the needs of climate-displaced populations. IOM's definition of environmental migrants as "persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes" provides important conceptual foundations for understanding climate-induced mobility.

IOM's World Migration Report 2024 demonstrates that environmental factors contribute to an average of 23 million displacements annually worldwide, with climate change increasingly recognized as a central driver of human mobility.[63] The report emphasizes that environmental migration occurs across a spectrum from voluntary mobility that enhances livelihood opportunities to forced displacement that represents failure of in-situ adaptation strategies. Understanding this spectrum requires moving beyond simple voluntary-forced distinctions to recognize complex decision-making processes through which households evaluate mobility options in relation to environmental changes, economic opportunities, and social networks.

Recent IOM assessments in Afghanistan provide crucial insights into climate-migration dynamics in one of the world's most vulnerable contexts.[64] The Afghanistan Climate Vulnerability Assessment reveals that nearly 5 million individuals (approximately 10% of the country's population) were impacted by environmental hazards in the first quarter of 2025 alone, with 79% of internal displacement driven by environmental factors. This represents a significant shift from historical patterns where conflict was the primary displacement driver, demonstrating how climate change is becoming a dominant factor in human mobility patterns even in conflict-affected contexts. The assessment documents that 175,000 Afghans were internally displaced during the first quarter of 2025, with over 396,000 people forced to migrate either within Afghanistan or across international borders. Rural areas were the hardest hit, with more than 80% of rural communities reporting lack of access to formal water systems and widespread damage to homes, agricultural land, and infrastructure. Food insecurity emerged as the most urgent concern, with 47% of communities citing lack of food as their biggest challenge, with climate impacts compounding existing humanitarian vulnerabilities.

IOM's Displacement Tracking Matrix[65] provides systematic monitoring of climate-induced displacement patterns across multiple countries, demonstrating that environmental hazards accounted for 73% of internal displacement in Afghanistan during 2024. The data shows that disaster-related displacement was most prevalent in Herat province (24% of environmentally displaced IDPs), followed by Balkh (12%) and Kandahar (6%). Among those displaced by environmental factors, 59% moved elsewhere within the same province, indicating that most climate displacement occurs over relatively short distances and often represents temporary rather than permanent relocation. IOM research demonstrates that climate migration patterns vary significantly by hazard type and duration. Between 2021-2024, flooding caused 1.1 million internal displacements while drought caused only 43,000 displacements according to Internal Displacement Monitoring Centre data,[66] but IOM surveys found that drought was cited as the reason for 54% of displacement decisions followed by flooding at 22%. This discrepancy highlights the importance of understanding both immediate displacement triggers and underlying factors that make communities vulnerable to climate-induced mobility.

63 Escribano, P. and D. Pons Ganddini (2024). Climate change, food insecurity and human mobility: Interlinkages, evidence and action. In: World Migration Report 2024 (M. McAuliffe and L.A. Oucho, eds.). International Organization for Migration (IOM), Geneva.

64 International Organization for Migration. (2025, February). *Afghanistan Climate Vulnerability Assessment (Round 1)*. https://crisisresponse.iom.int/sites/g/files/tmzbdl1481/files/appeal/documents/Afghanistan%20Climate%20Vulnerability%20Assessment%20_Round%201.pdf

65 https://dtm.iom.int/

66 https://www.internal-displacement.org/global-report/grid2025/

Table 3: Climate-Induced Migration Patterns in Focus Countries (2024-2025)

(Source: IOM)

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA
Internal Displacement 2024	45 thousand	1,750 thousand	890 thousand	2,800 thousand
Climate-driven Displacement	65%	79%	45%	28%
Projected Displacement by 2050	1.3 million	3.2 million	6.1 million	45 million
Cross-border Migration	340 thousand	1,500 thousand	650 thousand	1,200 thousand
Return Migration 2024	89 thousand	4,000 thousand	120 thousand	780 thousand
Primary Drivers	Drought, floods	Drought, extreme weather	Floods, heat waves	Varied by region

The organization's work on return migration reveals that environmental factors accounted for 65% of returns in 2024, including drought (47%), flooding (18%), and other environmental hazards (31%). This pattern indicates that environmental displacement is often temporary, with populations returning to their areas of origin when environmental conditions improve. However, repeated cycles of displacement and return can exhaust household resources and undermine long-term resilience, creating conditions where temporary displacement becomes permanent migration.

4. Methodology

Khar, Darchula, Nepal.
Photo: Jitendra Raj Bajracharya/ICIMOD

4.1 Multiple Approaches

The theoretical foundation for analysing systemic risks in climate-vulnerable regions builds upon complexity science approaches that recognize the emergent properties of interconnected socio-ecological systems. Traditional risk analysis relies on linear cause-effect relationships that assume predictable outcomes from specific interventions, but climate change generates nonlinear dynamics where small perturbations can trigger disproportionate system-wide changes. The HKH exemplifies such complex systems where glacier melt, precipitation variability, agricultural productivity, migration patterns, and urban development interact through multiple feedback loops that can amplify or dampen climate impacts depending on system conditions at the time of disturbance.

Climate security refers to the conditions under which climate-induced environmental changes either threaten or protect human populations from harm arising from resource scarcity, livelihood disruption, disaster risks, and institutional breakdown.[67] Unlike traditional security concepts focused on interstate conflict, climate security emphasizes how environmental stressors interact with existing social, economic, and governance vulnerabilities to create cascading threats across multiple dimensions of human wellbeing. In the HKH context, climate security encompasses protection from immediate climate hazards (GLOFs, extreme weather) while simultaneously addressing systemic vulnerabilities (water scarcity, food insecurity, displacement) that emerge when environmental changes exceed institutional adaptive capacity.

The recent Weathering Risk analysis for the Asia-Pacific region (June 2025) specifically identifies climate-related security risks in Central Asia and Afghanistan, a subregion that overlaps significantly with the study area, highlighting how "climate change, environmental degradation and infrastructure decay are increasing competition for transboundary water resources, leading to conflict," alongside concurrent impacts on agricultural livelihoods and potential displacement toward illicit economies.[68] The Weathering Risk approach complements this assessment by providing a systematic methodology for disaggregating how climate hazards interact with contextual factors (social, economic, political, and conflict-related) to create compounding security risks that standard vulnerability assessments alone cannot capture. For the HKH region specifically, the framework enables identification of entry points where adaptation measures can enhance climate resilience. For instance, by designing water allocation mechanisms that distribute both climate costs and adaptation benefits equitably, schemes address the underlying grievances that render communities vulnerable to conflict escalation when climate shocks occur. The Weathering Risk emphasis on context-specific analysis, participatory assessment with affected communities, and conflict-sensitive adaptation design provides critical methodological foundations for translating the human security framework into actionable policy instruments in the HKH's complex transboundary environment.

Systems thinking approaches to climate risk analysis emphasize the importance of understanding "system structure", or the underlying architecture of interconnected components and relationships, that determines how disturbances propagate.[69] In mountain regions, this structure encompasses physical infrastructure such as water storage and distribution systems, social infrastructure including kinship networks and community organizations, and economic infrastructure encompassing market relationships and financial systems. Climate change can alter these structural relationships by making previously reliable water sources unpredictable, disrupting traditional social cooperation mechanisms through resource scarcity, and undermining economic relationships based on predictable seasonal patterns. The concept of "adaptive cycles" provides a useful framework for understanding how climate-vulnerable systems evolve over time through phases of growth, conservation, collapse, and renewal.[70] Mountain communities in the HKH have historically experienced these

67 Elliott, L. (2023). Climate change and human security: implications for international security. In *Handbook on Climate Change and International Security* (pp. 34-50). Edward Elgar Publishing.

68 Rüttinger, L., Barry, S., Whitaker, E., & Pohl, B. (2025). Climate, Peace and Environmental Resilience in the Asia-Pacific Region. Weathering Risk Initiative / adelphi global. June 2025. Available at: https://weatheringrisk.org/sites/default/files/document/%28Final%29%20Climate%20Peace%20and%20Environmental%20Resilience%20in%20Asia_Pacific_Report_0.pdf

69 Bi, J., Yang, J., Liu, M., Ma, Z., & Fang, W. (2021). Toward systemic thinking in managing environmental risks. *Engineering, 7*(11), 1518-1522.

70 Castell, W. Z., & Schrenk, H. (2020). Computing the adaptive cycle. *Scientific reports, 10*(1), 18175.

cycles in response to environmental variability, developing institutional mechanisms for managing resource distribution during scarcity periods and rebuilding productive capacity during favourable conditions. However, climate change introduces "condition shifts" where systems may transition to fundamentally different states that cannot support previous livelihood patterns.[71] Understanding these potential condition shifts is crucial for developing human security responses that can either prevent unwanted transitions or facilitate positive transformations to more sustainable system configurations.

Network analysis approaches offer valuable tools for mapping the pathways through which climate impacts propagate across interconnected systems.[72] In the HKH context, such networks encompass physical connections like river systems that link upstream glacial environments with downstream agricultural areas, economic connections through supply chains that distribute mountain products to regional markets, and social connections including migration networks that link rural and urban areas. Climate impacts can propagate through these networks in ways that create unexpected vulnerabilities in seemingly distant locations, as demonstrated by how glacier retreat in high mountains affects urban water security hundreds of kilometres downstream. The application of "bow-tie analysis" provides a structured methodology for mapping how specific climate hazards can trigger cascading effects across multiple system domains.[73] This approach identifies "barriers" that can prevent hazard escalation and "recovery measures" that can limit damage once cascading effects begin. In mountain contexts, natural barriers might include watershed forests that regulate water flow, while institutional barriers could encompass early warning systems that enable communities to prepare for glacier lake outburst floods. Understanding both the robustness and fragility of these barriers is essential for designing interventions that strengthen system resilience without creating new vulnerabilities elsewhere in the network.

Critical transitions theory offers insights into how systems approach tipping points where small additional stresses can trigger sudden and potentially irreversible changes.[74] Mountain socio-ecological systems may exhibit "early warning signals" such as increased variability in system outputs, slower recovery from disturbances, and increased correlation among system components that indicate approaching critical transitions. Developing capacity to recognize these signals can enable proactive interventions that either prevent unwanted transitions or facilitate managed transitions to more desirable system states. The integration of "multi-scale analysis" acknowledges that climate impacts operate simultaneously across local, regional, and global scales with complex interactions among scale levels.[75] Local impacts such as spring source depletion can combine with regional impacts like changed monsoon patterns and global impacts including altered atmospheric circulation patterns to create compound stress conditions that exceed the adaptive capacity operating at any single scale. For example, when a spring's declining discharge coincides with delayed monsoon onset and altered winter precipitation patterns, communities cannot adapt through traditional timing or water harvesting strategies. Effective human security approaches must therefore coordinate interventions across multiple scales while recognizing that responses at one scale may have unintended consequences at other scales, which can be positive feedback loops that amplify adaptation benefits and maladaptive feedback loops that inadvertently increase vulnerabilities. For example, solar pump adoption may improve short-term agricultural productivity in water-scarce regions but enable unsustainable groundwater extraction that creates long-term water security crises. Conversely, ecosystem-based adaptation measures combining forest restoration with livelihood diversification can simultaneously improve local agricultural productivity and regional water availability. Coordination mechanisms must therefore integrate adaptive monitoring systems that can detect emergent maladaptive feedback while being flexible enough to amplify positive spillover effects across scales.

71 Mishra, K. K., Subbanna, A. R. N. S., Rajashekara, H., Paschapur, A. U., Jeevan, B., Singh, A. K., & Maharana, C. (2024). Perceptions on disease and pest status of major cultivated crops in Indian Himalayas under changing climate. *Adapting to Climate Change in Agriculture-Theories and Practices: Approaches for Adapting to Climate Change in Agriculture in India*, 121-141.

72 Debortoli, N. S., Sayles, J. S., Clark, D. G., & Ford, J. D. (2018). A systems network approach for climate change vulnerability assessment. Environmental *Research Letters, 13*(10), 104019.

73 Garcia-Aristizabal, A., Kocot, J., Russo, R., & Gasparini, P. (2019). A probabilistic tool for multi-hazard risk analysis using a bow-tie approach: application to environmental risk assessments for geo-resource development projects. *Acta Geophysica, 67*(1), 385-410.

74 Scheffer, M. (2009). *Critical transitions in nature and society.* Princeton University Press.

75 Prein, A. F., Mooney, P. A., & Done, J. M. (2023). The multi-scale interactions of atmospheric phenomenon in mean and extreme precipitation. *Earth's Future, 11*(11), e2023EF003534.

4.2 Research Methodology

The research methodology employed in this study integrates multiple analytical approaches to examine human security under climate stress across the four focus countries of Afghanistan, India, Nepal, and Pakistan. The methodology combines comprehensive literature synthesis, secondary data analysis from authoritative sources, focus group discussions, expert interviews, systems analysis approaches, and theoretical development of pathways to identify the complex interactions among climate impacts, human security dimensions, and adaptive responses.

The literature review component utilized systematic searches of peer-reviewed publications, international organization reports, and policy documents published between 2020 and 2025, with particular emphasis on contributions from the IPCC, IOM, UNDP, and regional research institutions such as ICIMOD. Search strategies included combinations of the terms "climate change," "human security," "Hindu Kush Himalaya," "migration," "vulnerability," and "adaptation", with specific attention to country-level analyses for the four focus nations. Database searches encompassed Web of Science, Scopus, Google Scholar, and organizational repositories including IPCC AR6 chapters, IOM World Migration Reports, UNDP Human Development Reports, and ICIMOD publications. Selection criteria for literature inclusion required publication within the past five years, direct relevance to climate-human security linkages in South Asian or mountain contexts, methodological rigor for empirical studies, and authoritative source credentials for policy documents. Priority was given to systematic reviews, meta-analyses, and large-scale assessments such as IPCC reports that synthesize evidence across multiple studies and regions. This approach ensured comprehensive coverage of recent developments in climate-human security research while maintaining focus on the specific regional and national contexts relevant to this analysis.

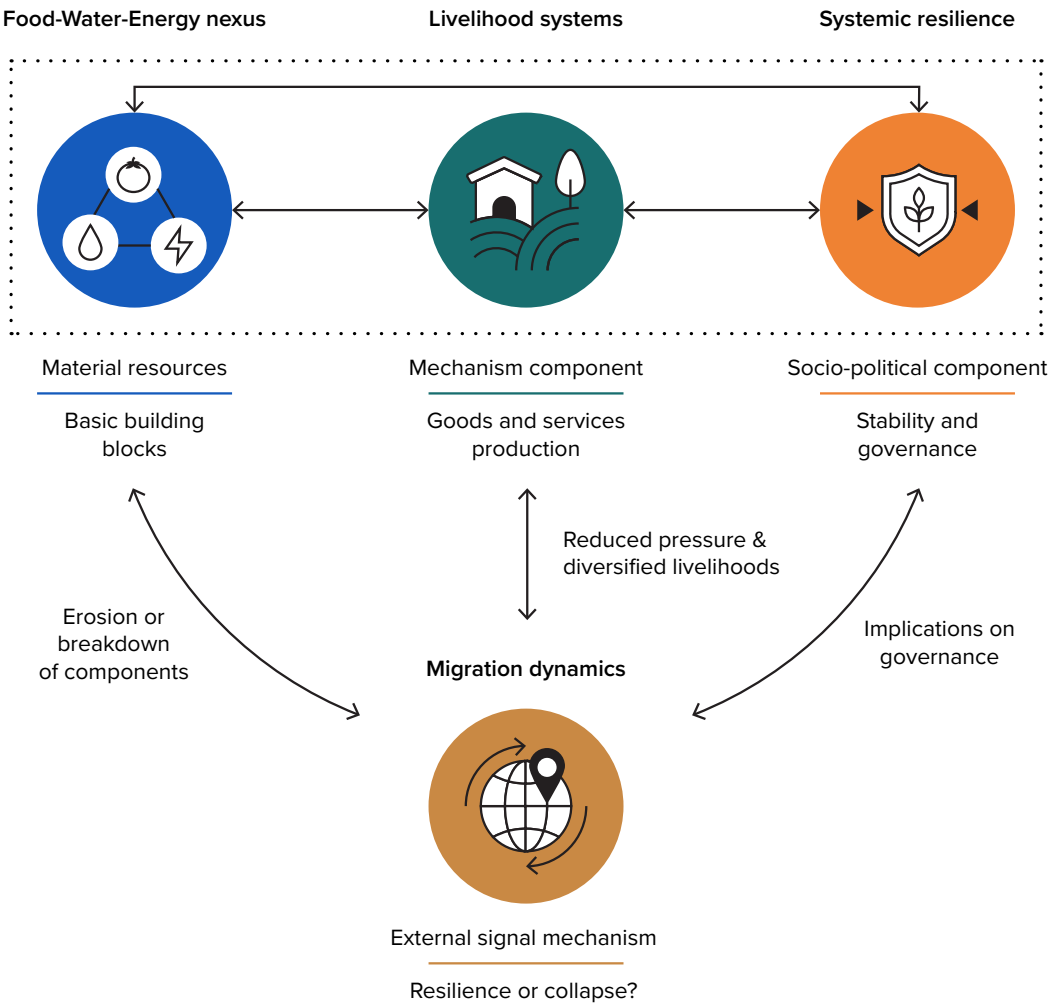
Beyond focus group discussions and expert interviews, secondary data analysis drew upon quantitative indicators from authoritative sources including IPCC Assessment Reports, IOM Displacement Tracking Matrix data, UNDP climate adaptation monitoring reports, World Bank Country Climate and Development Reports, and national climate assessments from the four focus countries. Climate impact data were sourced from peer-reviewed publications and official meteorological services, with validation through cross-referencing across multiple sources to ensure accuracy and reliability of quantitative indicators used in the analysis. Migration and displacement data were obtained from IOM assessments, national statistical offices, humanitarian organizations with established monitoring systems, and research institutions with field presence in the region.

The systems analysis approach employed network analysis techniques to map pathways through which climate impacts propagate across interconnected systems, identifying critical intervention points where cascading effects can be prevented or mitigated. This approach built upon complexity science frameworks that recognize emergent properties of interconnected socio-ecological systems under climate stress, with particular attention to feedback relationships that can either amplify or dampen climate impacts depending on system conditions and response strategies. The threshold analysis framework recognizes that socio-ecological systems possess finite capacity to absorb environmental stresses, beyond which additional pressures trigger cascading effects that may be difficult or impossible to reverse. Risk conditions exist when climate stresses operate within adaptive capacity, creating challenges that can be managed through existing institutional mechanisms and resource mobilization strategies. Threat conditions emerge when stresses exceed absorption thresholds and trigger cascading failures that propagate across multiple system domains simultaneously. Cross-country comparative analysis examined similarities and differences in climate vulnerabilities, adaptive capacities, and human security challenges across the four focus countries.

5. Theoretical Framework for Human Security Under Climate Stress

Solar for irrigation. Chanda Devi Shah, 42 years old farmer in Saptari, Nepal. Photo: Jitendra Raj Bajracharya/ICIMOD.

The theoretical framework developed for this analysis integrates human security concepts with systems thinking approaches to create a comprehensive understanding of climate-induced vulnerabilities and adaptive responses in mountain regions. The framework builds upon existing human security scholarship while incorporating insights from resilience theory, cascade risk analysis, and threshold dynamics to address the unique challenges that climate change poses for human wellbeing in complex socio-ecological systems. The framework recognizes four interconnected dimensions that together determine human security outcomes under climate stress. These dimensions (described below), were selected because they capture the full cascade of climate impacts from primary stressors, addressing a critical gap in conventional climate adaptation analysis that typically focuses on single sectors rather than system-wide breakdown. First, the Food-Water-Energy (FWE) nexus provides the material basis for human wellbeing. It includes the fundamental biophysical flows that climate change disrupts, causing individual or compound failures when systems are inter-dependent; for example, when cryosphere changes directly alter the water availability that underpins both food production and hydropower-dependent energy systems. Second, livelihood systems mediate between resource availability and welfare outcomes, determining how environmental shocks translate into economic impacts and human suffering. In mountain communities, livelihoods depend on specific agro-ecological niches and seasonal patterns that climate change fundamentally alters. Third, systemic resilience mechanisms, including governance capacity, social capital, and institutional adaptation, determine adaptive capacity; regions with weak institutions, fragmented governance, and low social trust prove more vulnerable to climate-induced state failure and conflict escalation. Fourth, migration dynamics represent both adaptation strategies and indicators of system breakdown; internal displacement and cross-border migration are simultaneous expressions of climate adaptation and of governance failure to manage climate impacts within existing territories and social contracts, making them critical indicators of whether human security is being maintained or is eroding.



The Food-Water-Energy nexus serves as the foundational layer of the framework, recognizing that these three resource systems are interconnected through complex relationships that can create cascading failures when disrupted by climate impacts.[76] Water availability determines agricultural productivity through rainfed crop production and irrigation systems, while also affecting energy generation through hydroelectric systems and cooling requirements for thermal power plants. Energy systems enable food processing, preservation, and distribution while supporting water pumping, treatment, and distribution systems. Food production systems provide biomass energy sources and influence land use patterns that affect watershed hydrology and energy system siting. Climate change affects each component of the FWE nexus differently, creating temporal and spatial mismatches that can propagate across the entire system to undermine human security. Temperature increases alter evapotranspiration rates and crop water requirements precisely when precipitation patterns become more variable and unreliable. Extreme weather events can simultaneously damage energy infrastructure, disrupt food distribution systems, and contaminate water supplies, creating compound impacts that exceed the sum of individual disruptions. The framework recognizes that effective climate adaptation requires integrated management of FWE systems rather than sectoral approaches that optimize individual components while ignoring system interactions.

Livelihood security operates as the critical mediating mechanism between environmental changes and human wellbeing outcomes, determining whether climate impacts translate into manageable adaptations or existential threats for affected populations. Livelihoods encompass not only income-generating activities but also the assets, capabilities, and institutions that enable people to maintain and improve their living standards over time. The framework recognizes that livelihood systems in mountain regions have evolved sophisticated strategies for managing environmental variability through diversified income sources, seasonal mobility patterns, and complex reciprocal arrangements that provide insurance against localized failures. However, climate change introduces forms and scales of environmental variability that can overwhelm traditional risk management mechanisms, forcing fundamental restructuring of livelihood systems with cascading implications for human security across multiple dimensions. Livelihood vulnerability analysis within the framework examines how climate impacts affect different types of assets and the feedback relationships among asset categories that can either strengthen or undermine overall livelihood security. Natural asset degradation through climate impacts can reduce income opportunities and force increased reliance on social networks for support, potentially overwhelming community-level risk management mechanisms. Human asset development through education and skill training can enhance adaptive capacity and enable livelihood diversification but may also increase expectations and mobility aspirations that conflict with traditional community structures.

Systemic resilience encompasses the network relationships, feedback mechanisms, and emergent properties that enable regions to maintain essential functions while adapting to changing conditions.[77] The framework distinguishes between component-level resilience that focuses on individual elements such as households or infrastructure systems, and systemic resilience that encompasses interconnected relationships among multiple system components. Key resilience mechanisms include diversity across multiple dimensions, connectivity patterns that enable resource sharing and knowledge transfer, modularity that creates semi-autonomous components, learning mechanisms that enable continuous adaptation, and transformative capacity that enables fundamental system restructuring when existing arrangements become unviable. Diversity represents a crucial mechanism for systemic resilience that operates across biological, economic, and social dimensions. Biological diversity provides ecosystem services and products that support multiple livelihood strategies while offering insurance against environmental changes that may affect some species more than others. Economic diversity reduces dependence on any single income source or market relationship that could be disrupted by climate impacts. Social diversity encompasses the range of knowledge systems, institutional arrangements, and cultural practices that provide alternative strategies for responding to environmental challenges.

76 Ioannou, A. E., & Laspidou, C. S. (2022). Resilience analysis framework for a water–energy–food nexus system under climate change. *Frontiers in Environmental Science, 10*, 820125.

77 Artime, O., Grassia, M., De Domenico, M., Gleeson, J. P., Makse, H. A., Mangioni, G., ... & Radicchi, F. (2024). Robustness and resilience of complex networks. *Nature Reviews Physics, 6*(2), 114-131.

Connectivity patterns within mountain systems determine how environmental changes, adaptation innovations, and support resources are transmitted across landscapes and social networks.[78] Physical connectivity through watersheds, transportation networks, and communication infrastructure enables resource sharing and coordinated responses to regional challenges. Social connectivity through kinship networks, market relationships, and institutional affiliations provides pathways for knowledge transfer and mutual assistance during crisis periods. However, connectivity can also transmit negative impacts such as disease outbreaks, economic shocks, or conflict situations that can undermine resilience if systems lack appropriate filtering mechanisms.

Migration and adaptive mobility represent both outcomes of human security stress and strategies for maintaining wellbeing under changing environmental conditions. The framework recognizes a spectrum of mobility patterns from seasonal labour migration integrated into traditional livelihood systems to permanent displacement representing complete breakdown of local adaptive capacity. Understanding this spectrum requires moving beyond simple voluntary-forced migration distinctions to recognize complex decision-making processes through which households evaluate mobility options in relation to environmental changes, economic opportunities, and social networks that enable successful relocation.[79] The framework incorporates analysis of migration as both a dependent variable influenced by climate impacts and human security conditions, and as an independent variable that affects origin and destination communities through population changes, remittance flows, knowledge transfer, and resource competition. Climate-induced migration can serve positive functions for human security by enabling access to new livelihood opportunities, reducing pressure on degraded environments, and providing remittance income that supports adaptation investments in origin areas. However, migration can also create vulnerabilities when it occurs as forced displacement without adequate support systems, or when it depletes origin communities of human capital needed for local adaptation efforts.

Understanding human migration is incomplete without considering the causes and consequences of human immobility. Many people are unable to move or migrate in the face of escalating climate risks, becoming part of “trapped populations”. Such groups remain in high-risk environments not by choice but because of deep-rooted structural inequities that constrain their adaptive capacities and mobility options. The aspiration capabilities framework provides a critical lens to understand how both the desire and the ability to move are constrained by environmental, social and political pressures, transforming migration from a voluntary act into a complex process of negotiation between agency and constraint.[80] Many low-income and marginalized groups are unable to relocate because of economic deprivation, inadequate state support or restrictive governance mechanisms, resulting in what is termed involuntary immobility. Empirical evidence further shows that as climate impacts intensify, mobility paradoxically decreases among the poorest populations, leading to heightened vulnerability and long-term entrapment within degraded landscapes.[81] Yet, immobility does not always signify helplessness; in many communities, staying put is a deliberate and culturally grounded act, shaped by deep emotional, spiritual and ancestral attachments to land and livelihood. Inadequate governance frameworks and institutional inaction often fail to acknowledge immobile populations, leaving them trapped in vulnerable situations with limited adaptation options.[82]

78 Galan, J., Galiana, F., Kotze, D. J., Lynch, K., Torreggiani, D., & Pedroli, B. (2023). Landscape adaptation to climate change: Local networks, social learning and co-creation processes for adaptive planning. *Global Environmental Change, 78*, 102627.

79 Szaboova, L., Adger, W. N., de Campos, R. S., Maharjan, A., Sakdapolrak, P., Sterly, H., ... & Abu, M. (2023). Evaluating migration as successful adaptation to climate change: Trade-offs in well-being, equity, and sustainability. *One Earth, 6*(6), 620-31.

80 Thomas, A., et al. (2025). Immobility in the context of climate change. *Annual Review of Environment and Resources*, 47–66.

81 Bergmann, J., & Martin, S. F. (2023). Addressing climate change-related human immobility. Global Knowledge Partnership on Migration and Development (KNOMAD).

82 Thornton, F., et al. (2023). Trapped or staying put: governing immobility in the context of climate change. Front. Clim. 5:1092264. https://doi.org/10.3389/fclim.2023.1092264

This framework treats adaptive capacity, defined as the ability of individuals, households, and communities to adjust to climate stress, as fundamentally social rather than merely technical or economic. Adaptive capacity depends not primarily on access to resources alone, but on individuals' and communities' positions within social systems that determine their participation in decision-making, access to institutional authority, and ability to act on adaptive strategies. Three interconnected social dimensions are critical: (1) personal security, which encompasses individuals' ability to participate in adaptation planning and implement adaptation decisions without threat or coercion; (2) community security, which reflects whether social networks, cultural institutions, and community trust structures remain intact to enable collective action and information-sharing during climate shocks; and, (3) political security, which determines whether communities have voice in governance structures that allocate resources, design adaptation programs, and set priorities in competing demands on scarce resources. These dimensions are determined by power structures, including institutional arrangements that recognize or exclude certain voices, cultural norms that shape who participates in decision-making, and political processes that allocate benefits and risks unequally across populations. Climate impacts thus do not affect all populations equally not simply because of differential exposure to hazards, but because power structures determine who participates in early warning systems, whose livelihood strategies receive investment support, whose knowledge is recognized as legitimate in adaptation planning, and whose displacement from climate-impacted areas is considered acceptable. Effective human security policy therefore requires explicit attention to how social position, determined by gender, caste, ethnicity, land tenure, and institutional access, mediates both climate vulnerability and adaptive capacity. This report recognizes that adaptive responses emerging from communities themselves often address these social dimensions (through communal decision-making about resource allocation, through recognition of multiple knowledge systems, through inclusive governance of adaptation resources); in contrast, adaptation interventions designed without this social lens frequently reproduce or exacerbate existing inequalities.

Threshold analysis provides the analytical foundation for distinguishing between risks that remain within system absorption capacity and threats that exceed resilience thresholds to trigger qualitative system changes.[83] The framework recognizes that socio-ecological systems possess finite capacity to absorb environmental stresses, beyond which additional pressures trigger cascading effects that may be difficult or impossible to reverse. Risk conditions exist when climate stresses operate within adaptive capacity, creating challenges that can be managed through existing institutional mechanisms and resource mobilization strategies. Threat conditions emerge when stresses exceed absorption thresholds and trigger cascading failures that propagate across multiple system domains simultaneously.

This integrated framework advances beyond conventional human security approaches by recognizing that climate stress propagates through interconnected systems in ways that exceed sectoral intervention capacity. The framework's analytical strength lies in its ability to identify critical intervention points where targeted investments can generate positive effects across multiple security dimensions simultaneously. For example, integrated water management can simultaneously address agricultural productivity, energy generation, and transboundary cooperation. The four-pillar structure (FWE nexus, livelihoods, resilience mechanisms, migration dynamics) enables systematic assessment of how climate impacts cascade through interconnected systems while distinguishing between manageable risks requiring adaptive response and existential threats demanding fundamental system transformation. This threshold-sensitive approach provides operational guidance for prioritizing interventions in resource-constrained environments where distinguishing between risk management and crisis response becomes critical for effective human security policy.

83 Cheng, Y., Elsayed, E. A., & Huang, Z. (2022). Systems resilience assessments: a review, framework and metrics. *International Journal of Production Research, 60*(2), 595-622.

5.1 Food-Water-Energy Nexus Dynamics and its Impact on Human Security

The Food-Water-Energy nexus is composed of interconnected systems whose disruption can trigger cascading failures across entire regional economies. This nexus operates with complex interdependencies where water availability determines agricultural productivity, energy systems enable food processing and distribution, and agricultural systems provide both food security and energy sources through biomass and hydropower development. Climate change disrupts these interdependencies by altering the temporal and spatial distribution of water resources, changing energy demand patterns through temperature extremes, and undermining agricultural productivity through altered precipitation regimes and increased pest and disease pressure.

5.1.1 WATER SYSTEMS AND CLIMATE VULNERABILITIES

Water systems in the HKH region exemplify the cascading vulnerabilities that characterize climate-stressed infrastructure. The region's water security depends on the coordinated functioning of glacial storage systems, seasonal snowpack, monsoon precipitation, groundwater aquifers, and constructed storage infrastructure including reservoirs and irrigation networks. Climate change affects each of these components differently, creating mismatches between water supply and demand that can persist for years or decades. Glacial melt initially increases water availability in many river systems, creating a temporary abundance that may mask underlying system vulnerability, but as glaciers retreat beyond critical thresholds, annual water availability begins to decline even as demand continues to increase with population growth and economic development.

The four focus countries demonstrate distinct patterns of water vulnerability under climate stress. Afghanistan exemplifies extreme water stress conditions, with 70% dependence on glacial water sources and annual water availability of only 65 billion cubic meters serving a population experiencing rapid growth and economic instability. Per capita water availability of 1,670 cubic meters per year places the country in the water-stressed category, while groundwater depletion rates of 4.8 centimetres annually indicate unsustainable extraction patterns. The country's irrigation dependency of 85% creates particular vulnerability to disruptions in water availability, as 98% of water consumption supports agriculture and livestock systems that employ the majority of the population.[84]

Table 4: Water Security Indicators for Focus Countries

(Source: ICIMOD and USAID Reports 2023)

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA (Himalayan States)
Glacial Water Dependency	90%	70%	72%	45%
Annual Water Availability	225 Billion Cubic Meters	65 Billion Cubic Meters	246 Billion Cubic Meters	1456 Billion Cubic Meters

84 Nasimi, Mohammad Najim & Sagin, Jay & Wijesekera, N.T.S.. (2020). Climate and Water Resources Variation in Afghanistan and the Need for Urgent Adaptation Measures. International Journal of Food Science and Agriculture. 4. 49-64. 10.26855/er.2020.02.009.

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA (Himalayan States)
 Per Capita Water Availability	7820 m^3/year	1670 m^3/year	1067 m^3/year	1486 m^3/year
 Groundwater Depletion Rate	2.1 cm/year	4.8 cm/year	3.2 cm/year	2.8 cm/year
 Water Stress Level	Medium	Extremely High	Extremely High	High
 Irrigation Dependency	68%	85%	93%	62%

Pakistan faces similar challenges with glacial water dependency of 72% and extremely high water stress levels affecting over 35 million people in the focus region. The country's per capita water availability of 1,067 cubic meters per year represents severe scarcity, while groundwater depletion rates of 3.2 centimetres annually indicate that adaptive strategies based on increased groundwater extraction are approaching sustainability limits.[85] The Indus River system, which provides water for Pakistan's agriculture, industry, and urban populations, depends heavily on glacial and snow melt from northern mountain areas, making the country particularly vulnerable to changes in high-altitude precipitation and temperature patterns.

Nepal's water security challenges reflect the paradox of high total water availability with significant seasonal and spatial variability that creates scarcity conditions locally. With annual water availability of 225 billion cubic meters and per capita availability of 7,820 cubic meters per year, Nepal appears water-rich by global standards. However, 90% dependence on glacial water sources creates extreme vulnerability to climate change impacts on high-altitude water systems.[86] Groundwater depletion rates of 2.1 centimetres annually in accessible areas indicate growing pressure on alternative water sources as surface water becomes less reliable.

India's Himalayan region (IHR), comprising of all Himalayan mountain states and hill districts of other states, demonstrates the complexity of managing water resources across diverse climatic and topographic conditions. With 45% glacial water dependency and per capita water availability of 1,486 cubic meters per year in mountain areas, the country faces high water stress levels that vary significantly across different states and watersheds. Groundwater depletion rates of 2.8 centimetres annually reflect increasing reliance on groundwater as surface water sources become less reliable.[87] The diversity of conditions across India's Himalayan regions provides both opportunities for adaptation through resource sharing and challenges for coordinated management across multiple jurisdictions.

85 Parry, J.-E., Osman, H., Terton, A., Asad, S. A., & Ahmed, T. (2016). *The vulnerability of Pakistan's water sector to the impacts of climate change: Identification of gaps and recommendations for action* (Report). United Nations Development Programme / International Institute for Sustainable Development. https://files.acquia.undp.org/public/migration/pk/Report.pdf

86 Bhusal, Jagat. (2024). Nepal's Water Resource Development Challenges. State, Society and Development: PMPD Perspectives. 2. 53-72. 10.3126/ssd.v2i01.67201.

87 Huda, Mir & Kumar, Rohitashw & Rather, Nasir. (2019). Water Resources Scenario of Indian Himalayan Region. 10.1201/9780429326400-18.

5.1.2 AGRICULTURAL SYSTEMS UNDER CLIMATE PRESSURE

Agricultural systems across the HKH region face multiple climate stresses that interact with water and energy systems in complex ways to threaten food security across the region. Traditional farming systems in the HKH evolved to manage seasonal water variability through diversified cropping patterns, soil moisture conservation practices, and integrated livestock systems that provided multiple products and services. However, climate change introduces variability that exceeds the bounds of historical experience, rendering traditional strategies inadequate. Temperature increases are shifting crop suitability zones upslope, forcing farmers to adopt new varieties or abandon traditional crops, while precipitation changes alter planting and harvesting schedules that have been refined over generations. Rising temperatures also increase crop water requirements precisely when water availability is becoming more uncertain, creating conditions where irrigated agriculture may become unviable in areas where it was previously productive.

Table 5: Food Security Indicators Under Climate Stress

(Source: ICIMOD 2021, FAO 2023 and World Bank 2024)

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA
Food Insecure Population	2.8 million	15.3 million	8.9 million	224.3 million
Agricultural GDP	27.1%	25%	22.7%	18.8%
Crop Yield Change 2020-2024	-8.5%	-15.2%	-12.1%	-3.4%
Drought-Affected Area	23%	67%	42%	19%
Irrigation Coverage	24%	32%	61%	48%
Post-Harvest Losses	15%	25%	18%	12%

The scale of food insecurity challenges across the region reflects both climate impacts and broader development challenges that interact to create compound vulnerabilities. Afghanistan faces the most severe food security crisis with 15.3 million people experiencing food insecurity, representing nearly 40% of the population. The agricultural GDP contribution of 25% indicates the critical importance of the sector for both nutrition and economic security, while crop yield changes of -15.2% between 2020-2024 demonstrate the severe impacts of climate stress combined with conflict and economic disruption. Drought-affected areas covering 67% of the country create widespread challenges for both irrigated and rainfed agricultural systems.[88]

Nepal's food insecurity affects 2.8 million people, representing approximately 10% of the population, and reflects both climate vulnerabilities and structural challenges in agricultural development. Agriculture's 27.1% contribution to GDP indicates the sector's continued importance for rural livelihoods, while crop yield declines of -8.5% between 2020-2024 result from cascading climate and socioeconomic pressures. Changed precipitation and temperature stress combine with labour shortages, driven by accelerated outmigration, to undermine agricultural productivity beyond the individual challenges raised by either factor. Drought-affected areas covering 23% of the country create regional variations in agricultural productivity that require diversified adaptation strategies. Irrigation coverage of only 24% leaves the majority of agricultural land dependent on increasingly variable precipitation patterns,[89] while simultaneous labour shortages constrain the capacity to implement water management intensification that could buffer against these variations.

Pakistan's food insecurity affects 8.9 million people, and reflects the interaction of climate impacts with population growth and economic constraints. An agricultural GDP contribution of 22.7% indicates the sector's continued importance despite economic diversification, while crop yield declines of -12.1% between 2020-2024 demonstrate severe climate impacts. Some 42% of agricultural land is affected by drought, which creates widespread challenges for crop production, while irrigation coverage of 61% provides some buffering capacity against precipitation variability. Post-harvest losses of 18% indicate additional opportunities for improving food security through better storage and distribution systems.[90]

India's food insecurity affecting 224.3 million people represents the largest absolute numbers globally, although this is a lower percentage of the national population compared to other regional countries. An agricultural GDP contribution of 18.8% reflects economic diversification while maintaining the importance of the sector for rural livelihoods. Crop yield changes of -3.4% between 2020-2024 indicate more moderate climate impacts compared to neighbouring countries, likely reflecting greater adaptive capacity and agricultural diversity. Drought-affected areas covering 19% of agricultural land demonstrate regional variations that require differentiated response strategies across the country, and especially for the IHR, where mountain geographies and contexts would require tailored strategies.[91]

88 Andree, Bo Pieter Johannes; Braimoh, Ademola; Gbadegesin, Tosin Kolajo. *Climate Shocks and Their Effects on Food Security, Prices, and Agricultural Wages in Afghanistan* (English). Policy Research working paper;PLANET;RRR Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/099903212122414533

89 Aashish Kumar Sharma, Robin Rijal, Sittal Thapa, Subash Thapa, Akash Shah, Prajina Neupane, and Shree Bhagavan Thakur. 2025. "Food Security Challenges in Nepal: Assessing the Existing Situation and Policy-Level Strategies for Mitigation and Resilience". *European Journal of Nutrition & Food Safety 17* (7):329–346. https://doi.org/10.9734/ejnfs/2025/v17i71789.

90 https://www.fao.org/faostat/en/#country/165

91 https://www.wfp.org/countries/india

5.1.3 ENERGY SECURITY AND CLIMATE DEPENDENCIES

Energy systems throughout the region face multiple climate-related stresses that affect both supply and demand sides of the energy equation. Hydroelectric power generation, which provides the majority of electricity in many mountain areas, becomes unreliable as river flow regimes shift toward earlier peaks and lower dry season flows. Traditional biomass energy sources, including fuelwood and crop residues, may become less available as forest productivity declines and agricultural systems are disrupted. Simultaneously, energy demand is increasing as communities require cooling systems to cope with higher temperatures, water pumping systems to access deeper groundwater sources, and food preservation systems to prevent spoilage in changing temperature conditions. These demand increases occur precisely when supply systems are becoming less reliable, creating energy security crises that compound other climate impacts.

Nepal demonstrates the extreme climate vulnerability of energy systems dependent on hydroelectric generation. With hydroelectric share of 87% and energy access rates of 95%, the country faces very high climate vulnerability as river flow changes directly affect electricity supply. An energy import dependency of 18% creates additional vulnerabilities when domestic hydroelectric generation is disrupted by extreme weather events or seasonal water scarcity. Grid reliability scores of 6.8 (on a 0-10 scale where 10 represents optimal stability and 1 represents critical failure) indicate moderate system performance, but climate impacts on hydroelectric generation threaten to undermine power system stability. The country's renewable energy target of only 15% reflects current policy priorities that may not adequately address climate vulnerabilities.[92]

Afghanistan's energy security challenges are compounded by conflict and economic instability that limit both generation capacity and access to international support. Hydroelectricity's share of 28% in total supply, and energy access rates of 84% are indicative of lower electrification levels and greater dependence on imported fuels and biomass. High climate vulnerability and an energy import dependency of 65% create significant exposure to external supply disruptions and price volatility. Grid reliability scores of 4.2 indicate poor system performance that affects economic development and quality of life. Limited access to climate finance due to political isolation prevents investments in climate-resilient energy systems.[93]

92 https://www.iea.org/countries/nepal

93 Ansari, Ahmad & Chifflard, Peter. (2025). The Water-Energy Nexus in Afghanistan: Challenges and Opportunities for Sustainable Energy Development.

Table 6: Energy Security Under Climate Stress

(Source: ERIN 2021 and IEA 2024 Reports)

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA
Hydroelectric Share	87%	28%	34%	12%
Energy Access Rate	95%	84%	95%	99%
Climate Vulnerability of Energy	Very high	High	High	Medium
Renewable Energy Target	15%	20%	30%	50%
Energy Import Dependency	18%	65%	28%	85%
Grid Reliability Score[93]	6.8	4.2	5.9	7.1

94 IRENA. (2023). Renewable energy for remote communities: A guidebook for off-grid projects, International Renewable Energy Agency, Abu Dhabi.

Pakistan's energy sector demonstrates the challenges of managing climate risks across diverse generation sources. An hydroelectric share of 34% creates moderate climate vulnerability, while energy access rates of 95% indicate successful electrification efforts. High climate vulnerability ratings reflect the combined effects of variability in hydroelectric generation, extreme weather damage to infrastructure, and increased cooling demand during heat waves. An energy import dependency of 28% and renewable energy targets of 30% indicate opportunities for reducing climate vulnerabilities through generation of a diversified portfolio for energy development. Grid reliability scores of 5.9 suggest room for improvement in system performance and climate resilience.[95]

The complexity of India's energy sector reflects the scale and diversity of the country's energy system. Hydroelectricity's share of 12% indicates lower dependence on climate-sensitive generation sources, while energy access rates of 99% demonstrate successes towards electrification. Medium climate vulnerability ratings reflect both the diversity of generation sources and the scale of infrastructure that can buffer against localized disruptions. Energy import dependency of 85% creates vulnerability to international price volatility and supply disruptions. Renewable energy targets of 50% indicate ambitious goals for reducing both climate and import dependencies. Grid reliability scores of 7.1 represent the highest performance among focus countries but still indicate opportunities for climate adaptation improvements.[96]

5.1.4 NEXUS INTEGRATION CHALLENGES AND OPPORTUNITIES

The integrated nature of Food-Water-Energy (FWE) systems means that disruptions in any single component can trigger cascading effects across the entire nexus. Water scarcity forces farmers to rely more heavily on pumping groundwater, which requires additional energy inputs and depletes aquifer resources that may take decades to recharge. Energy shortages prevent operation of irrigation systems, leading to crop failures that reduce food security and eliminate agricultural income that communities need to purchase alternative energy sources. Food production disruptions reduce the biomass energy sources that many rural communities depend upon, forcing increased reliance on purchased fuels that may be unaffordable for already stressed households.

The South Asian Association for Regional Cooperation (SAARC) region's experience with FWE nexus challenges demonstrates both the scale of integration challenges and the potential benefits of coordinated approaches.[97] With just 3% of the world's land supporting 1.6 billion people who account for one-fourth of the world's population, the region faces unprecedented pressures on natural resource systems. Rice and wheat, the staple foods in the region, require huge amounts of water and energy for production, processing, and distribution. Freshwater resources, once abundant, are under growing stress due to increased demand for competing uses, while climate change creates additional uncertainties that compound existing resource management challenges.

The temporal dimensions of FWE interdependencies create particular vulnerabilities under climate change conditions. Agricultural systems require coordinated timing of water availability, energy inputs for pumping and processing, and labour availability for planting and harvesting activities. Climate change disrupts these temporal coordination mechanisms by shifting seasonal patterns in unpredictable ways. Early snowmelt may provide water before planting seasons begin, while late monsoons may delay planting until optimal growing periods have passed. Energy demand for irrigation may peak when hydroelectric generation is at seasonal minimums, forcing reliance on expensive alternatives or accepting reduced agricultural productivity. Spatial interdependencies within the FWE nexus create additional vulnerabilities as climate impacts vary across elevation gradients and geographic regions.

High-altitude areas that generate much of the region's water resources through snowpack and glacial melt may experience different climate impacts than downstream agricultural areas that depend on those water sources. Energy systems that rely on biomass production in middle elevation zones may be disrupted by climate impacts that are distinct from those affecting high-altitude hydroelectric generation or low-altitude agricultural systems.

95 https://www.iea.org/countries/pakistan

96 https://www.iea.org/countries/india

97 Kumar, A. and Gurung, T.R., (Eds). 2015. SAARC Outlook on Water-Energy-Food Nexus in SAARC Region

These spatial mismatches can create situations where adaptation strategies that benefit one elevation zone impose additional stresses on others, complicating efforts to develop coordinated regional responses.

The governance dimensions of FWE systems present additional challenges for climate adaptation in transboundary regions where water resources, energy systems, and agricultural markets cross multiple jurisdictions. Effective nexus management requires coordination among water management authorities, energy utilities, agricultural extension services, and environmental protection agencies that often operate under different mandates and institutional frameworks. Climate change introduces additional complexity by creating needs for rapid response capabilities and adaptive management approaches that may not align with existing bureaucratic procedures and planning cycles. Technological solutions for strengthening Food-Water-Energy system resilience under climate change require integrated approaches that account for system interdependencies rather than optimizing individual components in isolation. Water-efficient irrigation technologies can reduce agricultural water demand, but their effectiveness depends on reliable energy supplies to operate pumping and control systems. Renewable energy systems can reduce dependence on climate-sensitive hydroelectric generation, but solar and wind systems may require backup storage that depends on reliable manufacturing supply chains and maintenance services. Climate-resilient crop varieties can maintain productivity under changed temperature and precipitation conditions, but their adoption requires extension services, credit systems, and market access that may themselves be disrupted by climate impacts. Furthermore, each component of the FWE nexus already comprises of embedded traditional systems that are deeply integrated into local economies. As such, transitions in the components, such as the transition to new and renewable energy systems, would require strong incentives and transformative measures that would only be possible through effective and sustained public interventions.

The economic dimensions affecting the resilience of the FWE nexus involve trade-offs between efficiency and redundancy that become particularly critical under climate stress conditions. Highly efficient systems that minimize resource waste under normal conditions may lack the buffering capacity needed to maintain function during extreme events or long-term environmental changes. Building resilience into FWE systems may require accepting lower efficiency under normal conditions in order to maintain functionality during stress conditions. Such trade-offs have implications for economic competitiveness and development priorities that must be carefully considered in regional planning processes.

5.2 Livelihood Security as the Mediating Driver of Human Wellbeing

Livelihood security operates as the critical mediating mechanism between environmental changes and human wellbeing outcomes in the Hindu Kush Himalaya, determining whether climate impacts translate into manageable stresses or existential threats for mountain communities. Livelihoods encompass not only income-generating activities but also the assets, capabilities, and institutions that enable people to maintain and improve their living standards over time. In mountain regions, livelihood systems have evolved sophisticated strategies for managing environmental variability through diversified income sources, seasonal mobility patterns, and complex reciprocal arrangements that provide insurance against localized failures. However, climate change introduces forms and scales of environmental variability that can overwhelm these traditional risk management mechanisms, forcing fundamental restructuring of livelihood systems with cascading implications for human security across multiple dimensions.

5.2.1 ASSET-BASED VULNERABILITY ANALYSIS

The asset base that underpins mountain livelihoods faces multiple climate-related stresses that can erode the foundation for economic security over time periods that span decades. Natural assets including agricultural land, forests, and water sources are directly affected by temperature and precipitation changes that alter their

productivity and reliability.[98] Human assets encompassing health, education, and skills may be undermined as climate stresses increase disease risks, disrupt educational systems, and render traditional knowledge less applicable under changed environmental conditions.[99] Physical assets including housing, tools, and infrastructure face increased risk of damage from extreme weather events, while financial assets may be depleted by increased expenses for climate adaptation measures or reduced income from climate-sensitive activities.

Social assets including community networks and institutional relationships may be strained by increased resource competition or disrupted by climate-induced migration. The framework for assessing livelihood assets recognizes that these different categories interact through complex feedback relationships that can either strengthen or undermine overall livelihood security. Natural asset degradation through climate impacts can reduce income opportunities and force increased reliance on social networks for support, potentially overwhelming community-level risk management mechanisms. Human asset development through education and skill training can enhance adaptive capacity and enable livelihood diversification but may also increase expectations and mobility aspirations that conflict with traditional community structures.

Box Item 2: Ecosystem-based adaptation

IUCN's work on ecosystem-based adaptation demonstrates how natural asset conservation can support livelihood security under changing climate conditions. The Scaling-up Mountain Ecosystem-based Adaptation Project implemented across Nepal, Bhutan, Peru, Colombia, Kenya, and Uganda from 2017-2022 provides evidence that ecosystem conservation and restoration can enhance both climate resilience and livelihood opportunities for mountain communities. In Nepal's Panchase mountain ecosystem, EbA actions, including conservation and restoration of community ponds, community forestry management, and sustainable agriculture practices, provided multiple benefits including improved water availability, reduced disaster risks, and enhanced income opportunities through ecotourism and sustainable forest product harvesting.[100]

Physical assets are vulnerable to the effects of climate change through multiple pathways, including direct damage from extreme weather events and gradual degradation from changed environmental conditions. Traditional housing construction in mountain areas often utilizes local materials including stone, wood, and mud that provide thermal mass and insulation appropriate for historical climate conditions. However, increased precipitation intensity, freeze-thaw cycles, and extreme temperature variations can accelerate structural degradation and increase maintenance requirements that may exceed household financial capacity. Infrastructure – including trails, bridges, and water supply systems – face similar vulnerabilities from extreme weather events that can isolate communities and disrupt access to markets and services.

Financial assets are vulnerable under climate change because of both reduced income opportunities and increased expenses associated with climate adaptation and disaster recovery. Agricultural income may decline due to reduced crop yields, increased production costs, or market disruptions caused by extreme weather events. Livestock income may be affected by heat stress, feed shortages, or disease outbreaks that reduce animal productivity or cause mortality. Off-farm income opportunities may be disrupted by climate impacts on tourism, transportation, or other economic sectors. Simultaneously, households face increased expenses for climate adaptation measures including water storage, improved housing, or alternative energy sources that can strain limited financial resources.

98 Kushawaha, J., Borra, S., Kushawaha, A. K., Singh, G., & Singh, P. (2021). Climate change and its impact on natural resources. In *Water conservation in the era of global climate change* (pp. 333-346). Elsevier.

99 Caruso, G., de Marcos, I., & Noy, I. (2024). Climate changes affect human capital. *Economics of Disasters and Climate Change, 8*(1), 157-196.

100 https://iucn.org/our-work/topic/ecosystem-based-adaptation/scaling-mountain-eba

5.2.2 TRADITIONAL LIVELIHOOD SYSTEMS AND CLIMATE ADAPTATION

Traditional livelihood systems in mountain regions demonstrate sophisticated strategies for managing environmental variability that provide important insights for climate adaptation under changing conditions. Historical adaptation mechanisms include diversification across multiple economic activities, temporal distribution of risk through seasonal mobility patterns, spatial distribution of risk through vertical integration across elevation zones, and social distribution of risk through reciprocal labour and resource-sharing arrangements. These traditional systems evolved through generations of trial and error to optimize livelihood security under conditions of environmental variability and resource scarcity that characterize mountain environments. Jodha's analysis of traditional two-way adaptation systems demonstrates how mountain communities historically adjusted both their demands to match environmental constraints and modified environmental conditions to meet their needs.[101] Demand-side adaptations included flexible consumption patterns that varied seasonally and annually based on resource availability, diversified production strategies that spread risk across multiple activities and locations, and social institutions that facilitated resource sharing during periods of scarcity. Supply-side adaptations included terracing to create cultivable land on steep slopes, water harvesting and storage systems to buffer against seasonal variability, and forest management practices that maintained ecosystem services while providing multiple products.

Box Item 3: Traditional Adaptive Strategies and Climate Change

Mountain communities have historically employed sophisticated adaptation strategies that provide important lessons for contemporary climate responses:

- **Vertical Integration:** Utilizing multiple elevation zones for different crops and activities to spread climatic risks.
- **Seasonal Mobility:** Moving livestock and people seasonally to access different resources and opportunities.
- **Diversification:** Combining agriculture, livestock, forest products, and off-farm income to reduce dependence on any single source.
- **Social Networks**: Reciprocal labour and resource sharing arrangements that provide insurance during difficult periods.
- **Traditional Knowledge:** Understanding of local environmental patterns and management practices refined over generations.

Agricultural livelihoods throughout the HKH exemplify the complex pathways through which climate change affects livelihood security. Farming systems in the region typically integrate crop production, livestock rearing, and forest management in ways that provide multiple income streams and reduce dependence on any single activity.[102] Climate change affects each of these components differently, creating both opportunities and constraints that require careful management. Higher temperatures may extend growing seasons at high elevations, enabling cultivation of new crops or additional harvests per year, but these same temperature increases may exceed tolerance thresholds for traditional varieties that have been selected over generations. Changed precipitation patterns may provide more water during some periods while creating drought conditions during critical growth stages, requiring farmers to modify planting schedules, adopt water conservation practices, or shift to different crops with altered market values and nutritional characteristics. Livestock systems face particular vulnerabilities from climate change that can have immediate implications for food security and long-term consequences for livelihood sustainability. Pastoral communities in high-altitude areas depend on complex seasonal mobility patterns that move animals among grazing areas as vegetation phenology and weather conditions change throughout the year. Climate change disrupts these patterns by altering the timing

101 Jodha, N. S. (2013). Global change and environmental risks in mountain ecosystems. In *Global Environmental Risk* (pp. 306-342). Routledge.

102 Samarasekara Witharana, D. L. (2023). Traditional ecological knowledge in agriculture for adaptation/resilience to climate change: high mountain Asia.

and location of suitable grazing conditions, potentially creating conflicts between different pastoral groups or between pastoralists and sedentary farmers. Extreme weather events including unseasonal snowstorms, floods, or droughts can cause massive livestock mortality that eliminates years of asset accumulation within single events. Heat stress from higher temperatures reduces livestock productivity and increases veterinary expenses that may be unaffordable for households with limited cash income. Forest-based livelihoods including timber production, non-timber forest product collection, and ecosystem service provision face climate impacts that operate over both short and long time horizons. Immediate impacts include increased wildfire risk, pest and disease outbreaks, and extreme weather damage to forest infrastructure. Longer-term impacts encompass species composition changes, productivity shifts, and ecosystem service degradation that can fundamentally alter the economic value of forest resources. Communities that depend on forest products for construction materials, medicines, or market income may find that traditional resources become unavailable or unreliable, forcing either adoption of alternatives that may be more expensive or less suitable, or abandonment of forest-based livelihood strategies altogether.

However, integration with mainstream economies has disrupted many traditional adaptation mechanisms through processes that prioritize short-term economic gains over long-term sustainability. Market integration provides opportunities for income diversification and access to external resources but may also undermine traditional risk management mechanisms through specialization pressures that reduce diversification. Infrastructure development improves access to markets and services but may also expose communities to external shocks and reduce reliance on local resources and knowledge systems. Educational opportunities enhance human capital and create new livelihood possibilities but may also contribute to out-migration that depletes communities of human resources needed for local adaptation efforts. The challenge for contemporary climate adaptation lies in strengthening traditional adaptive mechanisms while incorporating new technologies and opportunities that can enhance resilience under changing conditions. Ecosystem-based adaptation approaches demonstrate how traditional ecological knowledge can be combined with scientific understanding to develop locally appropriate climate adaptation strategies. In Central Asia's high mountainous regions, GIZ's work on enhancing livelihoods[103] demonstrates that combining traditional resource management practices with new technologies and market opportunities can support sustainable development that maintains ecosystem services while improving economic opportunities for local communities.

Community-based approaches to climate adaptation recognize that effective adaptation requires building upon existing social capital and institutional arrangements while enhancing capacity for collective action. Research in the Bhagirathi Valley of the Indian Himalayas demonstrates that community-based adaptation strategies that combine traditional knowledge with external technical support can enhance both livelihood security and climate resilience.[104] Successful approaches include participatory resource management, diversified livelihood strategies that combine traditional and modern activities, and institutional arrangements that facilitate collective action while maintaining flexibility to respond to changing conditions.

5.2.3 GENDER DIMENSIONS OF LIVELIHOOD VULNERABILITY

The gendered dimensions of climate impacts on livelihoods require particular attention as women and men often have differentiated roles in mountain economies that create distinct vulnerabilities and adaptive capacities. Women in many HKH communities have primary responsibility for water collection, fuelwood gathering, and food processing activities that are directly affected by climate change.[105] As water sources become more distant or unreliable, women may need to spend additional time on water collection that reduces availability for other productive activities or education. Similarly, degradation of forest resources may require longer travel times for fuelwood collection or force households to purchase expensive alternatives. These changes can increase women's workloads while simultaneously reducing their access to resources needed for adaptation. UNDP's

103 https://www.giz.de/en/projects/ecosystem-based-adaptation-climate-change-high-mountain-regions-central-asia

104 Srivastava, Shoryabh & Pandey, Bindhy & Negi, V.. (2024). Community-Based Approaches to Climate Change Adaptation and Livelihood Security in the High-Altitude Bhagirathi Valley of Garhwal Himalaya. Journal of Resources and Ecology. 15. 197-203. 10.5814/j.issn.1674-764x.2024.01.017.

105 Dhimal, M., Bhandari, D., Dhimal, M. L., Kafle, N., Pyakurel, P., Mahotra, N., ... & Müller, R. (2021). Impact of climate change on health and well-being of people in Hindu Kush Himalayan region: A narrative review. *Frontiers in physiology, 12*, 651189.

work on enhancing human security through local climate actions in Nepal demonstrates that effective climate adaptation requires addressing the differentiated impacts of climate change on women and men while building upon women's knowledge and capabilities.[106] The project's gender and social inclusion approach ensures that women have equal access to adaptation resources and decision-making opportunities while recognizing their specific vulnerabilities and capacities.

Climate change may create new opportunities for women's economic participation through climate-related services or adaptive technologies, but realizing these opportunities often requires overcoming social and institutional barriers that limit women's access to credit, training, and market opportunities. Research in Pakistan's northern areas demonstrates that women's roles in traditional agricultural systems provide important foundations for climate adaptation, but that realizing this potential requires supportive policies that address gender inequities in resource access and decision-making authority.[107] The intersection of gender with other social identities including age, ethnicity, and economic status creates complex patterns of vulnerability and adaptive capacity that require nuanced understanding for effective intervention design. UNDP's human security approach recognizes that climate adaptation interventions must address intersecting vulnerabilities while building upon existing capabilities and social networks. This requires participatory approaches that enable different groups to identify their own priorities and capacities while providing support for collective action that addresses common challenges.

5.2.4 YOUTH MIGRATION AND LIVELIHOOD TRANSITIONS

Youth employment presents both challenges and opportunities in climate-adapted livelihood systems throughout the region. Traditional agricultural and pastoral livelihoods may become less attractive or viable for young people who have acquired education and skills that prepare them for non-agricultural employment. Climate change may accelerate this trend by reducing the profitability and reliability of traditional activities, encouraging out-migration that depletes rural communities of human capital needed for adaptive management. However, climate adaptation also creates demands for new skills and services including weather forecasting, climate-resilient agriculture, renewable energy systems, and disaster risk management that could provide employment opportunities for educated youth if appropriate training and institutional support are available.

Research on climate change and internal displacement in Nepal reveals complex relationships between climate impacts, livelihood opportunities, and youth migration patterns.[108] Rural areas experiencing declining agricultural productivity, water scarcity, or repeated climate disasters are seeing accelerated out-migration of young adults through multiple migration pathways: seasonal internal migration to India in construction and agriculture; permanent rural-urban migration within Nepal to Terai cities and Kathmandu; and increasingly significant international migration to Gulf Cooperation Council countries (Qatar, United Arab Emirates, Saudi Arabia) where approximately 500,000 Nepalis seek formal employment annually according to historical patterns. Migration to the Gulf countries has emerged as the dominant long-term migration stream for educated rural youth, with formal labour agreements facilitating employment in construction, domestic work, hospitality, and service sectors while generating remittances that substantially exceed internal migration earnings.

This out-migration can provide important remittance income that enables households to invest in climate adaptation measures, but it can also deplete communities of human capital needed for local adaptation efforts and place additional burdens on remaining community members, particularly women and elderly populations. The feminization of agriculture occurring in many mountain areas as men migrate for employment creates new opportunities for women's decision-making authority but also increases their exposure to climate risks without necessarily providing access to the resources needed for effective adaptation. Women may inherit responsibility for agricultural decision-making but lack access to credit, extension services, or new technologies that could

106 http://undp.org/nepal/projects/enhancing-human-security-through-local-climate-actions

107 Bano, K., Waqar, K., & Ali, A. (2023). Contributions of women's collective farming to women's agency in the Upper Indus Basin in the face of climate change. *Journal of Cleaner Production, 432*, 139734.

108 Sherpa, L., & Bastakot, G. B. (2021, January). *Migration in Nepal through the lens of climate change: Case studies from Siraha, Bardiya, Ramechap and Udayapur districts* (Indrajit Bose, Researcher). Climate Action Network South Asia. https://cansouthasia.net/wp-content/uploads/2021/02/Migration_Nepal_20_02_2021-1.pdf

enhance climate resilience. This creates situations where women bear increased responsibility for managing climate risks while lacking the resources needed for effective adaptation.[109]

Regional migration patterns reflect both historical relationships among communities and changing economic opportunities created by development investments and policy changes. Internal migration within Nepal involves movements from rural hills and mountains to urban areas in the Terai and major cities, as well as seasonal migration to India for employment in construction, agriculture, and other sectors.[110] These migration patterns provide important livelihood diversification strategies for mountain households, but they can also create vulnerabilities when economic conditions in destination areas change or when migration becomes forced displacement due to climate impacts rather than voluntary livelihood improvement strategies.

5.2.5 INSTITUTIONAL MECHANISMS AND MARKET INTEGRATIONS

The institutional framework that supports livelihood security includes formal systems such as agricultural extension services, credit institutions, and market structures, as well as informal institutions including reciprocal labour arrangements, community risk-sharing mechanisms, and traditional ecological knowledge systems. Climate change may weaken both formal and informal institutions by creating demands that exceed their capacity or by undermining the resource base that supports their operation. Agricultural extension services may lack information about climate-adapted practices, while credit institutions may become risk-averse about lending for climate-sensitive activities. Traditional risk-sharing mechanisms may be overwhelmed when climate impacts affect large areas simultaneously rather than being localized to individual households or communities.

Market integration presents both opportunities and vulnerabilities for climate-adapted livelihoods in mountain regions. Access to regional and global markets can provide income diversification and reduce dependence on local environmental conditions, but market integration also exposes mountain communities to price volatility and supply chain disruptions that may be beyond their control. Climate change can affect market access through damage to transportation infrastructure, while extreme weather events in distant locations can alter commodity prices in ways that affect mountain producers. Developing climate-resilient livelihoods requires balancing the benefits of market integration with the security provided by local production and consumption systems. The development of value chains for mountain products demonstrates both opportunities and challenges for climate adaptation through market mechanisms. ICIMOD's work on mountain livelihoods[111] demonstrates that developing markets for high-value mountain products including medicinal plants, specialty agricultural products, and ecotourism services can provide income opportunities that are less climate-sensitive than traditional agricultural activities. However, developing these markets requires investments in quality standards, processing facilities, marketing systems, and transportation infrastructure that may be disrupted by climate impacts.

109 Chitiga-Mabugu, M., Henseler, M., Maisonnave, H., & Mabugu, R. (2023). Climate change and women-impacts and adaptation. *International Review of Environmental and Resource Economics, 17*(1), 99-152.

110 Kumar, S., & Sati, V. P. (2023). Patterns and determinants of rural–urban migration in the Garhwal Himalaya. *GeoJournal, 88*(4), 3679-3698.

111 https://www.icimod.org/mountain/mountain-livelihoods/

Table 7: Climate Adaptation Capacity Indicators

	NEPAL	AFGHANISTAN	PAKISTAN	INDIA
Adaptation Index Score	52.3	28.1	45.7	61.2
Climate Finance Access (USD)	145 million	12 million	298 million	2,456 million
Early Warning Coverage	67%	23%	71%	84%
Institutional Capacity Score	6.2	2.8	5.9	7.3
Technology Readiness	Medium	Low	Medium	High
Social Capital Index	0.68	0.34	0.52	0.61

Source: ND-GAIN Index 2021; Nepal NAP 2021; World Bank Climate Profile Nepal 2021; World Bank Afghanistan Training 2018; UNFCCC Afghanistan Report 2024; Solidarity Committee 2025; NDMA Pakistan Early Warning Plan 2024; Pakistan Met Department 2006; UNDP Pakistan 2025; ND-GAIN Index 2021; India Economic Survey 2024; CEEW Analysis 2023

Climate change can affect the comparative advantage of mountain products through changes in growing conditions, product quality, and production costs that alter competitiveness in regional and global markets. Some products may benefit from changing conditions, while others may face reduced quality or increased production costs that affect market viability. Understanding these changing comparative advantages is essential for developing livelihood strategies that can benefit from climate change while managing associated risks. The integration of traditional and modern market systems provides opportunities for maintaining livelihood diversity while accessing new economic opportunities. Local markets and exchange systems that operate through traditional social networks can provide security and flexibility during periods of market disruption, while also serving as platforms for introducing new products and services that respond to changing conditions. Maintaining both local and external market relationships enables communities to benefit from diverse opportunities while maintaining resilience to external shocks.

5.3 Migration and Adaptive Mobility under Climate Stress

Migration under climate stress represents one of the most complex and consequential dimensions of human security transformation in the Hindu Kush Himalaya. It operates simultaneously as an adaptive strategy that enables communities to maintain livelihoods and wellbeing, and as an indicator of adaptation limits when in-situ responses become insufficient to sustain human security. Climate-induced mobility encompasses a spectrum of movement patterns from seasonal labour migration that has long been integrated into mountain livelihood systems, to permanent displacement that represents complete breakdown of local adaptive capacity. Understanding this spectrum requires moving beyond simple classifications of voluntary versus forced migration to recognize the complex decision-making processes through which households evaluate mobility options in relation to changing environmental conditions, economic opportunities, and social networks that enable successful relocation.

The framework distinguishes between climate-induced migration as an adaptive response to gradual environmental change (such as rural-urban movement driven by declining agricultural productivity) and climate-driven displacement as involuntary, crisis-driven movement caused by sudden-onset extreme events (GLOFs, flash floods, landslides). Displacement represents adaptation failure, which takes place in circumstances in which environmental shocks exceed institutional response capacity and where populations face immediate threats requiring emergency evacuation, without planned destination or livelihood alternatives. In contrast, migration can represent successful adaptation when individuals and households leverage social networks and economic opportunities to relocate strategically in response to environmental stress. However, this distinction blurs when repeated displacement exhausts household resources and erodes social capital, converting temporary crisis evacuation into permanent distress migration, lacking adaptive benefit. The framework treats both phenomena as human security outcomes shaped by the interaction of climate hazards, institutional capacity, and social position, and recognizing that whether environmental stress generates adaptive migration or crisis displacement depends substantially on pre-existing vulnerabilities, resource access, and governance arrangements that either facilitate planned mobility or force emergency flight.

Recent research indicates that climate-induced migration in South Asia is approaching unprecedented scales that will fundamentally reshape regional demographics and economic patterns. ActionAid projections suggest that over 62 million South Asians will be forced to migrate due to climate disasters by 2050, representing a tripling of current displacement rates.[112] Nepal alone is projected to experience 1.3 million climate migrants by 2050, more than three times the 2006-2020 baseline.[113] These projections reflect both the increasing severity of climate impacts and the limited effectiveness of in-situ adaptation strategies in addressing systemic environmental changes. However, migration projections must be interpreted carefully as they depend on assumptions about future climate scenarios, adaptation investments, and policy responses that could significantly alter migration pressures.

A most recent modelling study by UNDP provides the following future projections of migration[114] for the four countries under different climate change scenarios associated with the IPCC's Shared Socioeconomic Pathways (SSPs) or Representative Concentration Pathways (RCPs).[115]

Scale of Climate Migration by 2050 (in Millions)			
Country	SSP / RCP Scenarios		
	Sustainable Development Pathway (SSP1/RCP2.6)	Fossil-fuelled Development Pathway (SSP5/RCP8.5)	Regional Rivalry (SSP3/RCP7.0)
Afghanistan	4.1	8.5	-
Nepal	0.6	2.3	-
Pakistan	2.7	-	13.2

Source: UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

The drivers of climate-induced migration in mountain regions operate through complex interactions among environmental changes, livelihood disruptions, and social factors that determine both the necessity and feasibility of relocation. Direct environmental drivers include extreme weather events such as floods, landslides, and droughts that destroy homes and productive assets, forcing immediate displacement. Gradual environmental changes including spring source depletion, soil degradation, and shifting precipitation patterns may undermine livelihood viability over longer time periods, creating conditions where migration becomes an attractive option for improving household welfare. Social and economic factors, including education levels, social networks, and access to financial resources, determine who has the capability to migrate successfully and who becomes trapped in degraded environments without alternatives. The temporal patterns of climate migration encompass both emergency displacement during extreme events and planned mobility that anticipates environmental changes. Emergency displacement typically involves short-distance movement to temporary shelter with expectations of eventual return, but repeated displacement events can exhaust household resources and social support systems, leading to permanent relocation. Planned mobility may involve seasonal patterns, where household members migrate for employment during specific periods while maintaining residence in the areas of origin, or permanent relocation where entire households relocate to areas with better environmental conditions and economic opportunities. Climate change may alter these temporal patterns by increasing the frequency of emergency displacement while making seasonal patterns less viable as environmental conditions become more unpredictable.

112 Singh, H., Faleiro, J., Anderson, T., & Vashist, S. (2020, December). *Costs of climate inaction: Displacement & distress migration* (ActionAid & Climate Action Network South Asia). https://actionaid.org/sites/default/files/publications/ActionAid%20CANSA%20-%20South%20Asia%20Climate%20Migration%20report%20-%20Dec%202020_3.pdf

113 Sherpa, L., & Bastakot, G. B. (2021, January). *Migration in Nepal through the lens of climate change: Case studies from Siraha, Bardiya, Ramechap and Udayapur districts* (Indrajit Bose, Researcher). Climate Action Network South Asia. https://cansouthasia.net/wp-content/uploads/2021/02/Migration_Nepal_20_02_2021-1.pdf

114 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

115 ibid

The gender dimensions of climate migration are a reflection of the differentiated impacts of environmental changes on women and men, as well as the distinct constraints and opportunities that affect their mobility options. Women may face particular vulnerabilities from climate change due to their roles in water collection, food production, and household management that are directly affected by environmental changes. However, women also may have fewer migration options due to social restrictions on mobility, limited access to resources needed for relocation, and primary responsibility for childcare and elder care that complicates household mobility decisions. Climate migration may create opportunities for women to access new forms of employment and greater economic independence, but it may also expose them to new vulnerabilities including exploitation, violence, and social isolation in destination areas.

5.3.1 URBAN DESTINATIONS AND MIGRATION OUTCOMES

Destination dynamics represent crucial but often overlooked dimensions of climate migration that determine whether mobility contributes to improved human security or creates new vulnerabilities for migrants and host communities. Urban areas throughout South Asia are experiencing rapid population growth that strains infrastructure systems and creates competition for employment, housing, and services.[116] Climate migrants often settle in informal settlements that lack basic services and face high risks from flooding, heat waves, and other climate hazards. The concentration of climate migrants in climate-vulnerable urban areas can cause or suffer from compound risks i.e. where environmental changes in origin areas combine with environmental hazards in destination areas to create particularly severe human security challenges. Urban labour markets may provide opportunities for climate migrants to access new forms of employment that are less climate- sensitive than traditional agricultural activities. However, competition for employment may be intense, and migrants may lack the skills, social networks, or legal status needed to access higher-quality employment opportunities. Many climate migrants work in informal sectors including construction, domestic work, and street vending that provide income but little security or social protection. Housing conditions for climate migrants in urban areas often involve overcrowded, poorly constructed informal settlements that lack access to clean water, sanitation, electricity, and other basic services. These settlements are frequently located in areas prone to flooding, landslides, or other hazards, creating situations where migrants face higher environmental risks than they experienced in origin areas. Urban heat island effects may create particularly severe challenges for migrants from cooler mountain areas who lack experience with extreme heat conditions.

Remittance flows from climate migrants to their communities of origin represent important but complex pathways through which migration can support adaptation and resilience in climate-affected areas.[117] Remittances provide financial resources that enable households to invest in climate adaptation measures such as water storage systems, drought-resistant crops, or alternative livelihood activities. However, remittance dependency can also create vulnerabilities when economic conditions in destination areas affect migrants' ability to send money, or when remittances substitute for local economic development that might provide more sustainable adaptation pathways. The gender dimensions of remittances are particularly important as male migration may increase women's decision-making authority over remittance use while also increasing their workloads in managing households and productive activities.

116 https://www.adb.org/features/facts-and-data-about-cities-and-urbanization-asia

117 Szaboova, L., Adger, W. N., de Campos, R. S., Maharjan, A., Sakdapolrak, P., Sterly, H., ... & Abu, M. (2023). Evaluating migration as successful adaptation to climate change: Trade-offs in well-being, equity, and sustainability. *One Earth, 6*(6), 620-631.

Circular migration patterns that involve repeated movement between origin and destination areas may provide mechanisms for maintaining connections to traditional livelihoods while accessing new economic opportunities. Such patterns may be particularly important for mountain communities where environmental conditions remain suitable for some activities during part of the year but become challenging during specific seasons. Climate change may either enhance or constrain circular migration patterns depending on how it affects seasonal variability in origin areas and economic opportunities in destination areas. Policy frameworks that support circular migration through flexible work arrangements and portable social services could enhance the adaptation benefits of mobility, while maintaining community connections that support resilience in the areas of origin.

5.3.2 INTERNATIONAL, REGIONAL AND CROSS-BORDER DYNAMICS

Cross-border migration presents additional complexities for climate adaptation in the transboundary Hindu Kush Himalaya region where environmental changes and economic opportunities may not align with political boundaries. Historical migration patterns among Afghanistan, Pakistan, India, and Nepal reflect ethnic, linguistic, and economic relationships that transcend national borders, but contemporary security concerns and border restrictions may limit traditional mobility options.[118] Climate change may create new pressures for cross-border migration as environmental degradation affects large areas simultaneously, but political tensions and restrictive migration policies may prevent movement that could otherwise provide adaptation benefits. Afghanistan's complex migration situation demonstrates the intersection of climate impacts with conflict and political instability that creates compound drivers of displacement. The country hosts approximately 1.5 million refugees from other countries while simultaneously experiencing massive internal displacement and emigration to neighbouring countries.[119] Climate impacts including drought and flooding compound existing vulnerabilities and may accelerate displacement patterns, while international sanctions and political isolation limit both internal adaptive capacity and external assistance. Pakistan's role as both a source and destination country for climate migrants reflects its position at the intersection of multiple migration systems and its exposure to extreme climate events. The country hosts over 3 million Afghan refugees while experiencing significant internal displacement from floods, droughts, and extreme weather events. The 2022 floods alone displaced over 8 million people internally, while economic pressures encourage emigration to Gulf countries and other destinations.[120] Nepal receives large scale remittances from its migrant population, a significant proportion of whom go to Gulf countries, and which illustrates the importance of labour migration to Gulf countries for adaptation and development needs of the households. Both Nepal and Bangladesh have well established policies and institutional arrangements in place for labour migration to Gulf countries and other destinations. India's complex federal structure and diverse geography create multiple internal migration patterns that may be affected by climate change in different ways across different regions and states. Internal migration from rural to urban areas, seasonal migration for agricultural labour, and permanent relocation for employment may all be affected by climate impacts on agricultural productivity, water availability, and extreme weather patterns.[121] Interstate migration may create political tensions when large numbers of people move from climate-affected areas to other states with different languages, cultures, and political systems.

The recognition of climate migration in international legal frameworks remains limited despite the growing scale and significance of climate-induced displacement. Existing refugee law under the 1951 Refugee Convention does not explicitly recognize climate change as grounds for protection, creating legal ambiguities about the rights and obligations related to climate migrants who cross borders. However, the Global Compact on Safe, Orderly and Regular Migration (GCM), adopted in 2018 and representing the first comprehensive international framework to explicitly address climate-driven migration, identifies "natural disasters, the adverse effects of climate change, and environmental degradation" as drivers of migration and calls for developing adaptation strategies that incorporate migration considerations alongside disaster risk reduction, planned relocation, and

118 Pattanaik, S. S. (2024). Transcending Borders: Interplay of Geopolitics, Geo-Economics and Geo-Cultural Dynamics in India's Relations with Its Neighbours. In *The Futures of Borders and Geopolitics in South Asia: Beyond a Statist Discourse* (pp. 123-150). Singapore: Springer Nature Singapore.

119 IOM (2025). Afghanistan Climate Vulnerability Assessment: Province Profiles, Eastern Region.

120 Government of Pakistan (2022). 2022 Floods: Post-Disaster Needs Assessment. Ministry of Planning.

121 Biella, R., Hoffmann, R., & Upadhyay, H. (2022). Climate, agriculture, and migration: exploring the vulnerability and outmigration nexus in the Indian Himalayan Region. *Mountain Research and Development, 42*(2), R9-R21.

regular migration pathways. Despite these developments, the GCM remains non-binding, and implementation mechanisms remain weak, with limited financial resources dedicated to supporting countries in operationalizing climate migration commitments. Some regional agreements and policy frameworks are beginning to address climate migration, but much more work is needed to develop legal and institutional mechanisms that can support climate migrants while addressing the legitimate concerns of host communities about rapid population changes and resource competition.[122]

The policy implications of climate-induced migration require coordinated approaches that address both the factors driving migration and the conditions affecting migrants in destination areas. Origin area policies might focus on strengthening climate adaptation and disaster risk reduction to reduce migration pressures while supporting those who choose to migrate. Destination area policies need to address urban planning, service provision, and labour market access to ensure that climate migrants can contribute to economic development while accessing basic services. Regional approaches may be needed to coordinate migration policies across multiple countries and address the transboundary nature of climate impacts and migration flows.

122 Sharma, A., & Manhas, N. S. (2025). Environmental Security Complex in the Hindu-Kush Himalayas: A Regional Perspective. *Strategic Analysis*, 1-13.

6. Country-Specific Climate Security Vulnerabilities

Photo: Jitendra Raj Bajracharya/ICIMOD.

6.1 Nepal: High-Altitude Vulnerabilities and Transboundary Water Risks

Nepal exemplifies the concentrated vulnerabilities that characterize small mountain nations facing disproportionate climate impacts relative to their adaptive capacity and greenhouse gas contributions. The country's position astride major Himalayan watersheds creates dependencies on glacier and snow-fed water systems that are experiencing rapid changes, while its limited economic resources and institutional capacity constrain adaptation responses. The framework characterizes Nepal as experiencing the convergence of high exposure to climate hazards with limited adaptive capacity, common to many mountain nations. While the country's ranking in the Climate Risk Index[123] has shown fluctuation (from 4th globally in earlier assessments to 69th-78th in recent evaluations), this shift reflects evolving methodological approaches and expanded global comparison samples rather than necessarily reduced vulnerability.[124] The improved ranking partially stems from enhanced disaster data reporting systems, but underlying systemic vulnerabilities persist and may be intensifying as climate change accelerates beyond historical bounds of variability. Nepal contains 47 glacial lakes classified as potentially dangerous by ICIMOD-UNDP assessments, with 42 located in the high-risk Koshi basin alone, posing high risks of glacial lake outburst floods that threaten both mountain communities and downstream populations across multiple districts.[125]

The agricultural sector, which employs 61.2% of Nepal's population and contributes 25-27% to GDP, faces multiple climate stresses that threaten both food security and economic stability.[126] Traditional farming systems have evolved sophisticated strategies for managing seasonal variability over centuries, including crop calendars synchronized with monsoon patterns, elevation-based cropping systems that utilize different agro-ecological zones, and indigenous varieties specifically adapted to local microclimatic conditions. However, climate change introduces forms of variability that exceed historical bounds and challenge the very foundations of traditional agricultural knowledge systems. The Thami community of Dolakha district exemplifies these challenges, where farmers report that their acquired indigenous knowledge has become "ineffective for adaptation to hazards in agriculture" due to the unpredictable nature of current environmental changes.[127] The middle hills region is experiencing changes in crop suitability zones as temperature increases, making traditional varieties unviable at historical elevations. This forces farmers to adopt new crops, or move to higher elevations, where suitable land may be limited and traditional farming systems may not be applicable. Population distribution projections from UNDP's climate mobility study[128] indicate sustained depopulation of many high-elevation municipalities by 2050 under all scenarios, reflecting the growing difficulty of sustaining traditional farming systems under altered climatic conditions. Traditional planting schedules based on seasonal indicators, such as the appearance of specific flowers, bird migration patterns, or changes in wind directions, are becoming unreliable as monsoon timing becomes more erratic and temperature patterns shift beyond the bounds of traditional knowledge systems.

Water security challenges in Nepal reflect both supply-side impacts from changing precipitation and glacial melt patterns, and demand-side pressures from population growth and economic development, creating a compound stress on already limited water resources. Urban areas, including the Kathmandu Valley, face severe water shortages as traditional sources become unreliable and demand increases, with current water demand

123 Adil, L., Eckstein, D., Künzel, V., & Schäfer, L. (2025, February 12). *Climate Risk Index 2025* (Germanwatch). https://www.germanwatch.org/sites/default/files/2025-02/Climate%20Risk%20Index%202025.pdf

124 https://thehimalayantimes.com/nepal/nepal-urgently-needs-national-climate-change-assessments

125 Bajracharya, S.R., Maharjan, S.B., Shrestha, F., Sherpa, T.C., Wagle, N., Shrestha, A.B. (2020). Inventory of glacial lakes and identification of potentially dangerous glacial lakes in the Koshi, Gandaki, and Karnali River Basins of Nepal, the Tibet Autonomous Region of China, and India. Research Report. ICIMOD and UNDP.

126 Nepal Rastra Bank, Economic Research Department. (2025, August). *Current macroeconomic and financial situation of Nepal* (Based on annual data 2024/25). https://www.nrb.org.np/contents/uploads/2025/08/Current-Macroeconomic-and-Financial-Situation-English-Based-on-Annual-data-of-2024.25.pdf

127 Thapa, B. J. (2019). Climate change perception and adaptation among indigenous farmers: A study on Thamis of Dolkha. *Banko Janakari, 29*(2), 42-48.

128 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

of 360 million litres per day far exceeding supply of 90-140 million litres per day.[129] UNDP's climate mobility study[130] projects that by 2050, the Kathmandu Valley is likely to absorb between roughly 156,000 and 550,000 climate migrants depending on the scenario, compounding existing stress on water supply systems and basic service delivery. The ambitious Melamchi Water Supply Project, designed to address Kathmandu's water crisis through inter-basin transfer, exemplifies the vulnerabilities of large-scale infrastructure to climate impacts and demonstrates how extreme weather events can undermine expensive adaptation investments. Catastrophic floods in 2021 buried the project's headworks under 15-20 meters of debris, disrupting water supply for six months and causing estimated damages exceeding NPR 20 billion (~140 million USD).[131] This disaster illustrates the framework's emphasis on understanding critical thresholds, such as infrastructure designed for historical climate patterns may be inadequate for future climate extremes, requiring fundamental rethinking of design standards and risk assumptions.

Climate-induced migration from Nepal represents both an adaptation strategy and an indicator of adaptation limits as environmental changes combine with limited economic opportunities to drive out-migration patterns that reshape rural demographics and community resilience capacity. Approximately 500,000 Nepalis seek foreign employment annually according to historical patterns, with climate impacts increasingly recognized as contributing factors to migration decisions.[132] Recent modelling across multiple development and climate futures[133] indicates that Nepal may experience between 125,000–550,000 climate-related movers by 2030, rising to approximately 613,000–2.3 million by 2050, depending on the scenario. This reinforces the trend that environmental stressors are becoming increasingly central to mobility decisions.[134]

Following COVID-19 and disruptions that temporarily depressed approvals to 72,081 in 2021/22, labour migration has recovered substantially, with the Department of Foreign Employment issuing 741,297 approvals in 2023/24 and 839,266 in 2024/25,[135] representing recovery to and beyond pre-pandemic levels. This recovery demonstrates resilience in formal labour migration systems, though climate impacts increasingly compound traditional migration drivers as environmental degradation interacts with economic opportunity-seeking to shape migration decisions. Rural areas experiencing water scarcity, declining agricultural productivity, or repeated climate disasters are seing accelerated out-migration. This depletes those communities of human capital needed for local adaptation efforts and is indicative of the feedback loops between environmental degradation and demographic change. However, remittances from migrants also provide financial resources that enable households to invest in climate adaptation measures, creating complex relationships between migration and community resilience including both the opportunities and constraints of labour mobility as a climate adaptation strategy. These remittance flows, totalling NPR 1.4 trillion annually[136] and representing between 26-33% of Nepal's Gross National Income equivalent,[137] create crucial financial buffers for rural households facing climate stress while potentially reducing incentives for local adaptation investments.[138]

The gendered dimensions of climate impacts in Nepal are particularly pronounced due to women's roles in water collection, agricultural production, and natural resource management, which are directly affected by climate variability while women simultaneously face structural barriers to accessing adaptation resources and

129 Shrestha, A., Bhattarai, T. N., Acharya, G., Timalsina, H., Marks, S. J., Uprety, S., & Paudel, S. R. (2023). Water, sanitation, and hygiene of Nepal: status, challenges, and opportunities. *ACS ES&T Water, 3*(6), 1429-1453.

130 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

131 Adhikari, T. R., Baniya, B., Tang, Q., Talchabhadel, R., Gouli, M. R., Budhathoki, B. R., & Awasthi, R. P. (2023). Evaluation of post extreme floods in high mountain region: A case study of the Melamchi flood 2021 at the Koshi River Basin in Nepal. *Natural Hazards Research, 3*(3), 437-446.

132 Adhikari, J., Rai, M. K., Baral, C., & Subedi, M. (2023). Labour migration from Nepal: Trends and explanations. In *Migration in South Asia: IMISCOE regional reader* (pp. 67-81). Cham: Springer International Publishing.

133 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

134 ibid

135 https://en.himalpress.com/839266-received-labor-permits-for-foreign-employment-in-2024-25/

136 https://thehimalayantimes.com/business/remittance-inflows-surge-331-percent-to-rs-352-billion-in-two-months-of-fy-202526

137 https://www.theglobaleconomy.com/Nepal/remittances_percent_GDP/

138 International Organization for Migration (IOM) Nepal. (2022). *Profiling returnee migrant workers for labour market integration.* Ministry of Labour, Employment and Social Security (MoLESS) & IOM Nepal. https://nepal.iom.int/sites/g/files/tmzbdl1116/files/documents/moless-iom-profiling-of-returnee-migrant-workers-for-labour-market-integration_0.pdf

decision-making authority.[139] As climate change makes water sources more distant or unreliable, women's workloads increase substantially, with some studies documenting increases in water collection time from 30 minutes to over 3 hours daily during dry seasons,[140] while their access to adaptation resources may be limited by social and institutional barriers. The increasing feminization of agriculture as men migrate for employment creates new opportunities for women's decision-making authority in agricultural practices but also increases their exposure to climate risks without necessarily providing access to the resources needed for effective adaptation, such as credit, extension services, or climate-resilient technologies. Women own only 19.7% of agricultural land and control just 5% of total land area, constraining their access to formal credit, government subsidies, and agricultural extension services that are typically tied to land ownership.[141] This creates a paradox where those most responsible for agricultural adaptation have least access to the resources and authority needed for effective climate adaptation responses.

6.1.1 FRAMEWORK ANALYSIS

The Food-Water-Energy nexus in Nepal demonstrates the framework's core premise that these systems function as an integrated material foundation for human security, with disruptions cascading across sectors to create compound vulnerabilities that exceed the sum of individual sectoral impacts. Nepal's agricultural sector depends fundamentally on reliable water and energy inputs, creating circular dependencies where disruptions cascade across sectors: irrigation requires energy for pumping and distribution systems; hydropower generation depends on consistent river flows that are increasingly variable; and food processing, storage, and transport require both water and energy inputs that may be disrupted simultaneously during extreme weather events. Climate-induced changes are systematically disrupting these interdependencies through multiple pathways. Nepal's mean annual temperature has increased by 1.8°C between 1975-2006, with an acceleration rate of 0.056°C annually (nearly double the global average), directly affecting the hydrological cycle through accelerated glacial retreat and increasingly erratic monsoon patterns.[142] ICIMOD's HI-WISE report notes that glaciers across the entire region will lose 30-50 percent of their volume by 2100 under 1.5-2 degree warming scenarios,[143] fundamentally destabilizing water availability patterns that have sustained mountain civilizations for millennia. The result is a fundamental destabilization of water availability that reverberates through energy and food systems, creating cascade effects that can transform manageable stresses into existential threats when multiple systems fail simultaneously.

Water security emerges as the most climate-sensitive component of the nexus, with multiple dimensions of vulnerability that interact to create compound risks exceeding individual hazard impacts. Nepal's per capita water availability of 7,820 m^3/year appears adequate by global standards, but temporal and spatial distribution creates severe stresses. This exemplifies the framework's emphasis on understanding system dynamics rather than static resource availability.[144] The Kathmandu Valley illustrates this paradox: despite abundant national water resources, the capital faces chronic shortages during dry seasons, with groundwater tables declining by 70-80 cm annually while demand continues increasing. Over 70% of springs in the Siwalik region have dried up in recent decades, representing irreversible changes to traditional water sources that have sustained communities for generations.[145] This reflects a broader pattern where 96% of groundwater use serves irrigation, creating competition between agricultural and domestic needs that intensifies under climate stress and may approach threshold conditions where traditional water management systems become unviable.[146]

139 Begho, T., Dendup, S., Tshering, D., Nepal, B., & Joshi, R. (2025). Agricultural resource access, decision-making and women's empowerment in climatevulnerable smallholder agriculture: Evidence from Nepal and Bhutan. *Frontiers in Sustainable Food Systems, 9*, 1654941.

140 Shrestha, A., Bhattarai, T. N., Acharya, G., Timalsina, H., Marks, S. J., Uprety, S., & Paudel, S. R. (2023). Water, sanitation, and hygiene of Nepal: status, challenges, and opportunities. *ACS ES&T Water, 3*(6), 1429-1453.

141 https://www.iom.int/news/securing-womens-land-and-property-rights-nepal

142 Gurung, Tek, Pokharel, Prakash and Wright, Iain. (2011). Climate Change : Livestock Sector Vulnerability and Adaptation in Nepal. 10.13140/RG.2.1.1548.6887.

143 ICIMOD. (2023). *Water, ice, society, and ecosystems in the Hindu Kush Himalaya: An outlook.* (P. Wester, S. Chaudhary, N. Chettri, M. Jackson, A. Maharjan, S. Nepal, & J. F. Steiner [Eds.]). ICIMOD. https://doi.org/10.53055/ICIMOD.1028

144 Winrock International. (2021). *Nepal country profile.* https://winrock.org/wp-content/uploads/2021/08/Nepal_Country_Profile_Final.pdf

145 Thapa, B., Bhattarai, C., Dahal, N., Tiwari, S., & Jacobsen, D. (2023). Drying of springs in the Himalayan region of Nepal: Perspectives of local government leaders on causes, consequences, and conservation efforts. *Mountain Research and Development, 43*(4), R9-R15.

146 Poudel, Govinda. (2019). Status of water resources in Nepal and existing use in Irrigation. Journal of Innovations in Engineering Education. 2. 44-48. 10.3126/jiee.v2i1.36663.

Considerations of Nepal's energy security demonstrate both the opportunities and vulnerabilities of dependence on renewable energy in climate-sensitive systems, with 87% of electricity generation from hydropower creating single-point failure risks within the FWE nexus.[147] While hydropower has significant clean energy potential, with an estimated theoretical capacity of 83,000 MW, it also creates extreme vulnerability to the hydrological variability that is increasing under climate change. Recent projections suggest Nepal's hydropower potential might increase by approximately 5.7% by 2030 due to initial glacial melting, but this temporary increase masks longer-term risks, as continued glacier loss could reduce hydropower potential by approximately 25% in the late 21st century.[148] Climate change is introducing unprecedented variability in energy generation through altered precipitation patterns, changing seasonality of river flows, and increased frequency of extreme events that can damage infrastructure. Dry season flows, traditionally sustained by glacier melt and snowpack accumulation, are becoming increasingly unpredictable as the timing and magnitude of melt water release changes. This affects not only large hydropower plants but also community-scale micro-hydro systems that serve rural areas and provide the foundation for rural electrification programs.

The framework identifies this as a cascade vulnerability pattern where energy disruptions immediately affect water pumping and treatment systems, which in turn impact agricultural irrigation and food processing capacity. Rural areas, where 95% have electricity access[149] but quality remains inconsistent, face particular vulnerability during climate-related energy shortages that can last for weeks during extreme events. Nepal's experience illustrates the double-edged nature of renewable energy transitions: while hydropower provides clean energy and reduced dependence on fossil fuel imports, concentration in a single renewable source creates systemic vulnerabilities when that source is highly climate sensitive. The seasonal variation in power generation creates additional challenges: Nepal can generate surplus electricity during monsoon months, selling NPR 15 billion worth to India in recent years, but faces shortages during winter months when it must import approximately 30% of peak demand to meet domestic needs.[150]

Agricultural livelihoods serve as the mediating system between the environment and human wellbeing outcomes and represent the critical interface through which changes in the FWE nexus translate into impacts on human security. With over 70% of women and 61.2% of the total population engaged in agricultural activities across 3,091,000 hectares under cultivation, farming systems are both the primary livelihood source and the sector most exposed to climate variability.[151] Traditional farming systems in Nepal evolved sophisticated strategies for managing seasonal variability that demonstrate remarkable adaptation to mountain environments, including crop calendars precisely aligned with monsoon patterns, elevation-based cropping systems that utilize different agro-ecological zones from 60 meters to over 4,000 meters elevation, and indigenous varieties adapted to specific microclimatic conditions within individual valleys. Indigenous knowledge systems include detailed understanding of seasonal indicators, such as the flowering patterns of specific plants, bird migration timing, changes in insect behaviour, and subtle variations in wind patterns, that guide agricultural timing and crop selection decisions.

However, climate change introduces forms of variability that exceed historical bounds and challenge the fundamental assumptions underlying traditional ecological knowledge. Temperature increases make traditional crop varieties unviable at historical elevations, forcing farmers to either adopt new varieties, or attempt cultivation at higher elevations where soil quality, terracing systems, and water availability may be inadequate. Specific impacts include the decline in potato yields by 27.8% during the 1997/98 cold wave, while changed temperature patterns have disrupted the traditional three-crop rotation systems that maintain soil fertility and provide year-

147 Bhandari, R., & Subedi, S. (2023). Evaluation of surplus hydroelectricity potential in Nepal until 2040 and its use for hydrogen production via electrolysis. *Renewable Energy, 212*, 403-414.

148 P. C., Shakti & Pun, Ishwar & Talchabhadel, Rocky & Kshetri, Darshan. (2021). The Role of Glaciers in Hydropower Production in Nepal. Journal of Asian Energy Studies. 5. 1-13. 10.24112/jaes.050001.

149 https://kathmandupost.com/money/2019/06/04/955-percent-of-nepalis-have-an-electricity-connection-report-says

150 https://nepaleconomicforum.org/climate-change-threatens-nepals-hydropower-future/

151 Khanal, K., & Dhungana, S. M. (2024). Women participation in agriculture in Nepal: A policy review. *American Research Journal of Humanities & Social Science, 7*(10), 49-51.

round food security.[152] The middle hills region exemplifies the broader challenges facing mountain agriculture under climate change. UNDP's climate mobility projections[153] show that in counterfactual no-climate scenarios, these municipalities register almost no population losses, underscoring climate change's role in future spatial reconfiguration.

Traditional cropping patterns included winter crops like wheat and barley at lower elevations, summer rice in irrigated areas, and maize and millet on rainfed terraces, with vegetables and pulses integrated throughout the system. Climate change is forcing adaptations that may undermine the integrated nature of these systems: earlier spring temperatures allow extended growing seasons but also increase water stress during critical growth periods; changed precipitation patterns make rainfed agriculture less reliable, increasing dependence on irrigation systems that may lack adequate water sources; and increased pest and disease pressure, associated with warmer temperatures and changing humidity patterns, requires new management approaches that may not be compatible with traditional organic farming methods. Farmers report adopting hybrid seeds that provide higher yields but require purchased fertilizers and pesticides, creating new economic vulnerabilities and dependencies on external inputs while potentially reducing the nutritional quality and taste preferences associated with traditional varieties.

The impact on food security is profound and multidimensional, reflecting the framework's emphasis on understanding system-wide effects rather than isolated impacts. With 2.8 million people food insecure and only 24% of agricultural land irrigated, Nepal's food system operates with minimal buffers against climate shocks.[154] The concentration of agriculture in smallholder systems means that individual households have limited capacity to absorb production losses, while the lack of crop insurance or reliable social protection systems amplifies the impacts of climate-related agricultural failures. Food security challenges are exacerbated by post-harvest losses of 15% that stem from inadequate storage infrastructure, transportation bottlenecks during monsoon seasons, and processing capacity constraints. Climate change increases post-harvest losses through higher temperature and humidity conditions that promote spoilage, while extreme weather events can disrupt transportation systems and damage storage facilities.

Migration patterns in Nepal exemplify the framework's understanding of movement as both adaptation strategy and system breakdown indicator, with climate impacts increasingly influencing traditional labour mobility systems while creating new forms of displacement that may exceed adaptive capacity. Migration serves multiple functions within Nepal's mountain economy: seasonal migration to India for agricultural work during Nepal's dry season provides crucial income when local agricultural opportunities are limited; longer-term migration to Gulf countries generates remittances that support household investments in education, housing, and agricultural improvements; and internal migration from hills to Terai or urban areas reflects both environmental pressures and expanding economic opportunities in destination areas. Projected climate-related mobility[155] also reflects this stress, with significant out-migration from the middle hills and movement toward urban centres and lower-lying municipalities. However, the framework distinguishes between adaptive migration that enhances overall system resilience and maladaptive migration that indicates system breakdown, with climate change potentially shifting the balance toward the latter. Rural areas experiencing water scarcity, declining agricultural productivity, or repeated climate disasters are seeing accelerated out-migration that depletes communities of productive-age population needed for local adaptation efforts. This is reinforced through the projected spatial patterns[156] that show high-altitude districts such as Dolpa, Humla, Jumla, Mugu and Mustang as persistent net senders of climate and non-climate migrants in all scenarios to 2050. This creates negative feedback loops where environmental degradation drives migration, which reduces local adaptive capacity and accelerates further degradation. The feminization of agriculture results partly from male out-migration patterns, placing greater adaptation burdens on women while they simultaneously face structural barriers to accessing adaptation resources and

152 Poudel, O., Acharya, P., Sharma, D. R., & Simkhada, D. (2024). Optimizing Potato Productivity in Nepal: Unveiling the Impact of Climate and Farming Practices through Econometric Insights. *Journal of Business and Social Sciences, 6*(1), 65-84.

153 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

154 Rajbhandari, Binayak, Nepal, Namita and Bhattarai, Supekshya. (2025). Status of Climate Change and Food Security in Kathmandu District. Nepalese Journal of Agricultural Sciences. 28. 10.3126/nepjas.v28i1.77623.

155 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

156 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

decision-making authority. Young people with education and skills increasingly migrate permanently rather than seasonally, creating “hollow villages” where traditional knowledge transfer systems break down and innovation capacity is reduced.

Remittances create complex feedback loops within the human security system that demonstrate both the opportunities and risks associated with migration-dependent development strategies. Remittances enable households to invest in climate-resilient housing, water storage systems, alternative energy sources, and alternative livelihood activities that reduce dependence on climate-sensitive agriculture. At the community level, remittances fund infrastructure improvements including roads, schools, health facilities, and communication systems that enhance overall adaptive capacity. However, the framework identifies both positive and negative feedback effects that complicate simple assessments of migration as adaptation. Dependence on remittances can reduce incentives for local adaptation investments and innovation, creating vulnerability to external economic shocks that affect labour demand in destination countries. When migration represents flight from environmental degradation rather than pursuit of economic opportunity, remittances may subsidize continued residence in increasingly marginal conditions rather than supporting either local adaptation or planned relocation to more sustainable areas.

Nepal’s adaptation to climate security challenges is fundamentally shaped by social institutions and community participation structures that determine adaptive agency. In Nepal’s post-conflict context, community-based organizations and local governance structures (Rural/Urban Municipality, User Groups) have emerged as platforms for collective adaptation decision-making; however, their effectiveness in supporting human security depends substantially on whether marginalized groups (particularly women, Dalit communities, and indigenous minorities) participate meaningfully in priority-setting and resource allocation. Adaptive capacity studies reveal that women’s participation in community water management groups correlates with better livelihood outcomes during drought, not because women possess different technical knowledge, but because their participation ensures that adaptation strategies address household water security and food production, which are dimensions often overlooked in male-dominated planning.[157] Similarly, indigenous communities’ access to adaptation finance and technology depends on whether their traditional resource management systems are recognized as legitimate by government institutions; when indigenous knowledge systems are marginalized in adaptation planning, communities lack both the social authority to implement customary adaptation strategies and access to complementary modern resources. Nepal’s peace-building framework explicitly recognizes that social cohesion as the foundation of collective adaptation, and it requires inclusion of historically marginalized groups in community decision-making. This social dimension of resilience means that human security in climate-stressed Nepal depends not only on livelihood diversification or technology access, but on whether adaptation processes strengthen or weaken community trust and social inclusion. Policy interventions that exclude marginalized voices from adaptation planning may be technically sound but socially counterproductive, undermining the community cohesion that sustains resilience through climate shocks.

6.1.2 THRESHOLD CHALLENGES

The policy framework for adaptive mobility remains underdeveloped in Nepal despite the crucial role of migration in household and national economic strategies. Bilateral labour agreements with major destination countries (Qatar, UAE, Saudi Arabia, Malaysia) provide some protection mechanisms, but coverage remains limited particularly for women migrants who represent less than 20% of formal migration streams.[158] Protection gaps include inadequate oversight of recruitment practices, limited consular services, and insufficient reintegration support for returning migrants. The framework suggests that effective migration governance should facilitate safe, voluntary movement while building origin area resilience, but current policies lack integration between migration management and climate adaptation planning. Return migration support remains particularly limited,

157 Debnath, S., Argade, S., 2024. Gender perspectives in integrated water resource management. In: Aquaculture Reimagined: Modern Approaches to Sustainable Fish Farming. (Eds.) Saini, V.P., Paul, T., Singh, A.K., Biswal, A. and Samanta, R. Biotica Publications, India. pp. 212-228. DOI: https://doi.org/10.54083/978-81-980121-3-5_17.

158 People Forum for Human Rights. (2024, September). *Study on Nepal’s bilateral labor agreements with destination countries.* https://peopleforum.org.np/wp-content/uploads/2024/09/study-on-bilateral-labour-aggrement-with-destination-countries-.pdf

representing a missed opportunity for utilizing returning migrants' skills, capital, and international experience for local climate adaptation and economic development.

Access to climate finance and institutional capacity represent critical constraints limiting Nepal's adaptation responses and illustrates the importance of building institutional resilience alongside physical adaptation measures. Despite sophisticated policy frameworks, including National Adaptation Plans, Local Adaptation Plans for Action, and climate budget codes for tracking expenditures, Nepal faces significant barriers in accessing and implementing climate finance. The institutional structure includes the Ministry of Finance as the National Designated Authority for the Green Climate Fund, with dedicated Climate Finance Steering Committees and Technical Committees providing coordination mechanisms. However, project development capacity remains limited, creating bottlenecks in proposal preparation and implementation that constrain access to available international funding. Current climate finance flows of USD 48.52 million annually from major international funds represent a small fraction of estimated annual adaptation needs of USD 2.3 billion, creating a finance gap exceeding 95%.[159]

The framework emphasizes multi-level governance challenges that are particularly evident in Nepal's ongoing federal transition, where provincial and local governments have primary responsibility for adaptation implementation but face severe capacity constraints. Key institutional constraints include technical capacity gaps in climate risk assessment and project design at sub-national levels; limited direct access to international climate finance mechanisms for provincial and local governments; coordination challenges between federal, provincial, and local levels that create implementation delays and duplicated efforts; and inadequate awareness of climate finance opportunities and requirements among key implementing agencies. Recent initiatives to build sub-national capacity through GCF Readiness funding[160] represent important steps, but implementation remains limited and may be insufficient given the scale of capacity building needs across Nepal's 753 local governments.

The framework emphasizes the identification, through integrated risk management approaches, of thresholds beyond which systems undergo irreversible transformation, and Nepal confronts several critical tipping points simultaneously. Glacial Lake Outburst Flood risk represents the most immediate catastrophic threat. The risk is increasing, as climate change accelerates glacial retreat and creates new supraglacial lakes that may be too small for standard satellite detection, but can still pose significant risks to downstream communities. Collapse of the system of groundwater replenishment represents a slower moving but potentially irreversible tipping point, with profound implications for urban water security and agricultural sustainability. These changes reflect over-extraction for urban water supply, agricultural irrigation, and industrial uses, combined with reduced recharge due to changing precipitation patterns and increased evapotranspiration rates under warmer temperatures.

A third critical threshold is the transformation of the traditional agricultural system(s) when farming systems may become unviable, forcing fundamental changes in rural livelihoods and food security strategies. Traditional crop varieties and farming calendars are becoming unviable across elevation zones, with temperature increases making historical varieties unsuitable, while new varieties require inputs and management practices that may exceed smallholder farmer capacity. Soil degradation from increased erosion during extreme rainfall events, combined with changing precipitation patterns that reduce the availability of soil moisture, threaten the productivity of terraced agricultural systems that represent centuries of landscape modification and accumulated agricultural capital. When combined with out-migration of the productive-age population and breakdown of traditional knowledge transfer systems, these changes threaten the viability of mountain agriculture as the foundation of rural livelihoods. Under all modelling scenarios,[161] high-altitude districts are projected to lose substantial shares of their population by 2050, in some cases exceeding fifty percent of current levels. Climate drivers account for as much as two-thirds of this out-migration in high-impact scenarios.

159 Rawal, S. B. (2024). Climate Change Finance in Nepal: A Review from Policy Framework and Practice. *Journal of Sustainability and Environmental Management, 3*(2), 121-128.

160 https://www.greenclimate.fund/countries/nepal

161 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

6.1.3 POLICY AND INSTITUTIONAL CONTEXT

The framework advocates for building institutional redundancy and flexibility as critical resilience measures, drawing lessons from Nepal's experience with multiple crisis events, including responses to the 2015 earthquake, 2017 and 2021 flood disasters, and the COVID-19 pandemic. These experiences demonstrate both the vulnerability of centralized systems and the importance of local institutional capacity for crisis response and recovery. Community-based early warning systems represent successful examples of institutional resilience building, with 13 municipalities in southern Nepal uniting to fund community-based flood early warning systems that provide 2-3 hours lead time for downstream communities.[162] These systems integrate technical monitoring with social communication networks, building upon traditional knowledge of river behaviour while incorporating modern forecasting and communication technologies.

Ecosystem-based adaptation initiatives in the Panchase Mountain Ecological Region demonstrate the potential for integrated approaches that enhance both ecosystem resilience and human adaptive capacity while preserving traditional livelihood systems.[163] The Mountain Ecosystem-based Adaptation project implemented by IUCN from 2011-2016 focused on enhancing the provision of ecosystem services while building the capacity of communities for climate adaptation. Project interventions included restoration of degraded grasslands and forests, promotion of climate-resilient agricultural practices, development of alternative livelihood opportunities including broom grass cultivation for women's income generation and strengthening of community-based natural resource management institutions. Results emerging from the pilot site suggest that ecosystem-based adaptation activities were cost-effective and helped vulnerable mountain communities maintain or improve their adaptive capacity while reducing vulnerability to climate change. However, benefits appeared to be dependent on location, institutional capacity, and resource availability, suggesting that successful ecosystem-based adaptation requires strong institutions at national, regional, and local levels, as well as adequate knowledge, skills, capacity, and financial resources.

Traditional ecological knowledge systems provide crucial foundations for climate adaptation but require integration with contemporary scientific understanding and institutional support to address novel climate conditions. Indigenous and traditional knowledge in Nepal encompasses sophisticated understanding of seasonal patterns, crop management, water resource management, disaster risk reduction, and ecosystem conservation that has enabled mountain communities to thrive in challenging environments for millennia. Examples include the Guthi social network system in the Kathmandu Valley that manages irrigation canals, community buildings and religious institutions through inherited and voluntary membership structures that maintain social capital and adaptive capacity across generations.[164] Traditional water management systems include stone spouts (hitis) and their feeder channels (kulo), and community-managed irrigation systems (sancho) that have functioned for centuries by working with natural water cycles rather than attempting to control them.

However, climate change introduces variability that may exceed the bounds of traditional knowledge, requiring integration of traditional and modern approaches rather than replacement of one with the other. The current altered and unpredictable state of the environment makes acquired indigenous knowledge less effective for adaptation to agricultural hazards, requiring new hybrid approaches that combine traditional understanding with contemporary climate science and technology. Traditional ecological knowledge provides crucial baseline understanding of local environmental conditions and tested adaptation strategies, while contemporary science can help identify when environmental changes exceed historical bounds and traditional responses may be inadequate. Integration requires respectful engagement with knowledge holders, recognition of intellectual property rights, and benefit-sharing arrangements that support both knowledge preservation and community development.

162 https://blog.icimod.org/cryosphere-water-risks/flood-early-warning-terai-2024/

163 https://www.adaptation-undp.org/projects/mountain-eba-nepal

164 Subedi, Salik & Shrestha, Sudha. (2024). A Case of the Guthi System in Nepal: The Backbone of the Conservation and Management of the Cultural Heritage. Conservation. 4. 10.3390/conservation4020015.

Regional and transboundary implications of Nepal's climate vulnerabilities extend far beyond national boundaries through shared river systems, migration flows, and economic linkages that create adaptation interdependencies across South Asia. Nepal's position within major transboundary river systems such as the Ganges, Indus, and Brahmaputra basins creates interdependencies where climate impacts on upstream glacier and snowpack systems affect downstream populations in India and Bangladesh, while upstream developments in China affect Nepal's water security. The Koshi River basin, shared among China, India, and Nepal, exemplifies these transboundary challenges with floods originating in any country potentially affecting populations and infrastructure in downstream areas.[165] These water security dynamics are closely tied to projected movement patterns, with modelled[166] out-migration from highland basins such as Koshi and increasing concentration of population in vulnerable downstream cities. Climate impacts, including changing precipitation patterns, glacial retreat, and increased frequency of extreme weather events, affect the entire basin system, requiring coordinated responses that transcend individual national adaptation strategies.

The framework identifies transboundary water governance as critical for regional human security, but current mechanisms remain fragmented and insufficient for addressing climate-related challenges. The Brahmaputra River Basin demonstrates both the opportunities and limitations of existing cooperation frameworks, with India and China maintaining a Memorandum of Understanding for sharing flood-related data during monsoon seasons that has operated successfully since 2002 but remains limited in scope and temporal coverage, especially in its exclusion of Nepal, an upstream riparian state which further reflects the need for regional integration.[167] Under this agreement, China shares rainfall, water level, and discharge data from three strategic stations in the Tibet Autonomous Region of China twice daily during flood seasons from June to October, enabling flood forecasting and early warning systems in downstream areas. However, the framework suggests that effective transboundary cooperation requires expansion beyond flood management to include coordinated climate adaptation planning, joint infrastructure development, and shared approaches to ecosystem management.

Nepal's human migration flows connect to broader regional patterns of climate-induced mobility that require regional cooperation on labour mobility, social protection, and development finance. Seasonal migration to India involves approximately 1-2 million Nepali workers annually,[168] while longer-term migration to Gulf countries continues growing despite policy restrictions and economic disruptions. Climate impacts in Nepal contribute to these flows by reducing agricultural productivity, increasing water scarcity, and creating repeated displacement from extreme weather events. Simultaneously, climate impacts in destination areas may affect labour demand and working conditions for Nepali migrants. The framework suggests that effective governance of migration requires regional cooperation mechanisms that facilitate safe labour mobility while supporting adaptation in both origin and destination areas. While SAARC historically provided a potential framework, regional cooperation on labour migration has increasingly shifted toward more functionally effective mechanisms including the Colombo Process[169] (established 2003, comprising 12 Asian labour-sending countries including all four HKH focus countries) and the Abu Dhabi Dialogue (established 2008, linking 12 Asian countries of origin with 6 Gulf Cooperation Council countries plus Malaysia to govern temporary labour migration along the Asia-GCC corridor).[170]

Recent Abu Dhabi Dialogue initiatives specifically address climate change impacts on labour mobility in Asian countries, recognizing that climate-induced environmental degradation in origin countries interacts with labour market opportunities in destination regions to shape migration flows. However, current arrangements through these mechanisms remain limited relative to the scale of migration flows and emerging climate challenges. By 2050, climate drivers are projected[171] to account for 16 to 52 percent of Nepal's internal movements, indicating

165 https://www.icimod.org/initiative/koshi-basin-programme-future/

166 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

167 https://www.mea.gov.in/Portal/LegalTreatiesDoc/CH13B0811.pdf

168 International Organization for Migration (IOM). (2023). *Baseline study on cross-border migration between India and Nepal* (PUB2023/014/R). https://publications.iom.int/system/files/pdf/pub2023-014-r-baseline-report-india.pdf

169 https://www.southasiamonitor.org/spotlight/south-asian-countries-must-adopt-colombo-process-safeguard-migrant-labour-interest

170 http://abudhabidialogue.org.ae/about-abu-dhabi-dialogue

171 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

that climate-related mobility will increasingly intersect with existing labour migration corridors into India and the Gulf. This strengthens the case for regional labour cooperation mechanisms that explicitly incorporate climate risk considerations.

Early warning systems and disaster risk reduction represent areas where regional cooperation has shown success and provides models for expanded climate adaptation cooperation. Community-based early warning systems for floods operate across India-Nepal borders in multiple river basins, demonstrating the potential for technical cooperation that transcends political boundaries when focused on shared humanitarian objectives. The SAARC Disaster Management Framework provides institutional foundations for regional disaster cooperation, though implementation has been limited by resource constraints and political tensions among member countries.[172] Strengthening these frameworks requires enhanced technical capacity, dedicated financing mechanisms, and political commitment to prioritize disaster risk reduction and climate adaptation as regional priorities that transcend bilateral political disputes.

6.1.4 IMPLICATIONS AND RECOMMENDATIONS

The policy implications emerging from this comprehensive analysis of Nepal's climate security challenges highlight the urgent need for transformation from sectoral approaches toward integrated system-wide responses that address the interdependent nature of climate impacts across the Food-Water-Energy nexus while building adaptive capacity at multiple scales. The framework's emphasis on threshold analysis proves particularly relevant for policy prioritization, enabling identification of approaching tipping points where proactive intervention can prevent system collapse at much lower cost than post-crisis reconstruction and humanitarian response. Nepal requires immediate establishment of basin-level resource councils with cross-sectoral mandates for the Koshi, Gandaki, and Karnali basins to coordinate water allocation, hydropower development, and agricultural planning while incorporating climate projections and threshold analysis into resource management decisions. These institutions should operate with sufficient authority to override traditional sectoral boundaries while maintaining accountability to affected communities and democratic governance structures.

Support for the diversification of livelihoods represents a critical policy priority that must address both the opportunities and constraints facing rural households adapting to climate change, while maintaining cultural values and social cohesion. Expansion of climate-smart enterprise development programs should prioritize women farmers and rural youth while building upon traditional knowledge and existing social capital rather than replacing them with external approaches. Priority areas include agroforestry systems that combine tree crops with annual agriculture to provide multiple income sources while enhancing ecosystem resilience; renewable energy services including solar panel installation and maintenance, micro-hydro system operation, and energy-efficient cookstove production; and eco-tourism development that builds upon Nepal's natural and cultural heritage while providing alternative income sources for mountain communities facing agricultural constraints. However, livelihood diversification programs must address structural barriers including limited access to credit for women and marginalized groups, inadequate transportation infrastructure that constrains market access, and social norms that may limit women's participation in new economic activities.

Investment in resilient infrastructure requires fundamental shifts from designs based on historical climate patterns toward adaptive approaches that can accommodate unprecedented variability, while maintaining essential services during extreme events. Priority investments should focus on distributed renewable energy systems that reduce single-point failure risks associated with centralized hydropower generation; community water storage systems that can capture monsoon precipitation for dry season use while accommodating variable precipitation timing; and multi-hazard resistant infrastructure that can withstand floods, landslides, earthquakes, and extreme weather events simultaneously. Infrastructure development should prioritize modular solutions that can be expanded or modified as conditions change, rather than large, fixed investments that may become stranded assets under changed climate conditions. Community-scale infrastructure that can be managed and maintained by local institutions provides greater resilience than centralized systems that require external technical expertise and may be vulnerable to service disruptions during extreme events.

172 SAARC Disaster Management Centre. (2007). *SAARC Comprehensive Framework on Disaster Management.* https://www.preventionweb.net/files/60968_framework.pdf

Climate finance capacity building represents an essential foundation for all other adaptation efforts, requiring coordinated efforts to build technical capacity at provincial and local levels while establishing dedicated climate finance units with appropriate staffing, training, and resources. Nepal's federal transition creates both opportunities and challenges for climate finance access, as local governments assume greater responsibility for adaptation implementation but may lack the technical capacity and institutional systems required for effective utilization of climate finance. Capacity building priorities include training programs for proposal development, financial management, and project implementation that can build local expertise rather than relying on external consultants; establishment of climate finance coordination mechanisms that can align federal, provincial, and local investments while avoiding duplication and ensuring complementarity; and development of tracking systems for climate finance that can monitor expenditures and outcomes while providing feedback for adaptive management and continuous improvement.

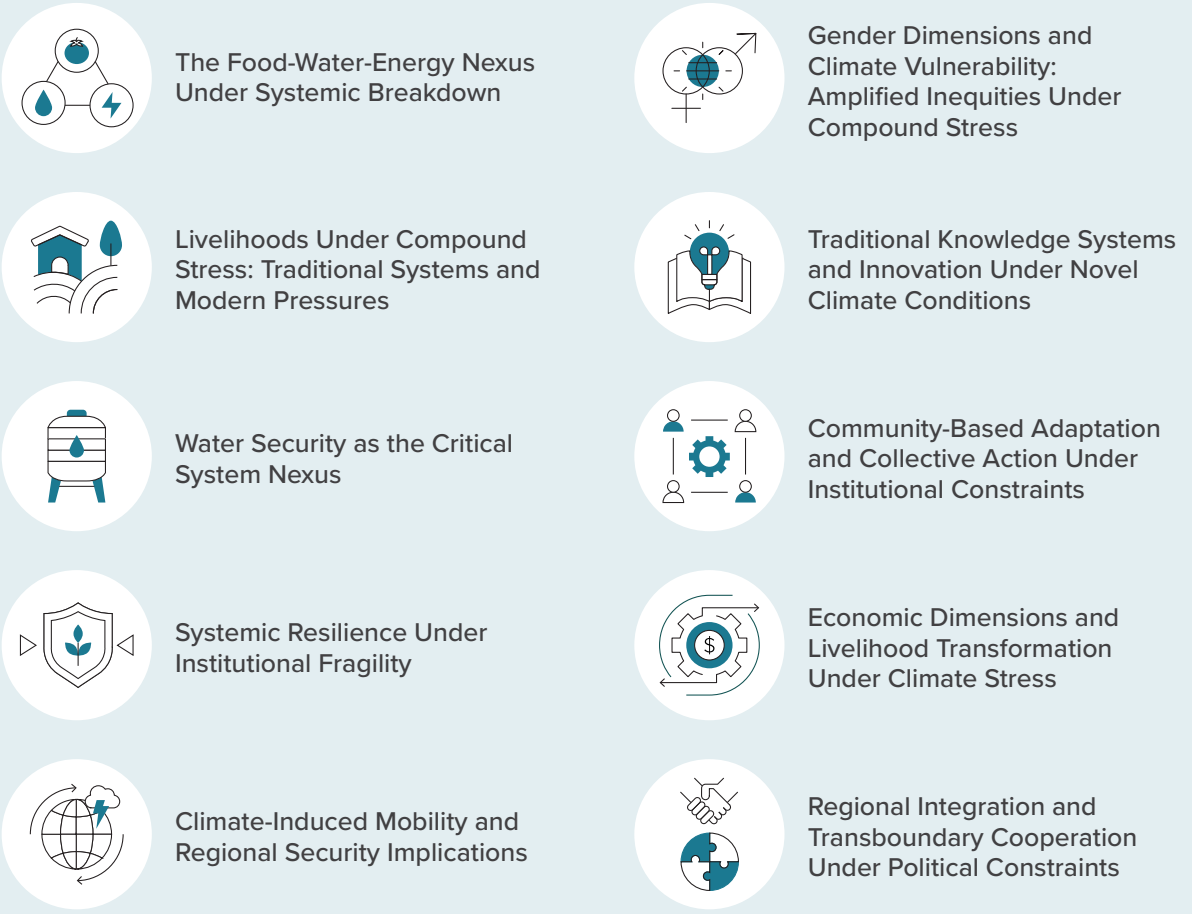
These priorities align closely with Nepal's revised National Climate Change Financing Framework (NCCFF, currently under preparation), which proposes targeted reforms to strengthen climate-responsive public financial management across federal tiers. The draft framework outlines enhanced budget coding guidelines, activity-level expenditure tracking through integrated PFM systems like LMBIS and FMIS, expanded parliamentary oversight of climate spending, and capacity building for sub-national governments to prioritize and manage climate finance effectively. By addressing persistent gaps in accountability and local-level absorption capacity, as identified through recent Climate Change Budget Integration Index assessments, the NCCFF aims to bridge the chasm between Nepal's USD 2.3 billion annual adaptation needs and current flows, ensuring finance delivers measurable human security outcomes in high-altitude contexts.

Gender-responsive programming must address structural barriers to women's participation in climate adaptation planning and implementation, while building upon women's knowledge, skills, and leadership capabilities. Ensuring women's meaningful participation requires addressing underlying constraints including land ownership patterns that limit women's access to formal credit and government services; social norms that restrict women's mobility and participation in public forums; and time burdens associated with unpaid care work that limit women's availability for training programs and economic activities. Policy interventions should include legal reforms to strengthen women's land rights and inheritance protections; targeted support for women's agricultural cooperatives and self-help groups that can provide collective access to credit, inputs, and markets; and leadership development programs that can build women's capacity to participate effectively in climate adaptation planning and implementation at community, local government, and higher levels.

Nepal's experience illustrates how climate adaptation requires simultaneous attention to material infrastructure (Food-Water-Energy systems), economic opportunities (livelihoods), institutional capacity (systemic resilience), and human mobility (migration) as interdependent components of an integrated human security system. Sectoral approaches that address these dimensions in isolation miss the systemic interdependencies that determine overall human security outcomes and may inadvertently create new vulnerabilities or undermine adaptation efforts in other sectors. As climate impacts intensify and approach irreversible thresholds, Nepal's experience offers insights for other mountain nations facing similar challenges. However, it demonstrates that effective adaptation requires unprecedented forms of integration across sectors, levels of government, and temporal scales. The integrated human security framework provides essential analytical tools for understanding these complex dynamics while identifying strategic intervention points for building resilience and maintaining human security under accelerating climate stress.

These analytical tools could find practical application in the proposed Human Security for Poly-Risk (HSPR) Methodology (November 2025, under preparation), which operationalizes integrated human security assessments for poly-risk environments like Nepal's HKH contexts. Based on draft versions, its structured four-phase cycle, rising from baseline risk mapping across economic/food/health/environmental domains, participatory solution co-design with externalities checks, inter-sectoral implementation protocols, and leading to adaptive evaluation frameworks directly addresses the systemic interdependencies Nepal exemplifies. This can enable whole-of-government/whole-of-society coordination that translates vulnerability analysis into coordinated resilience-building across Food-Water-Energy-livelihood-migration dimensions.

6.2 Afghanistan: Conflict, Climate Change, and Compound Vulnerabilities



Afghanistan's vulnerability to climate change has been substantially shaped by the legacy of four decades of armed conflict (1979-2021) that devastated institutional, infrastructural, and natural resource systems. While active armed conflict subsided following the Taliban's consolidation of state authority in August 2021, residual institutional weakness, conflict-damaged infrastructure, and governance challenges continue to constrain adaptive capacity. The country ranks among the most climate-vulnerable globally, while contributing less than 0.01% of global greenhouse gas emissions, exemplifying the profound inequities that characterize global climate impacts.[173] In the current political context, Afghanistan faces major constraints in directly accessing international climate finance mechanisms, at a time when climate impacts are intensifying and the country requires an estimated USD 17.4 billion for mitigation and adaptation between 2020 and 2030. These constraints heighten the importance of exploring complementary modalities, including regional initiatives and UN-implemented programmes, that can channel climate-relevant investments to communities while remaining consistent with international norms.[174]

173 https://www.unocha.org/publications/report/afghanistan/afghanistan-humanitarian-update-november-2024

174 Wikström, C. (2025, July). *Afghanistan's exclusion from global climate finance* (Policy brief No. 2025-2). Solidarity Committee for Afghanistan. https://solidaritycommittee.org/wp-content/uploads/sites/3/2025/07/Afghanistans-Exclusion-from-Global-Climate-Finance-.pdf

The human security framework proves especially important in Afghanistan's context, where shocks propagate across these core systems with devastating compounding effects. Recent climate vulnerability assessments indicate that nearly five million Afghans, approximately 10% of the population, were impacted by environmental hazards in the first quarter of 2025 alone, with 79% of internal displacement driven by environmental factors, surpassing conflict as the primary driver of population movement for the first time. The model results, from UNDP INCLUDE Modelling on climate mobility projections[175] for Afghanistan, highlight significant and consistent migration dynamics across all climate and socio-economic scenarios considered. Kabul emerges as the dominant net receiver of climate migrants, with projections of up to four million arrivals under the fossil-fuelled development and high-emissions scenario (SSP5/RCP8.5), potentially doubling the city's population to more than fifteen million.

Kandahar and Herat are also identified as major urban receivers across scenarios, while secondary destinations include provinces such as Logar, Paktya, Ghazni, and Paktika. Spatially, in-migration hotspots cluster around urban centres and medium-sized towns, usually on the fringes rather than the cores, reflecting rapid urban sprawl and growing demand for services and housing. Out-migration hotspots are concentrated in rural hinterlands close to cities, where social networks and geographic proximity lower the costs of mobility and encourage early movement. Out-migration patterns are most visible in rural and mountainous provinces, particularly Badakhshan and Takhar in the northeast, as well as in the eastern mountain valleys of Nuristan and Kunar under worst-case trajectories.

The country is experiencing its third consecutive year of drought-like conditions following the worst drought in three decades in 2022. This affects approximately 60% of the population that depends on rainfed agriculture and creates food insecurity that compounds the humanitarian crisis resulting from international sanctions and economic collapse.[176] According to modelling projections[177], Afghanistan could see millions of people on the move due to climate pressures by 2050, even in optimistic futures. Under the sustainable socio-economic pathway with strong emissions reductions (SSP1/RCP2.6), more than 4.1 million people, representing 47 percent of all internal migrants and six percent of the national population, are projected to move due to climate impacts. Under the fossil-fuelled development and high-emissions scenario (SSP5/RCP8.5), projections rise to 8.46 million people, equivalent to 82 percent of all migrants and over twelve percent of the national population.

6.2.1 THE FOOD-WATER-ENERGY NEXUS UNDER SYSTEMIC BREAKDOWN

Afghanistan's FWE system demonstrates the framework's core premise about systemic interdependencies under extreme stress conditions. The nexus is characterized by three fundamental vulnerabilities: extreme aridity affecting over 60% of national territory, critical dependence on mountain water resources for 80% of freshwater supplies, and massive infrastructure deficits from four decades of conflict.[178] These vulnerabilities interact to create cascade effects where disruptions in one system immediately undermine the others, generating compound impacts that exceed the sum of individual sectoral failures.

Afghanistan's water security depends heavily on snowpack and glacial melt from the Hindu Kush mountains, making the country particularly vulnerable to changes in high-altitude precipitation and temperature patterns. Eighty percent of the country's freshwater resources originate from mountain areas, while 98% of water consumption supports agriculture and livestock systems.[179] The human security framework identifies this concentration in supply as a single-point failure risk where climate impacts on high-altitude systems cascade through the entire FWE nexus. Recent data demonstrates thispossibility: annual renewable water resources declined from 74 km^3 in 2022 to 52 km^3 in 2024, a 30% reduction in just three years that reflects both reduced precipitation and accelerated glacier retreat.[180] Unequal distribution of water resources across regions, combined

175 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

176 International Organization for Migration (IOM). (2025, June 16). *Afghanistan Climate Vulnerability Assessment: Round 2, Quarter 1, 2025*. https://reliefweb.int/report/afghanistan/afghanistan-climate-vulnerability-assessment-round-2-quarter-1-2025

177 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

178 https://www.icrc.org/en/article/afghanistan-addressing-water-crisis-communities

179 Shokory, Jamal Abdul Naser & Schaefli, B. & Lane, Stuart. (2023). Water resources of Afghanistan and related hazards under rapid climate warming: a review. Hydrological Sciences Journal. 1-19. 10.1080/02626667.2022.2159411.

180 Nabavi, S. A., & Mohammadi, A. (2024). CLIMATE CHANGE AND WATER CRISIS IN AFGHANISTAN. *American International Journal of Social Science Research, 15*(1), 1-11. https://doi.org/10.46281/aijssr.v15i1.2199

with damaged infrastructure and growing population, create water stress conditions that are exacerbated by climate change. The framework's emphasis on threshold analysis proves particularly relevant in understanding Afghanistan's water crisis. Recent observations of substantial land subsidence in Kabul and Ghazni provinces due to groundwater depletion indicate that adaptation strategies based on increased groundwater extraction are reaching sustainability limits. In Kabul, ground subsidence totalled 31.2 ± 0.5 cm over six years, while in Ghazni, a more dramatic 77.8 ± 0.5 cm of subsidence occurred over seven years, with rates dramatically accelerating since 2018 as barren land was transformed into farmland requiring intensive irrigation.[181] Across all scenarios taken in the UNDP mobility study,[182] in-migration hotspots cluster around urban centres and medium-sized towns, usually on the fringes rather than the cores. Kabul is consistently identified as the largest net receiver of migrants, with hotspots of in-migration concentrated on the urban periphery rather than in central Kabul. Kandahar and Herat also emerge as major receivers, with migration spreading across both urban cores and surrounding peripheries.

The agricultural sector faces particular vulnerabilities as temperature increases and changes in precipitation combine with the legacy of conflict to disrupt food production systems. Focus group discussions (FGDs) in Bamyan province revealed that "villages are deserted when the main spring dries; there is simply no option but to move. The snow used to last until late spring—now, by March it is gone, and the rivers are dry by early summer. No water, no energy, no food". This testimony illustrates the framework's circular dependency concept where water shortages undermine energy supply through disruptions to small-scale hydropower systems, which in turn eliminates irrigation and food processing capacity, triggering livelihood collapse and migration. In modelling results,[183] the Central Highlands are projected to be among the strongest sources of climate out-migration, particularly under pessimistic scenarios. Southern dryland areas, especially Kandahar and Helmand, also show extensive climate out-migration, while western districts around Herat and northern provinces including Faryab, Sar-e-Pul, Ghor, and Badghis display large rural losses under the fossil-fuelled development and high-emissions scenario (SSP5/RCP8.5).

Wheat and rice yields are projected to decline substantially under continued warming, while livestock systems face heat stress and feed shortages that reduce productivity. Current data shows wheat production declining from 4.5 million tons in 2022 to 3.6 million tons in 2024, representing a 40 percent reduction that particularly affects rainfed areas where production declined up to 95 percent in some districts.[184] The disruption of agricultural extension services, credit systems, and market infrastructure due to conflict limits farmers' ability to adopt climate adaptation practices, creating conditions where climate impacts are amplified by institutional failures. FGD participants in Nuristan emphasized that about 80 percent of irrigation canals in their districts are "damaged, obsolete, or needing total rehabilitation," forcing communities to rely on direct snowmelt or uncertain rainfall patterns.

Afghanistan's agricultural vulnerability extends beyond crop production to encompass pastoral and agro-pastoral systems that constitute the foundation of rural livelihood security across much of the country. Livestock production forms the livelihood base for more than 80 percent of Afghan rural households, with livestock products contributing more than 50 percent of agricultural gross domestic product.[185] This livestock-dependent livelihood structure reflects the historical integration of pastoral and agro-pastoral systems across diverse agroecological zones, from high mountain pastures to arid rangelands and irrigated agricultural areas. The 18.3 percent decline in livestock populations between 2022-2025 reflects not merely overall sectoral decline but specific vulnerability of pastoral systems to Afghanistan's particular climate trajectory and rangeland management challenges.[186]

Pastoral livelihoods prove exceptionally sensitive to the specific climate variables most dramatically changing in Afghanistan. Droughts directly reduce forage availability and livestock water access; increased temperatures

181 Kakar, N. & Metzger, Sabrina & Schöne, T. & Motagh, Mahdi & Waizy, Hamidullah & Nasrat, N. & Lazecký, M. & Amelung, Falk & Bookhagen, B. (2025). Interferometric Radar Satellite and In-Situ Well Time-Series Reveal Groundwater Extraction Rate Changes in Urban and Rural Afghanistan. Water Resources Research. 61. 10.1029/2023WR036626.

182 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

183 ibid

184 Shoaib, Rahimi & Yan, Yunxian. (2025). An Exploration of the Technical Efficiency of Wheat Production and Its Determinants Among Smallholder Farmers in Kunduz Province, Afghanistan. Journal of Agricultural Science. 17. 45-45. 10.5539/jas.v17n10p45.

185 World Bank Group (2019). "Managing Afghanistan's Rangelands and Forests: Natural Resource Management Capacity Assessment."

186 GEF (2019). "Combating land degradation and biodiversity loss by promoting sustainable rangeland management."

create direct heat stress on animals and increase livestock disease burden; changed precipitation patterns disrupt traditional seasonal grazing calendars and water availability; flooding damages pastures and water sources. The interaction between rangeland degradation and climate impacts creates cascading vulnerability for pastoral households. Afghanistan's rangelands, which provide livelihoods for pastoral and agro-pastoral communities, have been degraded by decades of overgrazing, deforestation, and poor land management, with approximately 80 percent of the country's land now at risk of soil erosion. This pre-existing rangeland degradation significantly reduces the land's capacity to absorb additional climate stresses.

6.2.2 LIVELIHOODS UNDER COMPOUND STRESS: TRADITIONAL SYSTEMS AND MODERN PRESSURES

Framework analysis of Afghanistan's livelihood systems demonstrates how climate impacts interact with other stresses to undermine traditional adaptive capacity and can create new vulnerabilities. Traditional farming systems that evolved over centuries to manage seasonal variability now face forms of climate stress that exceed historical bounds, while simultaneously confronting conflict-related disruptions to markets, institutions and their support systems.

Results from UNDP's climate mobility study[187] indicate that Afghanistan could see millions of people on the move due to climate pressures by 2050, even in optimistic futures. Under the sustainable socio-economic pathway with strong emissions reductions (SSP1/RCP2.6), more than 4.1 million people, representing 47 percent of all internal migrants and six percent of the national population, are projected to move due to climate impacts. Under the fossil-fuelled development and high-emissions scenario (SSP5/RCP8.5), projections rise to 8.46 million people, equivalent to 82 percent of all migrants and over twelve percent of the national population.

The agricultural sector, which employs 80% of the rural population and contributes over 33% to GDP, represents the critical interface through which climate change translates into human security impacts.[188] Traditional systems developed sophisticated strategies for managing environmental variability, including elevation-based cropping systems, water harvesting techniques like karez irrigation, and indigenous crop varieties adapted to local conditions. However, climate change introduces challenges that overwhelm these adaptive systems. FGDs across Bamyan, Badakshan, and Nuristan provinces consistently reported that traditional seasonal indicators have become unreliable, with participants noting that "our acquired indigenous knowledge has become ineffective for adaptation to hazards in agriculture" due to unpredictable environmental changes.

The adaptive capacity of pastoral communities faces particular institutional constraints beyond those affecting crop agriculture. Traditional pastoral institutions, including community-based natural resource management groups, herder associations, and seasonal grazing coordination mechanisms, have been weakened by decades of conflict and population displacement. Contemporary rangeland governance operates in a context of undefined property rights, absent long-term management agreements for shared pasture resources, and institutional capacity gaps within both governmental resource management agencies and community-level organizations. The Ministry of Agriculture, Irrigation and Livestock lacks adequate staffing and coordination mechanisms for effective rangeland management at provincial and district levels.[189]

These institutional deficits directly constrain implementation of known pastoral adaptation strategies. Improved rangeland management practices, including rotational grazing systems, stocking rate adjustments, herd composition diversification, supplementary feeding during droughts, and improved breeding practices, are recognized as effective for building pastoral system resilience. However, their implementation depends on functional institutional arrangements for managing grazing pressure across wet and dry years, monitoring rangeland condition, and mediating resource access disputes.

187 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

188 Muradi, Ahmad & Boz, Ismet. (2018). The contribution of Agriculture Sector in the Economy of Afghanistan. International Journal of Scientific Research and Management. 6. 10.18535/ijsrm/v6i10.em04.

189 World Bank (2019). Natural Resource Management Capacity Assessment

The institutional weakness documented across Afghanistan's natural resource management sector limits the capacity of pastoral communities to deploy these adaptation strategies at the scale necessary to offset climate-driven livelihood stress.

The framework identifies this as a threshold-crossing situation where traditional knowledge systems, which provided the foundation for agricultural decision-making, lose their effectiveness under novel climate conditions. Temperature increases of 1.8°C between 1950 and 2010 – nearly twice the global average – have disrupted traditional crop calendars and made many indigenous varieties unviable at historical elevations.[190] The National Afghanistan Committee's seven-province study found that 71% of smallholder farmers report decreased agricultural productivity, with 83% citing drought as the primary reason for income loss.[191]

This represents a fundamental shift from historical patterns where multiple income sources provided buffers against environmental variability. Livestock systems, which traditionally served as mobile assets that could access different pastures during seasonal variations, now face compound stresses from heat stress, feed shortages, and degraded rangelands. Livestock populations declined by 18.3% between 2022 and 2025, representing not just economic losses but the erosion of traditional wealth storage and risk management strategies that enabled rural households to survive periodic crop failures.[192] FGD participants reported that "the costs related to animal husbandry have increased" while traditional grazing patterns have become impossible due to drought-induced pasture degradation and early snowmelt that disrupts seasonal mobility patterns.

The intersection of climate stress with conflict-related disruptions creates what the framework identifies as compound vulnerabilities that exceed the adaptive capacity of individual households and communities. The breakdown of agricultural extension services, credit systems, and market infrastructure due to conflict means that farmers cannot access the inputs, knowledge, or market connections needed to adapt their practices to changing climate conditions. This creates a vicious cycle where climate impacts reduce agricultural productivity, undermining rural incomes and forcing households to adopt coping strategies that may increase their vulnerability to future climate shocks.

However, the erosion of livelihoods does not translate uniformly into mobility, as significant segments of the population face constraints that limit their ability to move even as conditions deteriorate. The analysis from the modelling results[193] suggests that nearly 1.5 million people are trapped[194] under the regional rivalry scenario (SSP3/RCP4.5), equivalent to about 40 percent of the projected climate migrant population in that future. The largest concentrations of trapped populations are found in the Central Highlands, the western portions of the country east and south of Herat, and in the southern drylands. At the district level, Malistan and Nawur in Ghazni Province, and Panjwayi in Kandahar Province, are identified as having the highest trapped populations, each exceeding 30,000 people.

6.2.3 WATER SECURITY AS THE CRITICAL SYSTEM NEXUS

Water emerges as the most climate-sensitive component of Afghanistan's FWE nexus, with multiple dimensions of vulnerability that interact to create cascade effects across all human security dimensions. The framework's emphasis on understanding critical thresholds proves particularly relevant in Afghanistan's water crisis, where multiple indicators suggest the country is approaching irreversible tipping points in water security. Afghanistan's water resources face both supply-side impacts from changing precipitation and glacial melt patterns, and demand-side pressures from population growth, economic development, and unsustainable extraction practices.

190 Aich, V., Akhundzadah, N. A., Knuerr, A., Khoshbeen, A. J., Hattermann, F., Paeth, H., Scanlon, A., & Paton, E. N. (2017). Climate Change in Afghanistan Deduced from Reanalysis and Coordinated Regional Climate Downscaling Experiment (CORDEX)—South Asia Simulations. Climate, 5(2), 38. https://doi.org/10.3390/cli5020038

191 Hasani, Mustafa & Shrestha, Rajendra. (2024). *Assessing Farmers' Perception on Climate Change and its Consequences: A Case Study in the Baba Mountain Valleys of Bamyan, Afghanistan.* 12. 503-521. 10.14738/aivp.124.17185.

192 FAO. 2023. Afghanistan: Cold wave assessment on livestock – Data in Emergencies Impact report, July 2023. Rome. https://doi.org/10.4060/cc7193en

193 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

194 Commonly referred to as "trapped" populations in the climate migration literature, these are households that might choose to migrate under more optimal socioeconomic conditions, but are unable to do so.

The country's glacier systems have lost 33.2% of their volume since monitoring began, with accelerating retreat rates that threaten the long-term water supplies that sustain both agricultural and urban systems. Precipitation patterns have become increasingly erratic, with the 2023-2024 period experiencing 40-55% below-average precipitation across eastern and northeastern regions, creating what meteorological assessment describes as "historic levels of dryness."[195]

The framework identifies Afghanistan as experiencing what can be termed "water system collapse" where multiple components fail simultaneously. Traditional water sources including springs and karez systems that functioned for centuries are failing at accelerating rates. Thirty-two percent of springs in major watersheds have dried up by 2025, compared to 19% in 2022, representing a rapid loss of traditional water infrastructure that supported mountain communities for generations.[196] The length of active irrigation canals declined from 11,800 km in 2022 to 6,900 km in 2024, a 41% reduction that reflects both conflict damage and water scarcity that makes canal maintenance impossible. Groundwater systems, which serve as the backup water source during surface water shortages, show signs of severe overexploitation that threaten long-term sustainability. In Kabul and Ghazni provinces, groundwater tables are declining by 140 cm annually, rates that far exceed natural recharge capacity and have triggered substantial land subsidence. The human security framework interprets this as a threshold-crossing scenario where short-term coping strategies such as increased groundwater pumping during drought, create long-term vulnerabilities that may be irreversible within human timescales.

Urban water systems exemplify the cascade effects that characterize systemic breakdown under compound stress. In Kabul, 80% of residents now depend on commercial water tankers for basic water needs as municipal supply systems have failed. This shift represents not just a service delivery failure but a fundamental transformation in urban water systems that increases costs, reduces water quality, and creates new vulnerabilities for the most economically marginalized populations. The International Committee of the Red Cross reports that "for millions of Afghans, who are already struggling with many challenges and facing a dire humanitarian situation, vital activities such as getting water to drink or cook and providing irrigation for crops are often impossible."[197]

6.2.4 SYSTEMIC RESILIENCE UNDER INSTITUTIONAL FRAGILITY

Afghanistan's experience demonstrates the framework's emphasis on institutional resilience as fundamental to human security under climate stress. The country faces what can be characterized as "compound institutional failure" where climate impacts interact with conflict-related institutional breakdown and international isolation to create gaps in governance that exceed the capacity of any remaining institutions to address. The framework identifies early warning systems and disaster risk reduction as critical components of systemic resilience, but Afghanistan's capacity in these areas remains severely limited. Only 8% of villages have access to emergency services, while just 4% have early warning systems, leaving most communities without the institutional support needed to anticipate and respond to climate hazards.[198] This institutional deficit is particularly dangerous given Afghanistan's position as the sixth most vulnerable country to climate change according to the Notre Dame Global Adaptation Index, combined with an INFORM Climate Change Risk Index score of 74/100 indicating extreme risk levels.[199]

The breakdown of traditional governance systems compounds these institutional deficits. FGDs revealed that community-based institutions that historically managed water resources, resolved resource conflicts, and coordinated collective adaptation strategies have been weakened by decades of conflict and population displacement. Traditional knowledge systems that provided the foundation for agricultural and water management decisions are losing their effectiveness under novel climate conditions, while the institutional mechanisms for updating and transmitting this knowledge have been disrupted. International isolation creates

195 Shokory, Jamal Abdul Naser & Schaefli, B. & Lane, Stuart. (2023). Water resources of Afghanistan and related hazards under rapid climate warming: a review. Hydrological Sciences Journal. 1-19. 10.1080/02626667.2022.2159411.

196 ibid

197 https://www.icrc.org/en/article/afghanistan-addressing-water-crisis-communities

198 Noori, M & Sherzad, H. (2020). Current State of Early Warning System in Afghanistan: an outlook of the flood early warning system. Kabul: National Environmental Protection Agency, Afghanistan National Disaster Management Authority and United Nations Environment Programme

199 https://gain-new.crc.nd.edu/country/afghanistan

additional barriers to building institutional resilience at precisely the moment when climate impacts require enhanced capacity. Afghanistan currently faces very limited direct access to major multilateral climate finance instruments, including the Global Environment Facility, the Green Climate Fund, and the Adaptation Fund. Since 2021, most climate-related external resources have therefore been channelled through UN-implemented and partner-managed programmes (amounting to roughly USD 40 million) which is only a fraction of the estimated USD 17.4 billion required for climate mitigation and adaptation through to 2030. This situation underscores both the scale of Afghanistan's climate finance gap and the need for pragmatic, forward-looking arrangements that can strengthen community-level resilience while respecting the parameters of international engagement.[200]

Traditional social protection systems, including community-based mutual aid networks and Islamic charitable institutions, face overwhelming demand that exceeds their capacity to provide meaningful support during climate-related crises. The framework identifies this as "adaptive capacity overload" where traditional resilience mechanisms break down under stresses that exceed their historical experience and resource base.

Afghanistan's rapid population growth constitutes an additional compounding factor amplifying climate vulnerability across multiple sectors.[201] The country's population has increased 463.8 percent since 1950, reaching approximately 43.8 million in 2025. Approximately 42.6 percent of the population is under age 15, creating strong demographic momentum that will drive population growth for 2-3 generations regardless of fertility changes. The median age of 18.3 years and fertility rate of approximately 5.0 children per woman reflect one of the world's youngest and most rapidly growing populations. This demographic trajectory intersects critically with climate vulnerability. The growing population creates increasing demands for water, arable land, and agricultural production precisely as climate change reduces water availability and productive agricultural land. Approximately 1.8-1.9 million young people enter Afghanistan's labour market annually, requiring employment opportunities that climate-driven agricultural collapse is actively eliminating. In rural areas where approximately 80 percent of livelihood opportunities depend on agriculture and natural resources, demographic growth intensifies pressure for resource utilization that exceeds sustainable management capacity. This demographic-environmental interaction is particularly acute in urban centres experiencing rapid population growth (Kabul, Herat, Mazar-e Sharif, Jalalabad, Kandahar) due to both natural increase and rural-to-urban migration driven by environmental stress, placing additional strain on already stressed urban water and food systems.

The large youth population facing limited rural employment opportunities amplifies displacement pressures. Rural livelihoods collapse from climate impacts, combined with demographic pressure and economic collapse, creates migration pressure that drives rapid urbanization and internal displacement. These climate-induced displacement flows carry additional consequences: they place strain on urban resource systems already stressed by climate impacts; they reduce adaptive capacity of agricultural communities that lose working-age population; and they can exacerbate vulnerabilities of displaced populations who lose established livelihood systems without secure alternative income sources in urban areas.

6.2.5 CLIMATE-INDUCED MOBILITY AND REGIONAL SECURITY IMPLICATIONS

Afghanistan's position as a major transit route for regional migration and trade means that climate impacts within the country can have broader regional implications that extend far beyond national boundaries. The framework's understanding of migration as both adaptation strategy and system failure indicator proves particularly relevant in Afghanistan's context, where climate change is reshaping traditional mobility patterns while creating new forms of displacement that may destabilize regional migration systems. Climate-induced displacement within Afghanistan reached record levels in 2024, with over 500,000 people displaced by environmental hazards compared to roughly 100,000 displaced by conflict. This represents a historic shift where climate has become the primary driver of internal population movement for the first time in Afghanistan's modern history.[202] The

200 https://climatepromise.undp.org/what-we-do/where-we-work/afghanistan

201 Population Pyramids (2025). Afghanistan demographic data.

202 https://roasiapacific.iom.int/news/climate-crisis-drives-displacement-worsens-afghanistans-humanitarian-needs-iom-report

IOM reports that 79% of internal displacement in the first quarter of 2025 was driven by environmental factors, fundamentally altering traditional patterns where conflict was the dominant displacement driver. In the UNDP climate mobility modelling projections,[203] Kabul emerges as the dominant net receiver of climate migrants, with projections of up to four million arrivals under the fossil-fuelled development and high-emissions scenario (SSP5/RCP8.5), potentially doubling the city's population to more than fifteen million. Kandahar and Herat are also identified as major urban receivers across scenarios. Secondary destination areas include Logar, Paktya, Ghazni, and Paktika. Out-migration is most pronounced in rural and mountainous provinces. Badakhshan and Takhar in the northeast emerge as significant sources of out-migration, while eastern mountain valleys such as Nuristan and Kunar are projected to experience population decline under worst-case trajectories.

Displacement within Afghanistan creates pressures on neighbouring countries through multiple pathways. Direct cross-border movement occurs when environmental degradation makes traditional livelihoods impossible in border regions, forcing populations to seek opportunities in Pakistan and Iran. However, both countries are simultaneously implementing deportation policies that have resulted in 1.6 million Afghans returning in recent years, creating additional population pressure within Afghanistan at precisely the moment when climate impacts are reducing the country's capacity to support existing populations.

The shift from conflict-driven to environmentally-driven displacement should be understood as reflecting both intensification of environmental factors and subsidence of conflict as a primary displacement driver. Environmental factors have always contributed to displacement in Afghanistan, but were often obscured by concurrent conflict-related insecurity and may have been underestimated in classification systems that emphasized conflict as primary driver.[204] Pre-2021 droughts, including severe droughts in 2011-2012, 2014-2015, and 2018, displaced substantial populations and created food insecurity affecting millions of people, indicating that environmental hazards were driving displacement throughout the conflict period.[205] The post-2021 shift should be understood as: (1) relative intensification of environmental displacement drivers, as organized conflict subsided and environmental stresses continued or intensified; (2) greater analytical clarity regarding environmental factors that were always present but previously underestimated due to methodological emphasis on conflict; and (3) reduced "noise" from active conflict-related displacement that previously obscured underlying environmental vulnerabilities. Current data indicating 79 percent environmental attribution for displacement reflect this clarity more than the emergence of entirely new displacement drivers—though continued intensification of environmental impacts through multi-year droughts, glacier melt, and groundwater depletion has indeed increased the direct impact of environmental factors on livelihood security.

The framework identifies this as a "mobility squeeze" where traditional adaptation through migration becomes increasingly constrained while environmental pressures intensify. Model-based projections[206] indicate that these constraints translate into significant immobility. Under the regional rivalry scenario (SSP3/RCP4.5), nearly 1.5 million people are projected to remain trapped, equivalent to about 40 percent of the climate migrant population in that future. The largest concentrations of trapped populations are found in the Central Highlands, the southern drylands, and districts around Herat.

Rural-urban migration within Afghanistan is accelerating as drought makes agricultural livelihoods unviable, but Afghan cities lack the economic opportunities and infrastructure to absorb large numbers of rural migrants. In the UNDP's model-based future projections of climate migration for Afghanistan, Kabul emerges as the largest net receiver city, with up to 4 million arrivals under a SSP5/RCP8.5 (high emissions, fossil fuelled growth) scenario, thus potentially doubling its population beyond 15 million. This can lead to serious sustainability and human security challenges in the future considering that the city is already impacted by water scarcity and limited economic opportunities.[207] Beyond major urban centres, the modelling[208] indicates that climate-related

203 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

204 Migration Policy Institute (2022) on 2018 drought displacement

205 SIPRI (2023) Climate, Peace and Security Fact Sheet: Afghanistan

206 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

207 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

208 ibid

mobility is characterised by widespread population churn across much of the country, rather than movement limited to a small number of source areas. Even districts that record net population growth due to high fertility experience substantial out-migration. Under the business-as-usual pathway (SSP2/RCP4.5), 258 districts record such movements, while under the regional rivalry scenario (SSP3/RCP4.5), the number is 249.

International migration, which historically served as both an economic opportunity and adaptation strategy, faces new barriers from deportation policies and economic constraints in destination countries that limit remittance flows. Disruption of agricultural production can affect regional food markets given Afghanistan's role as a significant agricultural producer for regional consumption. The 40% decline in wheat production between 2022 and 2024 affects not only domestic food security but also regional food availability and prices.[209] The framework identifies this as a regional transmission mechanism where climate impacts in Afghanistan create food security challenges across South and Central Asia through reduced agricultural exports and increased demand for food imports.

6.2.6 GENDER DIMENSIONS AND CLIMATE VULNERABILITY: AMPLIFIED INEQUITIES UNDER COMPOUND STRESS

Afghanistan's gender dynamics under climate stress exemplify the framework's understanding of how environmental shocks interact with existing social inequalities to create compound vulnerabilities that exceed the sum of individual disadvantages. The intersection of climate change with restrictive policies affecting women's participation in public life creates what can be characterized as "double vulnerability" where environmental degradation compounds gender-based exclusions to undermine both individual and community adaptive capacity. Climate vulnerability manifests differently across gender groups due to both physiological differences and socially-constructed gender roles and relations. While this discussion emphasizes women's vulnerabilities and knowledge, based on documented evidence regarding women's roles in household food systems and resource management in Afghanistan's context, comprehensive climate vulnerability analysis must also recognize the distinct vulnerabilities experienced by men and boys, and the important knowledge and adaptive capacity held within male populations.

FGDs across Bamyan, Badakshan, and Nuristan provinces revealed that women bear disproportionate impacts from climate change while simultaneously facing barriers to accessing adaptation resources and decision-making processes. In Nuristan, participants reported that water scarcity has increased women's workloads substantially, with collection time increasing from traditional distances of 200-500 meters to journeys of 2-3 kilometres during drought periods. This increased burden occurs within a context where women's mobility is restricted, creating situations where households face water insecurity not only due to physical scarcity but also due to social constraints on women's ability to access distant water sources. The framework identifies this as a cascade effect where climate impacts amplify existing structural inequalities to create new forms of vulnerability. Traditional gender roles that assign water collection responsibilities to women become security risks when water sources become distant or dangerous to reach. FGD participants in Badakshan noted that "previously, farmers irrigated their fields weekly, but now it's once every three weeks due to water scarcity" while simultaneously reporting that women's responsibility for household water management has intensified as traditional sources have failed. This creates a situation where women face increased responsibility for managing water scarcity while having reduced access to the decision-making processes that determine water allocation and infrastructure investments.

Agricultural systems demonstrate similar compound vulnerabilities where women's roles in food production intersect with climate impacts to create gender-specific risks. In Bamyan province, FGD participants reported that women's involvement in livestock management has increased as male family members migrate for employment, but this occurs simultaneously with climate-induced pressures on animal husbandry including heat stress, reduced grazing areas, and increased costs for feed and veterinary care. The framework identifies this as "feminization of climate risk" where women assume greater responsibility for climate-vulnerable

209 https://humanitarianaction.info/plan/1263/article/food-security-and-agriculture-fsac-0

livelihoods without corresponding access to resources, training, or support systems. Traditional knowledge systems, which often rely on women's observation and management of household and community resources, are losing effectiveness under novel climate conditions while the mechanisms for updating and transmitting this knowledge are disrupted by social restrictions. Women in Nuristan traditionally managed seed selection, food storage, and household energy systems, but climate change is rendering many traditional varieties unviable while simultaneously limiting women's access to information about new agricultural techniques or climate-resilient varieties. This creates knowledge gaps that reduce overall community adaptive capacity while increasing women's vulnerability to climate-related livelihood failures.

The human security framework emphasizes that addressing gender dimensions requires understanding women not only as vulnerable populations but also as essential agents of adaptation whose exclusion undermines overall system resilience. FGDs revealed extensive traditional knowledge among women participants about water conservation, seed management, and household resource optimization that could contribute significantly to community climate adaptation if integrated into formal planning processes. However, current restrictions on women's participation in public forums and economic activities limit the utilization of this knowledge while creating additional barriers to developing new adaptive strategies.

6.2.7 TRADITIONAL KNOWLEDGE SYSTEMS AND INNOVATION UNDER NOVEL CLIMATE CONDITIONS

Afghanistan's experience reinforces the framework's treatment of traditional knowledge as both a crucial foundation for climate adaptation and a system that may require integration with contemporary approaches to address unprecedented environmental changes. Traditional ecological knowledge systems in Afghanistan encompass sophisticated understanding of seasonal patterns, crop management, water resource management, and disaster risk reduction that enabled communities to thrive in challenging mountain environments for millennia. FGDs across all three provinces documented extensive traditional knowledge systems that provided the foundation for agricultural and resource management decisions. In Badakshan, participants described traditional practices including "terracing hillsides to prevent soil erosion, rainwater harvesting using traditional tanks, collective livestock grazing to reduce land degradation, and use of wild edible plants and herbs during food shortages". These systems demonstrate sophisticated understanding of ecosystem management that enabled communities to maintain productivity while preserving environmental resources across generations.

However, climate change introduces variability that may exceed the bounds of traditional knowledge, requiring integration rather than replacement of traditional and modern approaches. FGD participants in Nuristan emphasized that "traditional methods are no longer sufficient in the face of intensifying climate change" while simultaneously noting that traditional practices provide essential baseline understanding for developing new adaptation strategies. This creates a critical need for approaches that combine traditional ecological knowledge with contemporary climate science and technology.

Water management systems exemplify both the strengths and limitations of traditional knowledge under changing climate conditions. Traditional irrigation systems including karez (underground channels), stone waterwheels, and community-managed canal systems functioned effectively for centuries by working with natural water cycles rather than attempting to control them. FGD participants in Badakshan noted that "wooden water wheels are used to lift water from deep canals to irrigation channels" and described sophisticated community institutions for managing water allocation during scarcity periods. However, these traditional systems were designed for historical climate patterns and may be insufficient for the unprecedented drought conditions and precipitation variability that characterize current climate change. Springs that sustained traditional systems for centuries are drying up, while traditional seasonal indicators that guided agricultural timing have become unreliable. FGD participants across all provinces consistently reported that traditional weather prediction methods based on plant phenology, animal behaviour, and atmospheric observations have lost their accuracy under changed climate conditions.

The framework suggests that effective climate adaptation requires the preservation of traditional knowledge while developing new hybrid approaches that integrate traditional understanding with contemporary science and technology. Examples from FGDs include combining traditional water harvesting techniques with modern materials and engineering, integrating traditional crop varieties with climate-resilient breeding programs, and linking traditional disaster preparedness approaches with modern early warning systems. Traditional livelihood diversification strategies demonstrate particular resilience potential when adapted for current conditions. FGD participants in Nuristan described "resorting to less climate sensitive livelihood opportunities including precious stone mining, carpet and rug weaving, and tourism" as traditional approaches to managing environmental variability. These strategies reflect sophisticated understanding of portfolio approaches to livelihood security that remain relevant under climate change but may require support to scale up and access markets.

6.2.8 COMMUNITY-BASED ADAPTATION AND COLLECTIVE ACTION UNDER INSTITUTIONAL CONSTRAINTS

Afghanistan's experience under conditions of institutional fragility provides crucial insights into community-based adaptation – as being both of necessity, and providing opportunity when formal institutional support is limited or absent. The framework emphasizes the importance of social capital and collective action for building resilience, but Afghanistan's situation reveals both the potential and constraints of community-based approaches under extreme conditions.

The governance of Afghanistan's natural resources is characterized by multiple institutional gaps that reduce communities' capacity to manage resources sustainably under climate stress. Inter-ministerial coordination among the Ministry of Agriculture, Irrigation and Livestock, the Ministry of Energy and Water, the National Environmental Protection Agency (NEPA), and other relevant agencies remains weak, with horizontal cooperation insufficient to address integrated natural resource challenges. Vertically, coordination between national, provincial, and district government levels is inadequate, leaving local-level resource management without sufficient guidance or resource allocation. Within the Ministry of Agriculture's Natural Resource Management structures, staffing remains insufficient for effective provincial and district-level management, management skills are limited, and equipment and operational budgets for field activities are inadequate. These governance deficits have immediate consequences for rangeland management, water resources governance, and forest protection, all critical for climate adaptation. Rangeland degradation, affecting more than 80 percent of Afghanistan's land area, results partly from climate impacts but substantially from poor management. The absence of long-term management agreements for shared pastoral resources, unclear property rights for rangeland access, and limited community-level institutional capacity for managing grazing pressure mean that rangelands degrade beyond recovery in many areas. Similarly, water resource governance failures, including dam development projects that create transnational tensions (Helmand basin conflicts with Iran, Kabul basin concerns from Pakistan), absence of domestic water allocation frameworks, and limited irrigation infrastructure development, mean that communities cannot effectively manage scarce water resources under climate stress.[210]

Natural resource access disputes constitute a primary source of local-level conflict in Afghanistan. Accessibility to land and water for agricultural purposes has been a consistent driver of community-level violence, with research indicating that competition for land and water accounts for more than half of all local-level conflict incidents. In the context of climate-driven scarcity of arable land and water resources, combined with weak governance institutions for managing resource access and resolving disputes, resource-driven tensions can escalate into armed conflict. The absence of effective environmental governance mechanisms means that communities lack institutional tools for adapting collectively to resource scarcity, reducing their capacity to develop cooperative resource-sharing arrangements that could mitigate resource-driven tensions.

210 Migration Policy Institute (2022). Water resources management and transnational disputes

FGDs documented extensive examples of community-based adaptation initiatives that emerged from local necessity rather than external programming. In Bamyan province, participants described community-organized "awareness raising via education, media, and community campaigns" and "restoration of vegetation and forest cover" as locally initiated responses to environmental degradation. These initiatives demonstrate significant community capacity for collective action despite minimal external support or formal institutional frameworks.

Traditional community institutions continue to function in many areas despite broader institutional breakdown, providing foundations for climate adaptation initiatives. FGD participants in Badakshan described traditional natural resource committees and producer groups that manage common property resources including pastures, forests, and water sources. These institutions embody decades or centuries of accumulated knowledge about sustainable resource management and conflict resolution that remain relevant for climate adaptation. However, community-based adaptation faces significant constraints under current conditions that limit its potential effectiveness. FGDs revealed that traditional governance institutions have been weakened by decades of conflict and population displacement, while new restrictions on civil society organizations limit the external support that could strengthen community initiatives. Poverty and economic constraints limit communities' ability to invest in adaptation measures even when technical knowledge and social organization exist.

The framework identifies "adaptive capacity overload" as a critical constraint, where traditional resilience mechanisms break down under stresses that exceed their historical experience and resource base. FGD participants consistently reported that community-based coping strategies that functioned during historical droughts or disasters are insufficient for current climate-induced conditions. Traditional mutual aid networks are overwhelmed by the scale and duration of current crises, while traditional livelihood diversification strategies may not provide adequate alternatives when multiple sectors are simultaneously affected by climate change. Women's exclusion from formal decision-making processes creates particular constraints on community-based adaptation since women often possess crucial knowledge about household resource management, food systems, and community needs. FGDs revealed extensive women's knowledge about seed varieties, food preservation, water conservation, and household energy management that could contribute significantly to community adaptation strategies. However, restrictions on women's participation in public forums limit the integration of this knowledge into community planning and decision-making processes.

Despite these constraints, community-based initiatives demonstrate remarkable innovation and persistence under difficult conditions. FGD participants described locally developed solutions including construction and rehabilitation of hydropower systems to reduce dependence on forest resources, development of drought-resistant crop varieties through farmer-to-farmer seed exchange, and creation of community-based early warning systems using traditional environmental indicators combined with modern communication technologies. These examples suggest significant potential for community-based adaptation if supported through appropriate policy frameworks and resource allocation.

6.2.9 ECONOMIC DIMENSIONS AND LIVELIHOOD TRANSFORMATION UNDER CLIMATE STRESS

Afghanistan's economic context is viewed by framework analysis as an example of how climate impacts interact with economic constraints to create compound vulnerabilities while simultaneously revealing opportunities for economic transformation that could enhance resilience. The country's economic structure, dominated by agriculture and natural resource extraction, creates high exposure to climate impacts while limited economic diversification constrains adaptation options.

The agricultural sector's contribution of over 33% to GDP, and employment of 80% of the rural population, creates systemic vulnerability where climate impacts on agriculture translate directly into national economic impacts. FGDs revealed that this economic dependence on climate-sensitive sectors creates cascade effects where environmental shocks immediately undermine household incomes, community economic activity, and government revenue streams. Participants in Bamyan noted that "reduced production, weak economy, lack of value-added processing, and limited market access" create compound economic vulnerabilities where climate impacts amplify existing structural economic constraints.

Traditional economic systems that evolved to manage environmental variability through diversification and flexibility are being overwhelmed by the scale and persistence of current climate impacts. FGD participants described traditional livelihood portfolios that combined agriculture, livestock keeping, seasonal migration, and natural resource extraction to spread risk across multiple income sources. However, current climate conditions are affecting multiple sectors simultaneously, reducing the effectiveness of traditional diversification strategies. The framework identifies significant opportunities for economic transformation that could enhance both climate resilience and economic development, but these require coordinated investment and policy support that exceeds current capacity. FGDs documented community interest in renewable energy development, climate-smart agriculture, sustainable natural resource management, and eco-tourism as potential pathways for economic diversification that could reduce climate vulnerability while creating new income opportunities.

Renewable energy development represents a particularly promising opportunity given Afghanistan's significant solar and hydropower potential combined with current energy deficits that constrain economic development. FGD participants in Nuristan noted that "there is enormous potential for the construction of micro hydropower projects that could improve irrigation systems, promote the construction of climate resilient infrastructure, protect land and people from recurrent flooding and improve access to electricity as alternative to wood for cooking and heating during winter months". However, realizing this potential requires technical expertise, financing mechanisms, and institutional frameworks that are currently limited. Women's economic exclusion creates both constraints and opportunities for economic transformation under climate stress. Traditional women's economic activities including handicrafts, food processing, and livestock management could provide foundations for climate-resilient enterprises if supported through appropriate policies and financing mechanisms. FGD participants noted potential for women-led enterprises in areas such as greenhouse agriculture, renewable energy services, and climate-resilient food processing, but emphasized that realizing this potential requires addressing structural barriers to women's economic participation.

6.2.10 REGIONAL INTEGRATION AND TRANSBOUNDARY COOPERATION UNDER POLITICAL CONSTRAINTS

Afghanistan's position within major transboundary watersheds and regional migration systems creates both opportunities and constraints for climate adaptation that extend far beyond national boundaries. The framework's emphasis on transboundary cooperation becomes particularly complex in Afghanistan's context where political isolation limits formal cooperation mechanisms while environmental and human security challenges require regional responses.

Water resource management exemplifies these transboundary dimensions, with Afghanistan's water resources originating from glacier and snowpack systems shared with neighbouring countries while downstream impacts affect regional water availability and food security. The Amu Darya (Oxus River) system, which originates in Afghanistan's Hindu Kush mountains, provides crucial water resources for irrigation and hydropower across Central Asia, while changes in upstream conditions affect downstream water availability in Uzbekistan, Turkmenistan, and other regional countries. However, current political constraints limit formal water cooperation mechanisms that could address shared climate vulnerabilities through coordinated adaptation planning.

Cross-border migration represents another critical transboundary dimension where Afghanistan's climate impacts create regional human security challenges. The (more than) 500,000 people displaced by climate hazards within Afghanistan in 2024 create potential pressures on neighbouring countries, while simultaneous deportation policies have resulted in 1.6 million Afghans returning from Pakistan and Iran, creating additional population pressure during periods of environmental stress.[211] This creates regional migration pressures that require coordinated policy responses but occur within contexts of limited formal cooperation mechanisms. Food security demonstrates regional interdependencies where Afghanistan's agricultural production affects regional food markets while climate impacts on regional agriculture affect Afghanistan's food import capacity. The 40% decline in Afghanistan's wheat production between 2022 and 2024 affects not only domestic food security

211 https://news.un.org/en/story/2025/07/1165377

but also regional food availability and prices, while Afghanistan's dependence on food imports makes the country vulnerable to climate impacts on regional agricultural production.[212] These interdependencies suggest significant potential for regional cooperation on climate-resilient agriculture and food security, but realizing this potential requires policy frameworks that can operate despite current political constraints.

Traditional transboundary cooperation mechanisms including tribal networks, trade relationships, and cultural connections continue to function despite formal political constraints and could provide foundations for climate adaptation cooperation. FGDs revealed that communities maintain cross-border connections through family networks, seasonal migration patterns, and trade relationships that could facilitate information sharing, technology transfer, and coordinated adaptation planning. However, strengthening these connections requires policy approaches that recognize informal cooperation mechanisms while building formal institutional frameworks for coordinated climate responses.

The framework suggests that effective regional climate cooperation requires innovative approaches that can function within current political constraints while building foundations for enhanced formal cooperation as conditions permit. Potential mechanisms include technical cooperation on shared environmental challenges, humanitarian cooperation on climate-related disasters, and economic cooperation on renewable energy development and climate-resilient agriculture that could provide foundations for broader regional climate cooperation frameworks.

6.2.11 FRAMEWORK APPLICATION AND POLICY IMPLICATIONS

Afghanistan's experience validates the human security framework's core insights about compound vulnerabilities while, at the same time, revealing the limitations of adaptation approaches under extreme stress conditions. Threshold analysis proves particularly valuable in Afghanistan's context, where multiple systems are simultaneously approaching tipping points that could trigger irreversible changes in human security conditions. The convergence of climate impacts, institutional fragility, and international isolation creates "adaptation limits": conditions where the stresses exceed the capacity of available adaptation measures to maintain basic human security. Afghanistan demonstrates how these limits emerge not from any single stressor but from compounded effects between climate change, conflict, and economic constraints to create challenges beyond the scope of traditional sectoral responses. Current policy responses remain fragmented across humanitarian, development, and security domains, missing the systemic integration that the framework identifies as essential for addressing compound vulnerabilities. Humanitarian assistance focuses on meeting immediate needs but lacks the long-term perspective needed to build resilience against recurring climate shocks. Development programming is constrained by political restrictions and funding limitations that prevent the large-scale investments needed for climate adaptation. Security approaches focus on conflict mitigation without adequately addressing the climate drivers that increasingly underlie social tensions and population displacement.

Afghanistan's adaptive capacity for human security under climate stress is deeply constrained by social fragmentation produced by decades of conflict, which has disrupted the social trust and institutional structures necessary for participation and collective adaptation. While the consultation recognized Afghanistan's framework linking climate resilience to stabilization, the practical implementation of adaptation depends on whether communities maintain sufficient social cohesion to coordinate water allocation, manage shared pastures, and organize responses to climate-driven food insecurity. In rural Afghan communities, tribal and community shura (councils) historically managed resource conflicts and coordinated collective adaptation to scarcity; however, conflict-driven displacement, social fragmentation, and ethnic tensions have weakened these institutions precisely when climate stress intensifies competition for water and grazing land. Women face particularly constrained adaptive capacity due to social restrictions on their participation in community decision-making; research in Bamyan and Badakshan provinces documents that women possess detailed knowledge of household food security and water access but lack recognized voice in community adaptation planning, a social constraint independent of technical capacity.

212 Chabot, Philippe & Dorosh, Paul. (2007). Wheat markets, food aid and food security in Afghanistan. Food Policy. 32. 334-353. 10.1016/j.foodpol.2006.07.002.

Additionally, Afghanistan's weak state capacity means that national adaptation programs reach communities unevenly, with those possessing stronger community leaders and social institutions more able to access climate finance and technology support. Framing adaptation for state capacity-building may strengthen some institutions (government line ministries, military logistics) while inadvertently overlooking whether community-level social participation and institutional trust are simultaneously being rebuilt. Effective human security policy in Afghanistan must recognize that adaptive capacity cannot be built through top-down state mechanisms alone; rather, adaptation that strengthens both human security and state capacity requires explicit investment in rebuilding community trust, inclusive decision-making institutions, and social cohesion that enable populations to coordinate collective responses to climate-driven resource scarcity.

The framework analysis suggests several critical policy priorities for addressing Afghanistan's compound vulnerabilities. First, recognition that climate change has become the primary driver of human insecurity requires humanitarian and development responses that prioritize climate adaptation and resilience building rather than treating climate impacts as secondary concerns. Second, the scale of needed investment, estimated at USD 17.4 billion for climate adaptation through 2030, requires innovative approaches to climate finance that can operate despite current political constraints. Third, the regional implications of Afghanistan's climate crisis require coordinated responses among neighbouring countries and regional organizations that can address cross-border displacement, food security, and water resource management challenges. However, Afghanistan's experience also reveals the limitations of the human security framework under conditions of extreme institutional breakdown. The framework assumes the existence of some institutional capacity that can be strengthened to enhance resilience, but Afghanistan's situation approaches what might be termed "state collapse under climate stress" where traditional governance mechanisms are insufficient to address the scale and complexity of emerging challenges. This suggests the need for new approaches to human security that can function under conditions of institutional failure while building the foundations for longer-term resilience.

Afghanistan's exclusion from international climate finance mechanisms creates a moral hazard where the populations most vulnerable to climate change are denied access to adaptation resources due to political considerations. The framework's emphasis on climate justice becomes particularly relevant in this context, as women and marginalized populations who bear the greatest burden of climate impacts also face the greatest barriers to accessing adaptation support. As one analysis notes, "women in Afghanistan are disproportionately affected by climate shocks, due to factors such as their heightened vulnerability during natural disasters, dependence on agriculture and livestock, and responsibility for water management. As a result, they bear the heaviest burden of Afghanistan's exclusion from climate finance". The comprehensive evidence from Afghanistan demonstrates that human security under extreme climate stress requires responses that address the full spectrum of FWE nexus vulnerabilities, livelihood disruptions, institutional failures, and mobility constraints simultaneously. Sectoral approaches that address these dimensions separately cannot adequately respond to the compound nature of the challenges, while the scale of intervention needed exceeds the capacity of traditional humanitarian and development responses. Afghanistan thus represents both a validation of the human security framework's analytical insights and a challenge to develop new approaches capable of addressing human security under conditions that exceed current institutional and financial capacities for effective response.

6.3 India: Scale, Diversity, and Transboundary Implications

The Food-Water-Energy Nexus Under Pressure: Regional Variations and Systemic Dependencies

Livelihoods Under Differentiated Climate Stress: Traditional Systems and Modern Pressures

Glacial Lake Outburst Flood Risks: Immediate Threats and Long-term Vulnerabilities

Water Security Challenges: Mountain-Plains Dependencies and Infrastructure Vulnerabilities

Regional Leadership and Innovation Capacity: Opportunities and Constraints

Systemic Resilience Under Multi-Level Governance Challenges

Climate-Induced Mobility: Patterns, Drivers, and Policy Responses

Traditional Knowledge Systems and Innovation: Integration and Transformation

Transboundary Dimensions and Regional Cooperation Potential

India's Himalayan regions encompass diverse ecological and social conditions that create highly differentiated climate vulnerabilities across elevational gradients and geographic regions, representing one of the world's most complex human security challenges under climate stress. The country's position as both an upstream and downstream nation in major river basins creates complex transboundary implications for climate adaptation that require coordination with neighbouring countries and climate impacts within its Himalayan regions can have implications both for the larger Indian economy and for regional and global systems. India's technical and institutional capacity provides opportunities for adaptation innovations that could benefit the broader region, but the scale and diversity of vulnerabilities across its mountain territories create challenges that exceed traditional governance approaches and require integrated responses spanning multiple scales and sectors.

The IHR region is experiencing varied manifestations of FWE nexus disruptions, livelihood transformations, challenges to systemic resilience and changes in mobility patterns. These could be accommodated through application of the universal principles of the framework analysis and simultaneously demonstrated the importance of context-specific adaptation approaches. The country ranks 7th globally in the Climate Risk Index for 2000-2019,[213] reflecting high exposure to climate extremes, while also contributing significantly to global greenhouse gas emissions and possessing substantial technical capacity for adaptation and mitigation responses. This positions India uniquely within the human security framework as both a contributor to, and victim of, climate change, with responsibilities and capabilities that extend beyond national boundaries to regional and global climate governance systems. The consultation findings from New Delhi in January 2025 emphasized how vulnerabilities across India's mountain communities intersect to compound the effects of climate, with participants noting that "interlinked climate risks are further affected by the intersectionality[214] of various identities of mountain communities" including gender, caste, ethnicity, and economic status. These overlapping identities create differentiated exposure and adaptive capacity within communities, requiring human security approaches that address structural inequalities alongside environmental stresses. Understanding compound vulnerabilities proves particularly relevant in India's context, where climate change interacts with existing social hierarchies, economic disparities, and governance challenges to create risks that exceed the sum of individual stressors.

6.3.1 THE FOOD-WATER-ENERGY NEXUS UNDER PRESSURE: REGIONAL VARIATIONS AND SYSTEMIC DEPENDENCIES

Analysis of of the FWE nexus for India emphasises the value of dealing with interdependent systems while revealing how geographic and climatic diversity creates varied manifestations of vulnerability across different regions and elevations. The country's agricultural sector employs 40% of the population and comprises 15% of GDP.[215] The sector faces differentiated climate impacts because of India's contextual diversity, spanning from 60 meters to over 8,000 meters in elevation. This creates diverse agro-ecological zones with distinct vulnerabilities and adaptation requirements. High-altitude areas may benefit from longer growing seasons and carbon dioxide fertilization effects, while lower elevations face heat stress and water scarcity that reduce crop productivity. The diversity of farming systems and crop varieties across different regions of India provides opportunities for adaptation through crop relocation and genetic resource utilization, but realizing these opportunities requires coordinated research, extension, and policy support that can operate across state boundaries and ecological zones. Recent projections indicate that rice and wheat yields will decline by 6-10% due to climate change, with wheat production potentially dropping by 6-25% by 2100 and rice yields declining by 7% by 2050 and 10% by 2080.[216] These impacts reflect differentiated regional vulnerabilities, with southern states potentially seeing rice yield declines of 5% in the 2030s, 14.5% in the 2050s, and 17% in the 2080s, while northeastern states might experience beneficial changes in precipitation patterns. Participants in the consultation emphasized regional variations in agricultural impacts, noting that Kashmir's horticulture-based economy faces severe disruption from landslides affecting supply routes, while Ladakh experiences GLOFs, changing rainfall patterns, and flash floods. Women, who "constitute the labour force" in agricultural systems, are particularly affected as they cope simultaneously with male out-migration. Traditional nomadic systems face unprecedented challenges, with Changpa pastoralists experiencing "thinning of pashmina wool" and traditional pasture allocation methods becoming unreliable due to climate variability.[217] The 2013 example of untimely snowfall blocking winter passes and causing livestock mortality, illustrates how climate change introduces novel risks that exceed the bounds of traditional knowledge and management systems.[218]

213 https://timesofindia.indiatimes.com/india/india-among-top-10-worst-hit-countries-due-to-extreme-weather-events-says-a-global-report-on-climate-risk-index/articleshow/80453389.cms

214 Intersectionality in this context refers to an analytical framework for understanding how multiple overlapping social identities—such as race, gender, class, sexuality, disability, age, and religion—interact to create unique combinations of discrimination and privilege

215 https://www.weforum.org/stories/2024/08/income-insurance-india-climate-resilience/

216 Geethalakshmi, V., Gowtham, R., Manikandan, N., Bhuvaneswari, K., Lakshmanan, A., Sekhar, N. U., & McDermid, S. (2024). Climate Change and Its Impact on Agriculture in India. In *Agrometeorological Applications for Climate Resilient Agriculture* (pp. 261-282). Cham: Springer International Publishing.

217 Pandit, A., Mir, M., Mir, M., Wani, Y., Bisati, I., Nisa, S. U., ... & Shah, R. A. (2024). Pastoralism in Changthang, Ladakh: Adaptations, Challenges, and Pathways for Sustainability. *Mountain Research and Development, 44*(1), A1-A7.

218 Malik, I. H., & Ford, J. D. (2025). Monitoring climate change vulnerability in the Himalayas. *Ambio, 54*(1), 1-19.

Water security challenges demonstrate the framework's understanding of cascade effects, where impacts on one system immediately affect others throughout the nexus. India faces a fundamental water security challenge: possessing 18% of the world's population but only 4% of its freshwater resources, creating baseline water stress that is exacerbated by climate change impacts on both supply and demand.[219] The consultation findings revealed systemic challenges in water management, with participants noting that "mountain springs are drying up, leading to challenges in managing rural versus urban water demands, especially when there is seasonal water scarcity, often leading to conflicts". The emphasis on improving "negotiation capacity of local governments" for water sharing aligns with the tenet that institutional capacity becomes critical when environmental resources become scarcer and more contested. Groundwater systems face severe overexploitation with depletion rates of 70-80 cm annually in major urban areas, creating sustainability thresholds where traditional water management approaches become inadequate.[220] Over 70% of India's water is contaminated, ranking the country 120th out of 122 countries on the Global Water Quality Index 2024, while 163 million Indians lack access to safe drinking water.[221] These conditions create compound vulnerabilities where water scarcity intersects with water quality challenges to undermine both agricultural productivity and human health outcomes, requiring understanding of the action of multiple, simultaneous stressors.

India has achieved historic growth in renewable energy capacity while maintaining significant dependence on climate-sensitive hydropower and fossil fuels. The country added a record 29.52 GW of renewable energy capacity in FY 2024-25, bringing total renewable installed capacity to 220.10 GW and positioning the country as the world's 4th largest renewable energy producer.[222] Solar energy led this expansion with 23.83 GW added during the year, while wind power contributed 4.15 GW of new capacity, demonstrating significant technological and institutional capacity for clean energy deployment.[223] However, framework analysis identifies vulnerability patterns within this renewable energy growth, particularly regarding hydropower dependence and potential impacts from climate variability on energy generation. Consultation participants noted concerns about large-scale solar pump deployment potentially creating "water crisis in future" through "excess withdrawal of groundwater because of solar pumps". This example of unintended consequences, where solutions in one sector create vulnerabilities in another, requires that integrated planning approaches consider system-wide effects rather than only sectoral optimization. The 2021 Uttarakhand disaster that destroyed the Tapovan Vishnugad Hydro-electric Power dam demonstrates how extreme events can undermine energy infrastructure designed according to historical climate assumptions, while consultation participants noted that dam construction continues "owing to surging electricity and irrigation demand in the plains" despite increased risks.[224] Development pressures can drive continued investment in vulnerable infrastructure, creating lock-in effects that increase systemic risk over time.

219 https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs

220 Singh, D.K. & Singh, Anil Kumar. (2002). Groundwater Situation in India: Problems and Perspective. International Journal of Water Resources Development - INT J WATER RESOUR DEV. 18. 563-580. 10.1080/0790062022000017400.

221 Van Dijk, A.I.J.M., H.E. Beck, E. Boergens, R.A.M. de Jeu, W.A. Dorigo, C. Edirisinghe, E. Forootan, E. Guo, A. Güntner, J. Hou, N. Mehrnegar, S. Mo, W. Preimesberger, J. Rahman, P. Rozas Larraondo (2025) Global Water Monitor 2024, Summary Report. Published by Global Water Monitor Consortium, available at www.globalwater.online

222 https://ibef.org/industry/renewable-energy

223 https://www.pib.gov.in/PressReleasePage.aspx?PRID=2120729

224 Wamane, G. V. (2022, September). Governance of Disaster Management: Lessons Learnt and a Roadmap to Avert a Future Chamoli Like Disaster. In *5th World Congress on Disaster Management: Volume I* (pp. 292-299). Routledge.

India's adaptive capacity for climate security in the IHR is significantly shaped by social structures that determine which communities have voice in adaptation planning and resource allocation. The India consultation highlighted that 'there is no coordination among government departments, and no integrated policy to address this challenge,' revealing an institutional arrangement where adaptive decisions occur in separate sectoral silos without mechanisms for affected communities—particularly marginalized groups—to influence priorities. In India's mountain regions, caste structures historically determine access to water systems, grazing commons, and forest resources. As climate change intensifies competition for these resources, adaptive capacity depends substantially on social position. Upper-caste communities often hold formal water rights and institutional voice in irrigation management committees, enabling them to advocate for allocation decisions during scarcity. In contrast, Dalit and Adivasi communities frequently lack formal rights recognition and have limited participation in resource governance, constraining their adaptive options even when they face equivalent climate exposure. Additionally, women's adaptive capacity in mountain agriculture is mediated by property rights. Women-headed households in several Indian mountain states have limited ability to invest in climate-resilient crop varieties or irrigation improvements because they lack land titles recognized by formal credit systems, a social constraint independent of the technical viability of adaptation strategies. The India consultation emphasized that 'blended governance models' are needed. Such models would require that adaptation planning explicitly include marginalized communities' participation in decisions about resource allocation and technology choice, recognizing that technical solutions (drought-resistant seeds, efficient irrigation) cannot be implemented by populations excluded from institutional decision-making about resource access. This social dimension of adaptive capacity means that effective human security policy cannot treat adaptation as primarily a technical or financial challenge, but must address how governance arrangements include or exclude vulnerable populations from decision-making power

6.3.2 LIVELIHOODS UNDER DIFFERENTIATED CLIMATE STRESS: TRADITIONAL SYSTEMS AND MODERN PRESSURES

Climate impacts interact with existing vulnerabilities in India's livelihood systems to create differentiated outcomes across social groups, geographic locations, and economic sectors. Findings from the consultation emphasized how "human mobility has always been due to 3 reasons: livelihood, social mobility and education of children, and local environmental degradation," but climate change is "aggravating local environmental change which is emerging as the reason for human mobility in many parts of the mountain region". Analysis suggests that climate change often amplifies existing drivers of vulnerability rather than creating entirely new categories of risk. Traditional livelihood systems face unprecedented challenges as climate variability exceeds historical bounds and, at the same time, must confront modernization pressures that may undermine adaptive capacity. Consultation participants emphasized conflicts arising "because of the introduction of new technology/practices without making communities a part of the change management," citing examples of "traditional farming versus modern farming techniques, and farmers' aversion to change". The framework analysis identifies this as a critical interface, where climate adaptation requires the balancing of innovation with preservation of traditional knowledge systems that embody centuries of accumulated understanding about managing environmental variability.

Analysis of the gender dimensions of livelihood reveals how climate change interacts with existing inequalities to create compound vulnerabilities that particularly affect women's economic participation and decision-making authority. Consultation findings noted that "with technology there is a strong gender issue. Women are often not comfortable with technology. There is also asymmetry in the access to disaster-related early warning and news dissemination". However, participants also identified opportunities, noting that "with ease of access to credit for women SHGs (self-help groups), the positive aspect is that women SHGs can emerge as water entrepreneurs," illustrating a case where adaptation responses can simultaneously address climate risks and social inequalities, when designed appropriately.

Agricultural livelihoods face particular challenges as traditional crop varieties and management practices become less viable under changed climate conditions. The consultation revealed regional variations in agricultural adaptation, with Himachal Pradesh farmers described as "more attached to land" with "Farmer Producer Organization Scheme (FPOs) working" and locals "not interested in big infra[structure]", contrasting with other regions where "high-rise buildings in Gangtok are a reflection of aspirations". These differences reflect varying adaptive capacity and livelihood diversification strategies that depend on local economic conditions, social capital, and governance systems. Pastoralism represents a particularly climate-sensitive livelihood system facing multiple stresses that illustrate the framework's tenet about threshold-crossing scenarios. Traditional pastoral systems in Jammu and Kashmir historically managed environmental variability through mobility and flexible grazing patterns, but consultation participants noted that "traditional open access pastures [are] getting restricted" and "smart cards to pastoralists showing location of pasture lands [are] of no help" when traditional grazing arrangements break down. The observation that "earlier it was win-win for both farmers and pastoralists because grazing took care of stubbles in farmlands and hence farmers could avoid the practice of stubble burning" demonstrates how climate impacts on one system can cascade through interconnected livelihood relationships. Tourism-based livelihoods face particular vulnerabilities as climate change affects both the natural resources that attract tourists and the infrastructure systems that support tourism activities. Consultation participants noted that "tourism driven infra[structure]-creation is at the cost of local mountain ecology" while simultaneously acknowledging tourism as an important economic opportunity for mountain communities. This creates dilemmas for adaptation planning where short-term economic benefits from tourism development may increase long-term vulnerabilities to climate impacts, exemplifying the the requirement for understanding trade-offs between immediate needs and long-term resilience. Livelihood diversification strategies face both opportunities and constraints under climate change, with consultation findings revealing mixed outcomes from different diversification approaches. Participants noted examples of successful diversification including "integrated livelihoods program successful in Western Odisha" that is "deeply participatory" and "mostly based on watersheds and community ownership". The key insight that "responding to community needs is the most important condition for future success" aligns with the framework's emphasis on building local ownership and adaptive capacity rather than imposing external solutions.

6.3.3 GLACIAL LAKE OUTBURST FLOOD RISKS: IMMEDIATE THREATS AND LONG-TERM VULNERABILITIES

Glacial lake outburst floods in the Indian Himalayan states represent an immediate category of risk that could affect millions of people and critical infrastructure systems. The 2021 Uttarakhand flood demonstrated the catastrophic potential of such events, claiming over 200 lives and causing massive infrastructure damage. Warming temperatures and continuing glacial retreat are creating conditions for increased GLOF risks that require enhanced monitoring systems, early warning capabilities, and evacuation planning across multiple states.[225] Recent research has identified 55 glacial lakes with potential to be hazardous across the Indian Himalayas, with 11 classified as high hazard, 18 as medium hazard, and the remainder requiring monitoring for changing risk levels.[226] The Vasundhara Lake in Uttarakhand, located at 4,676 meters above sea level, exemplifies these risks; its area expanded from 0.15 to 0.29 km^2 between 1994 and 2020—a near doubling in

225 Kansal, M. L., & Singh, S. (2022). Flood management issues in hilly regions of Uttarakhand (India) under changing climatic conditions. *Water, 14*(12), 1879.

226 Furian, W., Loibl, D., & Schneider, C. (2021). Future glacial lakes in High Mountain Asia: an inventory and assessment of hazard potential from surrounding slopes. J*ournal of Glaciology, 67*(264), 653-670.

size that reflects accelerated glacial retreat.[227] Hydrodynamic modelling indicates that a complete breach of this lake (worst-case scenario) could generate peak flows of significant magnitude to damage infrastructure along riverbanks. The consultation participants pointed out continuing infrastructure development in high-risk areas, despite known GLOF vulnerabilities, noting that the 2021 glacier burst that "destroyed and washed away the Tapoban Vishnugad Hydro-electric Power dam in Uttarakhand" has "not deterred increasing dam construction in the mountains owing to surging electricity and irrigation demand in the plains". This reflects the framework's insight about development pressures that drive continued investment in vulnerable locations despite known risks, creating situations where short-term economic needs override long-term risk considerations.

GLOF risks include cascading vulnerabilities that extend far beyond immediate flood impacts to include long-term disruptions of water supply, energy generation, transportation networks, and urban systems. Understanding systemic interconnections is particularly relevant for GLOF preparedness, as these events can simultaneously affect multiple critical systems while occurring in remote locations where emergency response capacity is limited. The 2023 GLOF event in Sikkim that resulted in the "collapse of a hydroelectric dam" and affected "more than 88,000 people" illustrates how upstream events can have downstream consequences that propagate through interconnected infrastructure and social systems.[228] Traditional early warning systems prove inadequate for GLOF risks due to the remote locations of most glacial lakes, the rapid onset of flood events, and the need for technical monitoring systems that exceed local capacity. Consultation participants noted general "lack of awareness among people exposed to climate risks in most vulnerable areas" and emphasized that communication of risks requires attention to "language" and the "digital divide in mountain regions" that create barriers to the effective dissemination of early warnings. The framework analysis suggests that effective GLOF risk management requires the combination of technical monitoring systems with community-based observation and response networks, that can bridge the gap between scientific risk assessment and local preparedness capacity.

6.3.4 WATER SECURITY CHALLENGES: MOUNTAIN-PLAINS DEPENDENCIES AND INFRASTRUCTURE VULNERABILITIES

Water security challenges in India's Himalayan regions have implications for both mountain communities and downstream populations in the heavily populated Indo-Gangetic Plain, again illustrating how climate impacts cascade through interconnected hydrological systems to affect populations far from the original source of change. Changes in the timing of glacier- and snowmelt affect river flow regimes that support irrigated agriculture and urban water supplies for hundreds of millions of people. Additionally, India's large-scale water infrastructure, including dams, canals, and groundwater systems, face operational challenges as climate change alters the hydrological conditions for which they were designed.[229] The consultation findings revealed complex water governance challenges that reflect both physical scarcity and institutional failures in water management systems. Participants emphasized that "systemic responses over water sharing" are needed, with particular attention to improving "negotiations capacity of local governments" for managing competing demands between rural and urban users. The observation that "piped transport of water over long distances during summer is marred because of leaks along the pipeline" illustrates how infrastructure deficits compound climate-related scarcity and vulnerabilities.

Seasonal water scarcity creates particular challenges for mountain communities, where traditional water sources, including springs and traditional water harvesting systems, are failing under changed precipitation patterns and increased temperatures. Consultation participants noted that "mountain springs are drying up" creating challenges that "often lead to conflicts" between different user groups. The framework's emphasis on threshold analysis proves relevant for understanding these changes, as spring failure often represents irreversible loss of traditional water sources that supported communities for generations. Groundwater systems face unprecedented

227 Raut, M., Pant, S., Kunmar, P., Mehta, M., & Singh, S. K. (2025). Identification and assessment of potentially dangerous glacial lakes in Uttarakhand, India. *Natural Hazards, 1*-28.

228 Saha, S., Bera, B., Bhattacharjee, S., Ghosh, D., Tamang, L., Shit, P. K., & Sengupta, N. (2024). Identification of the multiple causes of recent series of landslides and related damage by extreme rainfall and GLOF in Sikkim Himalaya, India, during October 2023. *Landslides, 21*(12), 2993-3009.

229 Vohra, K., & Saurabh. (2024). Climate-resilient water infrastructure in India. *Irrigation and Drainage, 73*(5), 1663-1674.

extraction pressures as surface water becomes less reliable, but consultation findings revealed concerns about sustainability limits of groundwater-based adaptation strategies. Participants noted that "solar pumping at large scale can possibly lead to water crisis in future" due to "excess withdrawal of groundwater because of solar pumps". Maladaptive responses are characterized by cases in which short-term coping strategies create long-term vulnerabilities, particularly when technological solutions enable resource extraction beyond sustainable limits. The FWE nexus dynamics are central to the human security framework as the interaction between water scarcity and energy systems has the potential to create compound vulnerabilities. Traditional water mills in Uttarakhand that "play a central role in local agri-based livelihoods are not running due to change in water flow," while consultation participants noted that "proven solutions based on distributed renewable energy for local processing as well as early learning systems are not getting scaled up". This demonstrates how climate impacts on water systems cascade through energy and livelihood systems to create multiple simultaneous disruptions. Urban water systems demonstrate particular vulnerability to climate variability due to concentrated demand, limited storage capacity, and dependence on distant water sources that may be affected by climate change. The consultation noted challenges in "managing rural versus urban water demands especially when there is seasonal water scarcity," reflecting competition between different user groups that intensifies as water becomes scarcer. The requirement therefore is that effective water security must address both supply-side impacts through improved infrastructure, and demand-side management through conservation and efficiency measures.

6.3.5 REGIONAL LEADERSHIP AND INNOVATION CAPACITY: OPPORTUNITIES AND CONSTRAINTS

India's role as a regional economic and technological leader creates opportunities for climate adaptation investments that could benefit neighbouring countries through technology transfer, capacity building, and regional cooperation initiatives, positioning the country uniquely within the human security framework as both a significant contributor to climate solutions and a nation experiencing severe climate impacts. The country's renewable energy achievements, including becoming the world's 4th largest renewable energy producer with 220.10 GW of installed capacity, demonstrate substantial technical and institutional capacity for clean energy transitions.[230] The consultation revealed significant examples of innovation that demonstrate India's potential for developing and scaling climate adaptation solutions. Participants highlighted the 'ice stupas' of Ladakhas representing "a nature-based solution with an integrated approach, but government recognition of this community initiative is absent". This example illustrates both the innovation potential within Indian mountain communities and the institutional barriers that prevent successful scaling of local solutions. In a human security framework, therefore, the importance of recognizing and supporting indigenous innovation is emphasized with the simultaneous building of institutional mechanisms that can facilitate knowledge transfer and scaling.

Policy innovations have demonstrated India's capacity for developing institutional responses to climate challenges, with examples including "One Nation One Ration[231] an example of social security for migrant labour" and district action plans that "balance conservation with development" through integration with "customary laws". However, consultation participants emphasized that "not everything can be scaled" and highlighted the importance of understanding local contexts and community ownership for successful adaptation initiatives. Technology transfer opportunities exist through India's substantial renewable energy manufacturing capacity, with the country's solar PV manufacturing capacity growing from 2.3 GW in 2014 to about 78 GW by March 2025, representing a 34-fold increase that demonstrates significant industrial capacity for clean energy technology production.[232] Wind power manufacturing includes 20 manufacturers producing 53 different turbine models with international quality standards and exports to Europe, United States, and other countries, positioning India as a potential regional hub for clean energy technology transfer.[233] However, consultation findings revealed

230 Lal SR, S., Herbert GM, J., Arjunan, P., & Suryan, A. (2025). Advancements in renewable energy transition in India: A review. *Energy sources, part A: recovery, utilization, and environmental effects, 47*(2), 2024921.

231 https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1580396

232 https://www.pib.gov.in/PressReleasePage.aspx?PRID=2156173

233 https://www.reuters.com/sustainability/climate-energy/indias-new-wind-turbine-norms-mandate-local-sourcing-data-control-2025-08-01/

institutional constraints that limit the realization of this innovation potential. Participants emphasized challenges including "long-term planning of actions for climate risks not happening adequately" and "capacity building based on long-term planning is mostly absent". The question "what stops policymakers from such long-term planning" reflects broader governance challenges that constrain India's ability to translate technical capacity into effective climate adaptation outcomes. Regional cooperation faces constraints from "transboundary water disputes and security concerns" that may limit the extent of cooperation on climate adaptation, potentially reducing the effectiveness of adaptation efforts that require coordination across national boundaries. The consultation findings did not extensively address transboundary issues but emphasized the importance of "ecological assessments with carrying capacity lens, especially for tourism driven economies" that could provide foundations for regional cooperation on shared environmental challenges.

6.3.6 SYSTEMIC RESILIENCE UNDER MULTI-LEVEL GOVERNANCE CHALLENGES

India's federal system creates both opportunities and challenges for building systemic resilience under climate stress. findings from the consultation revealed complexities in governance that span multiple levels and sectors while simultaneously demonstrating significant innovation potential at state and local levels. Participants emphasized that "there is no coordination among government departments, and no integrated policy(ies) address this challenge". Successful examples of integrated approaches were cited, including "landscape approach by GIZ"[234] that ensures "strong collective action" through strengthened community institutions. Institutional capacity challenges reflect both technical and political constraints that limit effective climate response despite significant financial and human resources. Consultation participants noted that "capacity for designing solutions at the local level needs to be created but this can be constrained because of remoteness," while emphasizing that "a bottom-up approach to building resilience requires strengthening of local community organizations". An emphasis on multi-level governance proves particularly relevant in India's context, where effective adaptation requires coordination across federal, state, and local levels while addressing significant capacity disparities between different institutional levels.

Policy coherence is undermined when sectoral approaches fail to address interconnected climate risks. Consultation findings noted examples where "policies are contributing to farm abandonment" and "perverse consequences of policy need to be addressed". Broader examples beyond the IHR region, such as the example of "water-intensive cotton production in Tamil Nadu[235] driven by watershed-based activities and permission for the use of forest area" illustrates how sector-specific policies can create unintended environmental consequences that increase climate vulnerability in other sectors. Early warning systems demonstrate both innovation potential and implementation challenges, with consultation participants noting that "the communication of risk to communities i.e. messaging of climate information and climate risks – is an area where institutional capacity building is required, along with mechanisms for last mile connectivity".

The emphasis in the consultation on language barriers and digital divides, illustrates that effective early warning requires addressing social and technological inequalities that determine access to life-saving information. Traditional governance systems provide foundations for resilience building but require integration with contemporary institutional approaches to address novel climate challenges. Consultation findings noted examples of successful integration, including in district action plans that "balance conservation with development" through incorporation of "customary laws". However, participants also noted challenges where traditional institutions may be inadequate for current challenges, emphasizing the need for "blended governance models" that combine traditional and modern approaches. Disaster preparedness reveals significant inequities in access to training and resources, with consultation participants noting that in Odisha (a coastal state), "who gets access to trainings [is] often determined by who has the time and bandwidth; poor people and women

234 Schütz, K., Büchler, B., Weinsheimer, H., & Jacobi, P. (2019). *Landscape approaches: Background paper* (GIZ 2020-0174en). Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.giz.de/de/downloads/giz2020-0174en-landscape-approaches-background-paper.pdf

235 Pahlow, M., Krol, M.S. and Hoekstra, A.Y. (2015). Assessment of measures to reduce the water footprint of cotton farming in India, Value of Water Research Report Series No. 68, UNESCO-IHE, Delft, the Netherlands.

[are] often excluded; the opportunity cost [is] much higher for daily wage workers". However, Odisha was also highlighted as "an outlier that is decentralizing disaster preparedness capabilities," demonstrating potential for more inclusive approaches to resilience building.

Climate finance and resource mobilization represent critical constraints limiting the implementation of adaptation measures despite policy frameworks and institutional systems. Participants to the consultation emphasized challenges with "post-project sustainability of interventions" and noted that "climate finance [is] going for mitigation more than for adaptation, and, even for adaptation, access to finance is highly unequal for the poor because of institutions that have discriminating mechanisms". This reflects broader patterns where climate finance systems may not adequately address the needs of the most vulnerable populations who face the greatest adaptation challenges.

6.3.7 CLIMATE-INDUCED MOBILITY: PATTERNS, DRIVERS, AND POLICY RESPONSES

India's migration patterns demonstrate mobility as both adaptation strategy and indicator of system breakdown, with climate change increasingly influencing traditional labour mobility systems while creating new forms of displacement that may exceed adaptive capacity. According to the Internal Displacement Monitoring Centre, about 3.6 million Indians were displaced annually between 2008 and 2018, with climate-related disasters becoming increasingly prominent drivers of both temporary and permanent population movement.[236] The findings of the consultation revealed complex relationships between environmental change and mobility decisions, emphasizing that climate change is "aggravating local environmental change which is emerging as the reason for human mobility in many parts of the mountain region of the HKH". However, participants also noted that "migrant remittances acted as insurance in the past. Now whole communities [are] leaving the hills" represents a qualitative shift from traditional circular migration patterns toward permanent departure from mountain areas, reflecting system breakdown rather than adaptive mobility.

Seasonal migration patterns historically functioned as risk management strategies that enabled mountain communities to diversify income sources while maintaining connections to traditional livelihoods and social systems. However, climate change is disrupting these patterns by making traditional seasonal work less reliable while simultaneously increasing environmental pressures on home communities. The observation that "whole communities are leaving the hills" suggests that current migration patterns are beyond simply adaptive mobility and now represent responses to system failure rather than strategic adaptation. Analysis of the gender dimensions of climate-induced mobility reveal how environmental stresses interact with existing social constraints to create differentiated mobility experiences and outcomes. Consultation findings noted regional variations in gender impacts, including areas where male out-migration leaves women with increased responsibilities for agricultural and household management under more difficult environmental conditions. These gender dynamics can be viewed as both constraints on adaptive capacity and as potential entry points for building women's leadership and decision-making authority in climate adaptation. Youth migration represents a particular challenge for mountain communities where out-migration of the productive-age population reduces local adaptive capacity while potentially providing economic resources through remittances. Consultation participants suggested that young people are becoming disconnected from traditional risk management systems which may limit both immediate disaster preparedness and long-term adaptive capacity building.

236 Panda, A. (2020, May 22). *Climate change, displacement, and managed retreat in coastal India*. Migration Policy Institute. https://www.migrationpolicy.org/article/climate-change-displacement-managed-retreat-india

Cross-border mobility adds complexity to India's climate migration patterns, particularly in regions where environmental degradation affects border communities with limited livelihood alternatives. The framework suggests that effective governance of mobility requires regional cooperation mechanisms that can address both internal displacement and cross-border movement while protecting migrants' rights and supporting adaptation in both origin and destination areas. Urban absorption capacity represents a critical constraint on climate-induced migration, with consultation findings noting challenges, including conflicts between displaced populations and host communities, particularly when displacement involves "backward castes" and creates tensions over access to resources and services. The example of "relocation of people displaced by disaster in local schools and panchayat buildings" creating tensions illustrates how climate-induced displacement can create secondary social conflicts. Inclusive approaches to management that address both the needs of displaced populations and host community concerns are required. Policy responses to climate-induced mobility remain fragmented across humanitarian, development, and migration management frameworks, with consultation participants noting that "there is no structured policy or action plan from the administration to provide social protection in countering climate change and related migration". Effective governance of climate induced mobility of populations requires integrated approaches that facilitate safe, voluntary movement while supporting adaptation in both origin and destination areas, through coordinated policies across multiple sectors and levels of government.

6.3.8 TRADITIONAL KNOWLEDGE SYSTEMS AND INNOVATION: INTEGRATION AND TRANSFORMATION

India's traditional ecological knowledge systems show indigenous knowledge to be both a crucial foundation for climate adaptation and a system requiring integration with hybrid, contemporary approaches to monitor, detect and address unprecedented environmental changes. The consultation findings revealed extensive traditional knowledge across India's mountain regions but also emphasized that traditional methods may be insufficient for current climate challenges while remaining essential for developing appropriate adaptation strategies. Traditional water management systems, including stone spouts, community-managed springs, and traditional water harvesting techniques provide foundations for contemporary adaptation approaches, but consultation participants noted that "mountain springs are drying up" and traditional water sources are failing under changed precipitation patterns and increased temperatures. Developing hybrid approaches requires the integration of traditional understanding with contemporary technology and institutional support.

Agricultural knowledge systems face particular challenges as traditional crop varieties and farming calendars become less viable under novel climate conditions. However, consultation findings also revealed the potential for innovation through integration of traditional and modern approaches, with participants noting successful examples where communities combine traditional practices with new technologies and institutional support. Traditional disaster preparedness and early warning systems provide important foundations for contemporary risk reduction approaches, but consultation participants emphasized that these systems require updating and institutional support to address novel climate risks. The previously mentioned example of Ladakh's 'ice stupas' represents successful integration of traditional knowledge with contemporary engineering to address water scarcity challenges, but participants noted that "government recognition of this community initiative is absent", illustrating institutional barriers to scaling indigenous innovation.

Intergenerational knowledge transfer faces challenges from out-migration patterns that remove young people from traditional learning environments, while climate change makes some traditional practices less effective. Experience with the integration of technology reveals both opportunities and challenges for combining traditional knowledge with contemporary approaches, with consultation participants noting examples of successful integration alongside concerns about technology access and appropriateness. The observation that "women are often not comfortable with technology" and "there is access asymmetry in disaster related early warning and news dissemination" reflects broader patterns where technological solutions may not be accessible or appropriate for all community members.

6.3.9 TRANSBOUNDARY DIMENSIONS AND REGIONAL COOPERATION POTENTIAL

India's position within major transboundary river basins creates interdependencies where climate adaptation requires coordination with neighbouring countries, while the country's size and economic capacity position it as a potential leader in regional cooperation for adaptation. The framework's emphasis on transboundary cooperation becomes particularly relevant in India's context, where climate impacts on upstream glacier and snowpack systems affect downstream populations across multiple countries and meaning that India's adaptation responses can have regional implications. Water resource management represents the most critical area for transboundary cooperation, with India's rivers, including the Ganges, Indus, and Brahmaputra systems originating in or flowing through multiple countries where climate change is altering flow patterns, seasonal timing, and extreme event frequency. However, existing cooperation mechanisms remain limited; although consultation findings did not extensively address transboundary dimensions the need for "systemic responses over water sharing" was emphasized, that could provide the foundations for enhanced regional cooperation.

Technology transfer opportunities exist through India's substantial renewable energy and adaptation technology capacity, with the country's manufacturing capabilities and technical expertise providing potential foundations for regional cooperation on clean energy transitions and climate adaptation. The International Solar Alliance, initiated by India, demonstrates the country's potential for leading regional and global cooperation on clean energy deployment, though consultation findings did not extensively address these international dimensions.[237] Governance of migration requires regional cooperation mechanisms that can address climate-induced displacement while facilitating safe labour mobility and protecting migrants' rights across borders. India's position as both origin and destination for climate-related migration creates opportunities for developing innovative approaches to the governance of population mobility that could inform regional frameworks, Current policy responses, however, remain fragmented and limited in scope. Disaster risk reduction represents an area where regional cooperation has shown some success and provides models for expanded cooperation on climate adaptation. Effective transboundary adaptation requires building upon existing cooperation mechanisms while developing new institutional arrangements that can address shared climate challenges through coordinated planning, resource sharing, and joint implementation of measures.

6.3.10 POLICY INTEGRATION AND SYSTEMIC TRANSFORMATION REQUIREMENTS

The comprehensive analysis of India's human security under climate stress reveals the urgent need for transformation from sectoral approaches toward integrated system-wide responses that address the interdependent nature of climate impacts across the FWE nexus while building adaptive capacity at multiple scales. The findings of the consultation emphasized the need for "integrated policy to address this challenge" while noting successful examples of integration including "landscape approach" initiatives that strengthen community institutions and build capacity for collective action. The framework's emphasis on threshold analysis proves particularly relevant for policy prioritization in India's context, enabling identification of approaching tipping points where proactive intervention can prevent system collapse at much lower cost than post-crisis reconstruction and humanitarian response. Priority areas for immediate intervention include water security systems which are approaching sustainability limits, agricultural systems facing unprecedented climate stress, and energy systems requiring integration of variable renewable sources with reliable grid operation.

237 https://isa.int/about_uss

Support for the diversification of livelihoods represents a critical policy priority requiring coordination across multiple sectors and levels of government to address both opportunities and constraints facing rural households adapting to climate change. Consultation findings emphasized the importance of “responding to community needs” as “the most important condition for future success”. Challenges, including limited access to credit, inadequate market linkages, and social barriers that constrain livelihood diversification options, were also noted. Investment in resilience infrastructure requires fundamental shifts from designs based on historical climate patterns toward adaptive approaches that can accommodate new variability while maintaining essential services during extreme events. Priority investments should focus on distributed systems that reduce single-point failure risks, multi-purpose infrastructure that serves multiple functions and user groups, and modular solutions that can be adapted and expanded as conditions change.

Building capacity in climate finance represents an essential foundation for all other adaptation efforts, requiring coordinated efforts to build technical capacity at state and local levels while establishing dedicated climate finance units with appropriate staffing, training, and resources. Consultation findings emphasized the currently inequitable access to climate finance with “discriminating mechanisms” that exclude poor and marginalized populations from adaptation resources. Gender-responsive programming must address structural barriers to women’s participation in climate adaptation planning and implementation while building upon women’s knowledge, skills, and leadership capabilities. Consultation findings noted both constraints, including technology access barriers, and opportunities including women’s potential role as “water entrepreneurs” through SHG participation. The consultation’s emphasis on the need for “blended governance models” accords with the framework’s tenet that effective climate adaptation requires innovative institutional arrangements that can combine traditional and modern governance approaches while operating effectively across multiple scales and sectors. Activation of this concept requires policy frameworks that recognize and support indigenous innovation while building institutional mechanisms for the integration of knowledge, resource coordination, and adaptive management.

Most critically, India’s experience demonstrates that improving human security under climate stress requires unprecedented forms of integration across sectors, levels of government, and temporal scales. This exceeds traditional governance approaches while, at the same time, building upon existing institutional foundations and social capital. The country’s substantial technical and institutional capacity provides opportunities for innovation that could benefit not only India’s own adaptation needs, but also contribute to regional and global efforts to build human security under accelerating climate stress. However, realizing this potential requires addressing fundamental governance challenges including sectoral coordination, multi-level planning, and inclusive participation to ensure adaptation benefits reach the most vulnerable populations.

6.4 Pakistan: Intersectional Vulnerabilities and Systemic Climate Risks

The Food-Water-Energy Nexus Under Extreme Stress: Systemic Dependencies and Cascade Effects

Urban Vulnerabilities and Infrastructure Resilience Challenges

Regional Variations and Intersectional Vulnerabilities: From Mountains to Plains

Institutional Resilience and Governance Challenges Under Climate Stress

Glacial Lake Outburst Flood Risks: Immediate Threats and Cascade Vulnerabilities

Regional Cooperation and Transboundary Dimensions Under Political Constraints

Climate-Induced Displacement and Migration: Scale, Patterns, and Regional Implications

Economic Transformation and Livelihood Adaptation Under Climate Stress

Traditional Knowledge Systems and Innovation Under Environmental Stress

Pakistan's climate vulnerabilities are based on the country's high dependence on water resources originating from Hindu Kush Himalayan glaciers combined with exposure to extreme weather events that are increasing in frequency and severity. The country is at the centre of global climate crisis impacts although contributing less than one percent of global greenhouse gas emissions. The 2022 floods, which affected over 33 million people and caused damages exceeding USD 30 billion, demonstrated the country's vulnerability to extreme precipitation events that are projected to become more intense under continued climate change.[238] These events led to Pakistan's ranking as the most climate-affected nation globally in 2025 based on 2022 disaster data.[239] Climate change acts as a threat multiplier that exacerbates existing vulnerabilities across all dimensions of human security. In recent years, these concerns have increasingly entered high-level national policy discourse in Pakistan. Senior government representatives, including the Deputy Prime Minister and Minister for Foreign Affairs, have explicitly framed climate action as a strategic imperative for economic resilience and human security in speeches such as his 2026 address at the Pakistan Governance Forum titled "Navigating International Relations Amidst Changing Geo-Politics".[240]

238 Cui, P., Bazai, N.A., Qiang, Z. et al. Flood risk assessment with machine learning: insights from the 2022 Pakistan mega-flood and climate adaptation strategies. npj *Nat. Hazards 2*, 42 (2025). https://doi.org/10.1038/s44304-025-00096-1

239 Adil, L., Eckstein, D., Künzel, V., & Schäfer, L. (2025, February 12). *Climate Risk Index 2025: Who suffers most from extreme weather events?* Germanwatch. https://www.germanwatch.org/sites/default/files/2025-02/Climate%20Risk%20Index%202025.pdf

240 Statement by Senator Mohammad Ishaq Dar, Deputy Prime Minister and Minister for Foreign Affairs, at the Pakistan Governance Forum 2026 "Navigating International Relations Amidst Changing Geo-Politics", Ministry of Foreign Affairs, Government of Pakistan, 25 February 2026, available at: https://mofa.gov.pk/press-releases/statement-by-senator-mohammad-ishaq-dar-dpmfm-at-the-pakistan-governance-forum-2026-navigating-international-relations-amidst-changing-geo-politics

With a population of nearly 254 million in 2024, Pakistan is already one of the world's most populous countries, and even under optimistic scenarios the population is projected to increase by some 30 million by mid-century. Under pessimistic scenarios, population projections rise to nearly 350 million by mid-century, an increase of over 100 million compared to present levels.[241] This scale of population growth alone is projected to place significant stress on existing urban systems.

Northern Pakistan contains 33 glacial lakes at risk of outburst floods, threatening over 7 million people in downstream areas,[242] while the country's 13,680 km^2 of glacier coverage represents the most extensive collection of glaciers outside polar regions, making Pakistan uniquely vulnerable to high-altitude climate change impacts.[243] The human security framework's emphasis on understanding compound vulnerabilities proves particularly relevant in Pakistan's context, where the roundtable consultation findings revealed how "interlinked climate risks are further affected [enlarged] by the intersectionality of various identities of mountain communities" including gender, ethnicity, economic status, and geographic location. These intersecting factors mean that the effects of exposure are experienced differently and that adaptive capacity varies within communities, requiring approaches to human security that address structural inequalities alongside environmental stresses. The consultation participants emphasized that Pakistan's diversity across the Hindu Kush-Himalaya-Karakoram region encompasses "various cultures, traditions, religions, and languages" that necessitate context-specific solutions rather than "one-size-fits-all approaches". This diversity creates both challenges and opportunities for human security approaches, as successful adaptation requires understanding how climate impacts interact with existing social hierarchies, economic disparities, and governance challenges that amplify risks above the sum of individual stressors.

6.4.1 THE FOOD-WATER-ENERGY NEXUS UNDER EXTREME STRESS: SYSTEMIC DEPENDENCIES AND CASCADE EFFECTS

Within Pakistan's FWE nexus the Indus River system serves as the critical connector linking mountain water resources to agricultural productivity, energy generation, and urban water supplies across the country. Over 60% of Pakistan's water originates from glacial and snow melt from northern mountain areas and feeds the river systemwhich provides water for Pakistan's agriculture, industry, and urban populations.[244] Climate change affects this system through altered timing of peak flows, reducing water availability in the dry season, and an increase in variability that complicates water management planning. Pakistan's limited water storage capacity relative to annual river flows makes the country particularly vulnerable to changes in seasonal distribution of water availability. Threshold analysis proves particularly relevant for understanding Pakistan's water crisis, where multiple indicators suggest the country is approaching irreversible tipping points in water security, each with distinct timelines and cascading human security implications. Two scenarios emerge from the literature. Under the moderate climate change scenario (SSP1-RCP4.5), Pakistan's per capita water availability will decline from the current 860 m^3 annually to approximately 700 m^3 by 2050, remaining manageable through incremental adaptation but still below UN water stress thresholds and limiting growth in food production necessary for a population projected to reach 300 million.[245] Under a high emission scenario (SSP3-RCP8.5), the decline accelerates far more severely: per capita availability could fall to 500 m^3 by 2040, triggering what researchers' term "extreme water scarcity" as defined by UN standards of 500 m^3 per capita, a threshold beyond which societies experience severe ecosystem degradation and irreversible groundwater depletion.[246] Most critically, the International Water Management Institute warns that if current glacier melt rates and groundwater over-extraction continue simultaneously, the Indus River itself may become a seasonal river by 2050, dependent on monsoon precipitation rather than glacier-fed baseflow that currently sustains 240 million people through

241 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

242 https://www.greenclimate.fund/project/fp018

243 https://www.aljazeera.com/news/2025/8/28/behind-pakistans-repeated-floods-melting-glaciers-depleted-forests

244 Bilal, Hazrat & Siwar, Chamhuri & Mokhtar, Mazlin & Lahlou, Fatima-Zahra & Kanniah, Devi & Al-Ansari, Tareq. (2024). Snow runoff modelling in the upper Indus River Basin and its implication to energy water food nexus. Ecological Modelling. 498. 10.1016/j.ecolmodel.2024.110871.

245 Abdullah et al. (2025): Glacier mass loss scenarios and water availability projections under high emissions

246 World Bank (2015): Indus Basin of Pakistan: Impacts of Climate Risks on Water and Agriculture

the dry season – a transition that would represent a fundamental regime shift in South Asian hydrology.[247] This represents what the framework identifies as single-point failure risk, where climate impacts on high-altitude systems cascade through the entire FWE nexus to create compound impacts that exceed the sum of individual sectoral failures. The UNDP study's projected patterns of spatial population change[248] indicate that drier portions in the west of the country and disputed regions in the north are expected to experience population decline under multiple scenarios, while movement towards more fertile and urban regions, particularly along the Indus River, Punjab, and coastal and southern Sindh, is projected over the period 2020–2050.

Agricultural productivity, which supports 42% of Pakistan's workforce and contributes approximately 24% to GDP,[249] faces multiple climate stresses including heat extremes, water scarcity, and increased pest and disease pressure. The roundtable consultation revealed that "traditional farm-based livelihoods are declining" while climate change creates "low agricultural returns and land abandonment" that force communities to seek alternative livelihood strategies. Current projections indicate severe impacts across major crops: wheat yields in some regions could decline by 50% by 2050 without adaptation measures, while cotton and rice production face reductions of 6-18% and 3-17% respectively under 2°C warming scenarios.[250] The consultation findings emphasized regional variations in agricultural impacts, with participants noting that in Gilgit-Baltistan, "deforestation, urbanization, and erratic rainfall patterns have reduced agricultural productivity and contributed to water scarcity," while "declining snowfall has further affected water availability and hydropower generation, leading to energy imbalances". Agricultural production is concentrated in areas that are exposed to both high water stress and extreme weather events which creates food security risks that could affect regional markets and political stability more boadly. Traditional farming systems face new challenges as climate variability exceeds historical experience while simultaneously confronting pressures for modernization but with infrastructure deficits. The consultation participants noted that "rice cultivation, the primary source of food and income for the community, was heavily impacted" by climate disasters, while "damages to agricultural infrastructure led to an estimated 20 million USD in economic losses" in single events like the Reshun Village flash flood.[251] However, improved climate adaptation in Pakistan's agriculture remains structurally constrained by land tenure systems that lock tenant farmers and sharecroppers into subordinate and non-adaptive production relationships. In rural Sindh alone, approximately 40% of agricultural workers are sharecroppers (hari) operating under informal verbal contracts where landlords retain control over all technology, input, and crop-choice decisions, with output shares ranging from 50-75% landlord control.[252] As mechanization has advanced and input costs risen, tenant obligations have expanded—with landlords now financing tractors, fertilizers, and chemicals, yet tenants bear economic risk without decision-making power, rendering them unable to adopt climate-resilient crop varieties, alter planting dates, or diversify livelihoods, even when extension services and technologies are available.[253] The human security implication is stark: climate adaptation in agriculture remains technically feasible for well-resourced landowners, but increasingly impossible for the tenant and landless populations whose food security and livelihood options are most severely threatened.

247 Baig, S., Sayama, T., & Yamada, M. (2022). Quantifying the changes in the runoff and its components across the Upper Indus River Basin under climate change. *Journal of Water and Climate Change, 13*(9), 3416-3434.

248 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

249 https://www.pbs.gov.pk/content/agriculture-statistics

250 Ali, M. A., Hassan, M., Mehmood, M., Kazmi, D. H., Chishtie, F. A., & Shahid, I. (2022). The potential impact of climate extremes on cotton and wheat crops in Southern Punjab, Pakistan. *Sustainability, 14*(3), 1609.

251 Waqas, H., Lu, L., Tariq, A., Li, Q., Baqa, M. F., Xing, J., & Sajjad, A. (2021). Flash flood susceptibility assessment and zonation using an integrating analytic hierarchy process and frequency ratio model for the Chitral District, Khyber Pakhtunkhwa, Pakistan. *Water, 13*(12), 1650.

252 FAO/Sindh Tenancy Evaluation. (2021); Khalil et al., n.d.

253 Khan et al. (2020); OPML South Asia Climate-Resilient Agriculture Framework. (2018).

Energy security demonstrates both vulnerabilities and opportunities within Pakistan's energy transition, with the country's 7,320 MW of installed hydropower capacity facing operational challenges as glacier retreat and altered precipitation patterns affect river flow regimes.[254] The consultation findings revealed concerns about the vulnerability of energy infrastructure, noting that disasters often destroy power generation facilities, as demonstrated by the loss of "a 4.5-megawatt hydropower station" during the Reshun Village flood that "further disrupted access to essential services, exacerbating the crisis". However, Pakistan has also achieved significant growth in renewable energy capacity, reaching over 5,100 MW of installed renewable capacity, demonstrating a technical capacity for clean energy deployment that could enhance energy security while reducing climate vulnerability.[255] Framework analysis identified critical interdependencies within Pakistan's FWE nexus where disruptions in one system immediately affect others. The consultation participants emphasized that "access to energy, reliant on water resources, is essential for livelihoods" while "reduced water availability and forest degradation severely impact rural households," creating cascade effects where water scarcity undermines both agricultural productivity and energy generation. Over 80% of rural households in the HKH region lack access to modern energy sources for cooking, while nationally, over 23% of the population lacks access to grid-based electricity, creating energy poverty that compounds climate vulnerabilities.[256]

6.4.2 REGIONAL VARIATIONS AND INTERSECTIONAL VULNERABILITIES: FROM MOUNTAINS TO PLAINS

Pakistan's geographic diversity from the Arabian Sea coast to 8,000+ meter peaks, shapes dramatically different manifestations of climate vulnerability that require differentiated adaptation approaches while recognizing systemic connections across regions. The consultation findings revealed how different regions face distinct combinations of climate hazards that interact with local social, economic, and governance conditions to create unique vulnerability profiles requiring context-specific responses. Gilgit-Baltistan represents the epicentre of Pakistan's glacial climate risks, with consultation participants identifying multiple climate threats including "glacier lake outburst floods, changing seasonal patterns, altered rainfall and snowfall, and shifting seasonal timelines" combined with "rising temperatures" that create "significant challenges for local communities". The region faces compound vulnerabilities where environmental hazards interact with development pressures and governance challenges to create risks exceeding individual threat impacts. Key contributing factors include "carbonization, unplanned settlements, deforestation, and mining" while "unregulated settlements along riverbanks expose communities to heightened risks". The consultation emphasized that infrastructure vulnerabilities create particular challenges for mountain communities, as "disasters often destroy roads, bridges, and essential facilities, disrupting access to water, education, healthcare, and livelihoods". Communities demonstrate remarkable adaptation, relying on "mountain paths for travel in summer and frozen rivers in winter," but this adaptation remains regionally differentiated and also highlights exposure to climate hazards as warming temperatures make traditional transportation routes unreliable. This adaptation itself has underlying exposure to climate hazards, and the loss of traditional infrastructure combines with climate impacts to create compound vulnerabilities that exceed individual household or community adaptive capacity in most contexts.[257] However, the institutional response to these challenges differs markedly between regions, illustrating how governance capacity mediates climate vulnerability. In Gilgit-Baltistan, institutionalized disaster management structures, including the Gilgit-Baltistan Disaster Management Authority working with community-based flood early warning systems (CBFEWS), where women and men serve as community caretakers in 250 monitored villages, have enabled coordinated responses that exceed what isolated households can manage.[258] In contrast, Pakistan's southern provinces (Sindh and Punjab), where tenant farmers comprise 40-60% of the agricultural workforce, lack equivalent community-based governance structures, and land tenure constraints prevent even wealthier

254 https://interactive.carbonbrief.org/the-carbon-brief-profile-pakistan/index.html

255 Xin, Y., Bin Dost, M. K., Akram, H., & Watto, W. A. (2022). Analyzing Pakistan's Renewable Energy Potential: A Review of the Country's Energy Policy, Its Challenges, and Recommendations. *Sustainability, 14*(23), 16123. https://doi.org/10.3390/su142316123

256 Choi, H. J., Qayyum, S., & Koo, B. B. (2024, May). *Pakistan energy survey: Insights into the true energy access situation in Pakistan based on the Multi-Tier Framework* (Pakistan Sustainable Energy Series). The World Bank. https://documents1.worldbank.org/curated/en/099062824120620952/pdf/P1693131aa11a409b1bd991b944e3711bfe.pdf

257 ICIMOD CBFEWS Report 2019

258 ICIMOD CBFEWS Empowerment Report 2020; ADPC 2025

farmers from adapting to cascading climate impacts independently. The loss of traditional infrastructure and climate-driven changes to predictable seasonal patterns create distinct human security outcomes depending on whether communities possess institutional capacity and secure land tenure. In Gilgit-Baltistan's stronger institutional contexts, responses can be coordinated. In the Indus Basin's tenure-constrained agricultural systems, individual household adaptive capacity collapses entirely when facing compounding shocks. This regional differentiation demonstrates that climate impacts and human security are mediated fundamentally by pre-existing governance capacity and control of resources, the same physical climate hazard can be responded to collectively in one region or create fragmentation and individual vulnerability in another. Projected patterns of spatial population change over the period 2020–2050 indicate that disputed regions in the north, as well as drier portions in the west of the country, are expected to experience population decline under multiple scenarios, while significant movement towards more fertile and urban regions, particularly along the Indus River, Punjab, and coastal and southern Sindh, is projected.

The Malakand Division, encompassing districts including Chitral, Swat, Lower Dir, Upper Dir, and Shangla, demonstrates how climate change impacts interact with conflict legacies and governance challenges to create complex vulnerability patterns. Consultation participants noted that "geopolitical tensions further exacerbate risks, leading to severe socioeconomic consequences" while "climate events, particularly flash floods, have intensified these vulnerabilities". The region's experience with insurgency has "significantly weakened traditional institutions" including customary dispute resolution mechanisms, creating governance gaps precisely when climate adaptation requires strong institutional coordination. Agricultural impacts in the Malakand region illustrate the framework's insights about cascade effects, with consultation findings revealing that "a significant portion of agricultural land in Chitral was lost to floods, forcing many communities to migrate to urban centres like Chitral City in search of economic opportunities."[259] Traditional seasonal grazing practices were disrupted, "particularly during monsoons, leading to heavy livestock losses and further destabilizing rural economies," demonstrating how climate impacts propagate through interconnected livelihood systems to create compound economic and social disruptions. Sindh and Balochistan provinces experienced the most severe impacts during the 2022 floods, with Sindh receiving 680.5mm of rainfall (six times the average) and Balochistan recording 284mm (also six times the average), creating unprecedented flooding that demonstrated the intersection of extreme weather events with existing vulnerabilities.[260] The consultation noted that these provinces face "severe impacts in Balochistan and Sindh" regarding food insecurity, while "traditional food systems are being replaced by rice and wheat, which are less resilient to climate shocks". Balochistan's position as "the driest region in the country" experiencing "a 500% increase in rain in July 2022" illustrates how climate change introduces novel risks that exceed historical experience and traditional adaptive capacity. The Sindh and Punjab provinces face particular challenges as Pakistan's agricultural heartland, where consultation participants noted that "four-fifths of the total crops in Sindh have been damaged" during the 2022 floods, affecting "roughly one-third of Pakistan's total cotton crop".

The province's role in national food production means that climate impacts on Punjab agriculture have cascading effects on national food security and economic stability, exemplifying the general tenet that local climate impacts can have systemic consequences that extend far beyond the immediately affected areas. Karachi, the most populous and economically important city in Pakistan, is already a major migrant destination from flood-prone regions of rural Punjab and Sindh in the Indus River Valley, as well as from Khyber Pakhtunkhwa and the formerly Federally Administered Tribal Areas, all of which are projected[261] to experience continued out-migration under multiple scenarios of the climate mobility study.

259 Jehan, S., Sarwar, T., Khattak, S. K., & Khan, M. J. (2024). Climate Change and its Impact on Water Resources of Selected Areas in District Chitral with High Climatic Vulnerabilities. *Sarhad Journal of Agriculture, 40*(4).

260 Government of Pakistan, Asian Development Bank, European Union, United Nations Development Programme, & World Bank. (2022, October 28). *Pakistan floods 2022: Post-Disaster Needs Assessment* – Main Report. Ministry of Planning, Development & Special Initiatives. https://thedocs.worldbank.org/en/doc/4a0114eb7d1cecbbbf2f65c5ce0789db-0310012022/original/Pakistan-Floods-2022-PDNA-Main-Report.pdf

261 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

Situational analysis reveals how climate impacts interact with existing inequalities to create differentiated vulnerabilities for both men and women across regions. The consultation findings emphasized that disaster impacts show "gender-specific vulnerabilities, as women in the region face unique challenges during disasters, [because they have] limited access to resources, lower physical strength, and the added responsibility of caregiving for children and the elderly". Women's specific vulnerabilities during climate-related disasters extend to limited access to early warning information, constrained physical mobility due to cultural norms around women's movement outside the home, lower participation in community disaster planning that is often male-dominated, and caregiving responsibilities for children, elderly, and disabled family members that cannot be abandoned during emergencies. The Reshun Village case study revealed that "the loss of four lives, three of whom were women" reflected these differential vulnerabilities, while "lack of disaster preparedness and training for women further increased their risks." Furthermore, research after the 2010 Pakistan floods documented that women comprised 70% of casualties despite comprising 49% of the population.[262] Simultaneously, men in Pakistan's mountain regions and agricultural plains face distinct climate-related vulnerabilities: young men increasingly migrate in search of work as glacier melt disrupts seasonal water availability for irrigation and reduces agricultural labour demand, breaking household economic stability and contributing to marriage delays (resulting in 40% of men age 25-30 unmarried in some districts, as compared to <10% of women), which reduces social integration and generates psychosocial stress.[263] Additionally, male-dominated community structures for disaster management, while providing some coordinated response capacity in Gilgit-Baltistan, can exclude women's knowledge and create maladaptive responses. The Reshun case documented that lack of gender-inclusive disaster planning led to evacuation routes that were suboptimal for women carrying children and elderly dependents. Gender vulnerabilities thus operate bidirectionally: women face barriers to adaptation stemming from limited mobility, caregiving demands, and institutional exclusion; men face livelihood disruption and migration pressures that fracture social structures; and institutional gender dynamics (male-dominated structures) produce adaptive failures that endanger both women and men.

6.4.3 GLACIAL LAKE OUTBURST FLOOD RISKS: IMMEDIATE THREATS AND CASCADE VULNERABILITIES

Glacial Lake Outburst Flood risks in Pakistan represent immediate threats of catastrophe with climate change creating new categories of extreme risk that exceed traditional disaster management approaches with the possibility of creating cascade effects across multiple systems and scales. Northern Pakistan's 33 glacial lakes at risk of outburst floods threaten over 7 million people in downstream areas,[264] with consultation participants emphasizing that GLOFs represent "climate risks in Gilgit-Baltistan and Khyber Pakhtunkhwa" that require "enhanced early warning systems, strengthened disaster risk management capacities, and building infrastructure such as irrigation channels, gabion walls, and safe havens". The January 2010 Attabad event, while technically a landslide-generated flood rather than a GLOF, exemplifies the cascade vulnerabilities and prolonged cross-border impacts that can result from valley-blocking hazards. A 45 million m^3 landslide creating a natural dam which in turn generated a 27-30 km lake that blocked the Karakoram Highway (China-Pakistan strategic trade corridor) for more than 8 months, displaced 6,000 people upstream while stranding 25,000 downstream from essential services. It subsequently required emergency reconstruction of the highway, with 7.12 km of new tunnels and 2 new bridges (2012-2015) at costs exceeding USD 1 billion. This demonstrates how a single mountain hazard event can disrupt regional infrastructure networks and require years of emergency investment to restore connectivity.[265]

262 Ambreen et al., 2024; Pakistan Disaster Management Authority 2010 Analysis

263 Gioli et al., 2014; Pakistan Population Welfare Division 2024

264 https://www.adaptation-undp.org/projects/scaling-glacial-lake-outburst-flood-risk-reduction-northern-pakistan

265 Iqbal, M. J., Shah, F. H., Chaudhry, A. U. H., & Baig, M. N. (2014). Impacts of Attabad Lake (Pakistan) and its future outlook. *European Scientific Journal, 10*(8).

The GLOF-II Project, implemented by Pakistan's Ministry of Climate Change, demonstrates institutional recognition of these risks and efforts to enhance community resilience through multi-faceted approaches including infrastructure development, capacity building, and early warning systems.[266] However, the scale and complexity of GLOF risks exceed the capacity of traditional disaster management approaches, requiring system-wide responses that address not only immediate flood hazards but also the broader cascade effects that propagate through interconnected social, economic, and environmental systems.

Traditional early warning systems prove inadequate for GLOF risks due to the remote locations of most glacial lakes, the rapid onset of flood events, and the technical monitoring requirements that exceed local institutional capacity. The consultation emphasized the need for "early warning mechanisms" that can "provide timely alerts, allowing farmers and local authorities to take preventive measures and reduce losses," but noted that effective GLOF early warning requires integration of advanced monitoring technologies with community-based observation and response networks. GLOF risks demonstrate particular challenges for vulnerable populations, with consultation findings noting that indigenous communities like the Kalash have "unique culture, traditions, and language" that make them "particularly susceptible to the negative effects of climate change and natural disasters," requiring "tailored disaster risk management strategies that respect and incorporate their cultural contexts". The Kalash possess distinct religious and cultural traditions, rich systems for oral knowledge transmission, and community-based social governance institutions. However, this cultural specificity creates distinct GLOF vulnerability pathways. First, Kalash agricultural knowledge, developed through centuries of adapting to Bumburet valley's particular microclimate and soil conditions, becomes maladaptive when GLOF events occur with increasing frequency. Second, the Kalash language and cultural transmission are threatened by climate-induced displacement: the repeated 2010, 2013, 2015, 2020, 2022, and 2023 floods have forced successive Kalash families to migrate to Gilgit city, where they lose cultural practices (seasonal festivals, traditional stories, and knowledge transmission ceremonies) that occur in specific valley locations with particular ecological features and seasonal cycles now disrupted by climate change.[267] This displacement creates a vicious cycle where language erosion follows livelihood loss, children relocated to Gilgit adopt Shina (the lingua franca) rather than Kalash, and displaced Kalash knowledge holders no longer transmit traditional ecological knowledge about valley-specific resource management and risk prediction. Third, the Kalash have historically faced challenges in ensuring that their specific needs and vulnerabilities are fully reflected in disaster risk management and recovery mechanisms, including where identity documentation categories and programme design have not always captured the circumstances of very small, geographically concentrated communities. Consultation participants noted that repeated flood events have affected both their physical security and cultural continuity, as damage to land, homes, and temples can accelerate loss of language and ritual practices. However, recent government and partner efforts, including targeted disaster-risk reduction investments and outreach in Kalash valleys, indicate growing recognition of these issues and the potential to make future assistance more inclusive and responsive to the community's distinct context.[268]

The framework emphasizes that effective GLOF preparedness must address not only technical monitoring and infrastructure challenges but also social vulnerabilities that determine communities' exposure and adaptive capacity. The consultation participants noted that GLOF events can simultaneously affect multiple critical systems while occurring in remote locations where emergency response capacity is limited, creating compound vulnerabilities. The cascade effects of GLOF risks extend far beyond immediate flood impacts to include long-term disruptions of water supply, energy generation, transportation networks, and regional economic systems. Infrastructure damage from GLOFs can disrupt access to essential services for extended periods, while economic losses affect both local communities and regional systems that depend on mountain water resources and transportation routes.

266 https://mocc.gov.pk/Detail/ZmI3OWZlMzYtMTdkYy00ZGU5LTgyZjAtMzIxODdkMTBmMTEy

267 Dialogue Earth 2024; Prevention Web Climate Languages 2024

268 PreventionWeb 2023; Chitral CCAAP 2024

6.4.4 CLIMATE-INDUCED DISPLACEMENT AND MIGRATION: SCALE, PATTERNS, AND REGIONAL IMPLICATIONS

Climate-induced displacement in Pakistan demonstrates that human mobility can be both an adaptation strategy and indicator of system failure. The floods in 2022 created the largest single displacement event in the country's history while revealing broader patterns of climate-related population movement that reshape demographics and create new governance challenges. The 2022 floods temporarily displaced over 8 million people, with many permanently relocating from repeatedly affected areas, representing a fundamental shift in Pakistan's displacement patterns so that climate became a dominant driver of population movement.[269] The consultation findings emphasized the scale and complexity of climate-induced displacement, noting that "disasters displaced 5.3 million people in South Asia, including 70,000 in Pakistan" in 2021 alone, while "climate-induced migration, both temporary and permanent, is expected to increase, with estimates suggesting nearly two million climate migrants within Pakistan by 2050". These projections[270] suggest that Pakistan faces sustained displacement pressures that will require long-term policy responses rather than temporary humanitarian assistance, challenging traditional approaches to the management of displacement that focus on emergency response rather than systematic adaptation. UNDP study's model-based projections[271] indicate that under an optimistic climate pathway, nearly 2.7 million people could migrate due to climate change by mid-century, representing just over one percent of the national population and almost 13 percent of all projected migrants. Under a pessimistic scenario, climate-induced migration could exceed 13.2 million people by mid-century, comprising nearly four percent of the population and over 40 percent of all migrants.

The ancient Mohana water-dependent community of coastal Sindh and Balochistan, further exemplifies how the intersection of environmental degradation and systemic governance challenges can undermine human security. Once comprising approximately 20,000 members in the 1980s, the Mohana population has experienced a substantial decline to an estimated 450 individuals,[272] reflecting cumulative pressures from ecological changes and institutional failures. Environmental stressors, including water quality deterioration from industrial and sewage discharge, ecosystem collapse (evidenced by the loss of 14 of 200 historically abundant fish species),[273] sedimentation and reduced freshwater inflows from upstream dam construction have rendered water-based livelihoods increasingly unviable. These compound stressors have necessitated the permanent relocation of many Mohana households from their ancestral water-based traditions to terrestrial settlements and urban centres, reflecting how adaptation pathways can become constrained under environmental pressures that exceed the absorptive capacity of traditional livelihood systems.

Rural-urban migration patterns demonstrate how climate change interacts with economic pressures to reshape population distribution across Pakistan. The consultation revealed that "male labour migration to urban centres has intensified, placing additional burdens on women in rural communities" while "migration patterns highlight inequities, as marginalized groups face discrimination and limited access to social services". The case studies documented relocation of entire communities, with consultation participants noting that "whole communities are leaving the hills" rather than maintaining traditional circular migration patterns. At this scale, such fundamental changes in mobility systems exceed adaptive migration and represent responses to livelihood system failure. The consultation emphasized intersectional dimensions of climate migration, revealing how gender, ethnicity, and economic status create differentiated mobility experiences and outcomes. Women face particular challenges during displacement, with consultation findings noting "food insecurity increased as rice crops were destroyed, and the loss of agricultural livelihoods disrupted household incomes" while "mental health support was identified as an essential component of disaster recovery, particularly for women who face unique emotional challenges in the aftermath of such events". The framework identifies this as compound vulnerability where displacement compounds existing inequalities to create new forms of marginalization and risk. International migration from

269 Shan, Rafi. (2025). Internal Displacement and Migration due to the 2022 Flood.

270 https://www.iwmi.org/news/the-hidden-crisis-of-disaster-displacement-and-host-community-struggles-in-rural-areas-of-pakistan/

271 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

272 https://jawadshariffilms.com/a-legacy-on-water/

273 https://www.dawn.com/news/1208624

Pakistan includes substantial numbers seeking employment in Gulf countries, Europe, and North America. Climate impacts are increasingly recognized as factors contributing to migration decisions alongside traditional economic motivations.[274] The consultation noted that "while migration can enhance resilience, remittances are rarely reinvested in climate adaptation or agriculture," suggesting missed opportunities for linking migration benefits to origin area adaptation. International movement to Gulf countries represents a significant adaptation strategy, with 0.5-0.8 million Pakistanis engaged in climate-influenced migration to UAE, Saudi Arabia, and Qatar, generating remittances that provide crucial economic buffers for rural households facing climate stress.[275]

Urban absorption capacity represents a critical constraint on climate-induced migration, with rapid urbanization concentrating population in areas that are highly vulnerable to climate impacts, including flooding, heat waves, and water scarcity. Urban planning and infrastructure systems are often inadequate to address current climate risks, much less the increased risks projected under continued climate change. Informal settlement patterns that characterize much urban growth create particular vulnerabilities for low-income populations who lack access to climate-resilient housing and services. The consultation findings noted that "urbanization and climate-induced migration have further exacerbated vulnerabilities, leading to the expansion of slum areas in unsafe locations such as riverbanks". According to the UNDP climate mobility study, Karachi, the most populous and economically important city in Pakistan, is projected[276] to absorb significant climate-induced migration under all scenarios. Net climate-induced migration to the city is projected to exceed 200,000 people under an optimistic scenario, but could rise to approximately 2.36 million new arrivals under a pessimistic scenario. Under the latter, the city's total population is projected to exceed 30 million by mid-century.

This could be termed a "mobility squeeze" in Pakistan, where environmental pressures intensify the need for population movement while constraints on mobility options increase due to economic stress, policy barriers, and destination area limitations. Trapped populations in disaster-prone areas face particular vulnerabilities, with an estimated 15-20 million people exposed to GLOFs, sea level rise, and other climate hazards but lacking resources or opportunities for safe relocation.[277] Model-based projections[278] indicate that under pessimistic futures, population immobility persists alongside large-scale movement, with some districts experiencing net out-migration despite overall urban growth, reflecting constraints related to water stress and settlement conditions. These populations require adaptation support that enables building resilience in situ, while maintaining options for planned relocation when environmental conditions become unviable. There are regional implications of Pakistan's climate-induced mobility and displacement; effects extend beyond national boundaries through multiple pathways, including pressure on neighbouring countries, disruption of regional labour markets, and potential for climate-related conflicts over resources and territory. The consultation noted "transboundary challenges, such as downstream vulnerabilities and cross-border mobility issues" while emphasizing that "regional cooperation is critical for managing transboundary risks". However, political tensions with neighbouring countries may limit cooperation on the governance of climate migration precisely when such cooperation becomes most essential for regional stability.

274 Arif, G. & Farooq, Shujaat & Iqbal, Nasir. (2020). Labour Migration from Pakistan to the Gulf Countries: An Investigation of Regional Disparities in Outflows of Workers, Remittances and Poverty. 10.1007/978-981-32-9287-1_11.

275 https://climate-diplomacy.org/magazine/conflict/pakistans-policymakers-must-address-climate-migration

276 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

277 Ullah, Wahid & Nihei, Takaaki. (2016). *Climate Change Vulnerability of Pakistan Towards Natural Disasters: A Review.* International Journal of Environmental Protection and Policy. 4. 126-132. 10.11648/j.ijepp.20160405.13.

278 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

6.4.5 TRADITIONAL KNOWLEDGE SYSTEMS AND INNOVATION UNDER ENVIRONMENTAL STRESS

Pakistan's traditional ecological knowledge systems are both a crucial foundation for climate adaptation and a system requiring integration with contemporary approaches to address unprecedented environmental changes. The consultation findings revealed that "indigenous knowledge, such as water conservation techniques and agricultural practices like traditional crop rotation, has always been climate-friendly and adaptable to changing conditions," but emphasized that "terms like resilience or adaptation may not even exist in local languages, making it challenging for external programs to align with local knowledge and practices".

Traditional water management systems, including community-managed springs, traditional irrigation channels, and indigenous water harvesting techniques provide important foundations for contemporary adaptation, but consultation participants emphasized that these systems face unprecedented stress under novel climate conditions. The case study from Shimshal Valley revealed both the potential and constraints of traditional approaches, with residents making "significant contributions to plantation and forestry efforts, leading to environmental conservation and community resilience" through initiatives funded by GB Wildlife and Conservation and the Aga Khan Rural Support Program.[279] However, the consultation also noted critical implementation challenges, including "plants [were] damaged by livestock" due to lack of fencing and "plants [were] transported from outside Shimshal which dried during the transportation and due to difference in plant[ing] seasons." Traditional agricultural knowledge systems face particular challenges as climate change renders many historical practices less effective while simultaneously undermining the social institutions that transmitted and adapted traditional knowledge across generations. The consultation emphasized that "indigenous ways of understanding and responding to climate challenges" often differ fundamentally from external adaptation programs, creating "disconnect between external adaptation efforts and the indigenous ways of understanding" that limits the effectiveness of both traditional and modern approaches. This disconnect reflects broader patterns where climate change exceeds the bounds of traditional knowledge while external interventions fail to build upon existing adaptive capacity.

Disaster preparedness and early warning systems based on traditional environmental observations provide crucial foundations for contemporary risk reduction approaches but require updating and institutional support to address novel climate risks. The consultation noted that traditional knowledge holders can observe environmental changes and predict local weather patterns but emphasized that "these languages may lack vocabulary for climate-induced changes that fall outside the bounds of historical experience, complicating communication about unprecedented risks. This creates challenges for integrating traditional and scientific early warning systems that could combine local environmental knowledge with broader scale climate monitoring. Traditional conflict resolution mechanisms show potential for resilience but also institutional vulnerabilities under climate stress. The consultation noted that "customary dispute resolution mechanisms, such as jirgas and community elders, have historically played a key role in managing conflicts, particularly those related to communal resources," but emphasized that "insurgency-related violence has significantly weakened these traditional institutions". The erosion of traditional governance institutions creates particular challenges for managing climate-related resource conflicts that require collective action and social coordination across community groups.

The framework suggests that effective climate adaptation requires the preservation of traditional knowledge while developing hybrid approaches that integrate traditional understanding with contemporary science and technology. The consultation findings revealed examples of successful integration, including traditional forestry management approaches that "not only tackled immediate ecological challenges but also built long-term resilience, showcasing how localized solutions can be more effective than top-down interventions". However, realizing this integration potential requires addressing institutional barriers that prevent recognition and scaling of indigenous innovations, while building mechanisms for knowledge adaptation that can address novel climate conditions.

279 Ali, I., & Butz, D. (n.d.). *Report on Shimshal Nature Trust (SNT): Ghojal, Northern Areas, Pakistan*. Brock University. https://brocku.ca/social-sciences/geography/wp-content/uploads/sites/152/ALI_Butz_SNT.pdf

6.4.6 URBAN VULNERABILITIES AND INFRASTRUCTURE RESILIENCE CHALLENGES

Pakistan's rapid urbanization is concentrating population in areas that are highly vulnerable to climate impacts, with urban systems facing compound stresses from population growth, inadequate infrastructure, and intensifying climate hazards that exceed the adaptive capacity of existing governance and service delivery systems. The consultation findings emphasized that "urbanization and climate-induced migration have further exacerbated vulnerabilities, leading to the expansion of slum areas in unsafe locations such as riverbanks" while noting examples of "unregulated hotel construction in Gilgit and Swat" that has "significantly increased exposure to climate risks". Model projections[280] further indicate that climate-induced in-migration to Karachi is unevenly distributed within the city. Certain central areas are projected to experience substantial population pressure from in-migration, while other districts are projected to lose population, primarily due to water stress. The model also suggests rapid growth of informal settlements under pessimistic scenarios, particularly in peripheral districts.

Urban planning and infrastructure systems demonstrate vulnerabilities to climate change impacts, with consultation participants noting that "infrastructure damage was another significant consequence" of climate disasters, affecting "houses, schools, roads, and health facilities" with "extensive destruction, particularly semi-cultured [semi-pucca] homes, which were more vulnerable to flooding". This creates differential vulnerabilities within urban areas where low-income populations face greater exposure to climate hazards while having reduced access to climate-resilient housing and essential services.

Understanding cascade effects proves particularly relevant for analysis of urban climate vulnerability, where the effects of disruptions to critical infrastructure systems can propagate across entire urban areas to affect millions of people simultaneously. The consultation noted that power outages from climate disasters create cascading impacts, with "the destruction of the hydropower station cut off electricity, further straining the community's ability to recover". Urban water systems face particular vulnerabilities during extreme weather events, with flooding contaminating water supplies while simultaneously disrupting distribution infrastructure. Heat wave risks represent an emerging urban climate threat that interacts with urbanization patterns, population density, and infrastructure design to create compound vulnerabilities. Pakistan's cities face increasing exposure to extreme heat events, and the occurrence of temperatures exceeding human physiological limits has become more frequent and intense under climate change.[281] Urban heat island effects compound regional warming to create even more extreme conditions, while energy poverty (defined here as the lack of access to adequate, reliable, affordable, and sustainable modern energy services) limits access to cooling systems that could provide protection during heat waves. Informal settlement patterns that characterize much of Pakistan's urban growth create particular vulnerabilities for low-income populations who lack access to climate-resilient housing, water and sanitation services, and disaster preparedness resources. The consultation emphasized that these settlements often locate "in unsafe locations such as riverbanks" that face direct exposure to flooding while lacking the infrastructure needed to manage flood risks. The concentration of vulnerable populations in high-risk areas creates potential for catastrophic impacts when extreme weather events affect urban areas. These challenges for urban governance, and inadequate coordination across sectors and levels of government, compound climate vulnerabilities. The consultation noted "lack of coordination among government institutions, private sector stakeholders, and community organizations has hindered the development of effective solutions". Effective climate adaptation for urban areas requires integration across multiple sectors, including water supply, energy, transportation, housing, and emergency management, but institutional fragmentation limits the development of coordinated responses.

280 UNDP (forthcoming, 2026). Building Resilient Futures Through Climate Mobility Insights in Asia-Pacific.

281 Khan, M. R., Abubakar, M., Tahir, A., Dilawar, M. W., Hassan, H. M. A., Ahmad, S. R., ... & Chand, M. U. (2024). Escalating global threat of heatwaves and policy options for adaptation and mitigation. *Journal of Asian Development Studies, 13*(3), 980-995.

6.4.7 INSTITUTIONAL RESILIENCE AND GOVERNANCE CHALLENGES UNDER CLIMATE STRESS

Governance is fundamental to human security under climate stress, with the consultation findings revealing both significant institutional innovations and persistent governance challenges that limit effective climate responses in Pakistan. The country has developed substantial institutional capacity for climate action, including the National Adaptation Plan (NAP) 2023,[282] the GLOF-II Project, and various climate finance initiatives, but consultation participants emphasized that "institutions may possess some level of capacity" while highlighting "considerable room for improvement in their readiness to address climate change effectively". The consultation revealed fundamental challenges in institutional coordination, noting that "there is no coordination among government departments, and no integrated policy to address this challenge" while emphasizing that "climate change is a multifaceted, multi-sectoral issue" requiring "multi-sectoral and integrated approach[es]". This coordination challenge reflects broader governance patterns where sectoral approaches dominate policy making while climate impacts require system-wide responses that span multiple departments, levels of government, and time scales.

Data, evidence and capacities for their correlation represent critical gaps that limit effective climate planning and response. Consultation participants emphasized that "one of the most pressing issues is the absence of data-driven policies and initiatives" while noting that "without solid, accurate, and timely data, institutions are essentially operating without a clear direction". Information systems are identified in the analytical framework as essential infrastructure for adaptive governance and effective responses to changing conditions and emerging risks. Traditional governance institutions face particular challenges under climate stress, with consultation findings revealing how conflict and social change have weakened customary institutions precisely when climate adaptation requires strong capacity for collective action. The consultation noted that "thousands of community elders were assassinated" during insurgency periods in conflict-affected areas such as Swat, Lower Dir, Upper Dir, and former tribal areas, leading to "the erosion of peace-building mechanisms" that historically managed resource conflicts and coordinated community responses to environmental challenges. In the absence of functional customary institutions, insurgent groups exploited the governance vacuum by offering coercive, swift justice, further undermining indigenous dispute resolution systems that had managed water rights, grazing conflicts, and land disputes for generations. However, across much of Pakistan's mountain regions, including Gilgit-Baltistan, Hunza, and Upper Chitral, informal governance systems remain functionally active and continue performing critical mediation work. Community elders, tribal leaders, and particularly religious leaders (Imams) maintain authority over community relations and resource management, regularly mediating disputes over water distribution (especially between upper and lower-terrain farmers), grazing rights, and infrastructure conflicts. The roundtable participants emphasized that "customary dispute resolution mechanisms…remain relevant, especially in addressing environmental and climate-related disputes," and noted that informal mediation by community leaders has successfully brokered compromises in environmental disputes, including in cases where road expansion projects balanced development needs against community environmental concerns.

In recognition of this functional capacity in operational regions, the government has begun formalizing alternative dispute resolution (ADR) mechanisms. Consultation participants also noted innovations in dispute resolution, including "mediation centres have been established at the high court level and are expected to extend to district courts in the future." Recognizing these distinctions is critical for the design of adaptation strategies. In areas severely affected by conflict, such as Swat and former tribal agencies, adaptation requires institutional reconstruction alongside state-building and reconciliation efforts, addressing the capacity vacuum left by institutional collapse. In functionally-intact mountain regions like Gilgit-Baltistan and Hunza, adaptation strategies can leverage existing customary authority networks by providing training to community leaders and religious figures on climate-informed resource management, water allocation during scarcity, livelihood diversification, and disaster preparedness, and so building on institutions that already command community trust and maintain dispute resolution capacity. The implication is that climate adaptation cannot be separated

282 Government of Pakistan, Ministry of Climate Change & Environmental Coordination. (2023). *National Adaptation Plan Pakistan 2023*. https://ndrmf.pk/wp-content/uploads/2024/06/National-Adaptation-Plan-Pakistan-2023.pdf

from governance recovery where institutions have been destroyed but that there are regions where traditional mediation systems, though weakened, continue functioning. This distinction determines whether adaptation requires reconstruction or strengthening of existing frameworks"

Early warning systems and disaster preparedness represent critical institutional functions that require integration across multiple levels and sectors to be effective under climate change conditions. The consultation emphasized that "early warning systems should be a priority, especially in flood-prone areas, as they are a primary line of defence", with consultants noting that "floods can take days to travel from upper regions to downstream communities," allowing time for protective action if warning systems function. However, significant challenges limit implementation and coverage. Consultation findings documented significant challenges including "digital divide in mountain regions" and language barriers that create "access asymmetry in disaster-related early warning and news dissemination". These technical barriers to access information intersect with complexities in governance arrangements: regions with distinct administrative arrangements face particular coordination challenges between central early warning agencies and decentralized operational structures, where institutional capacity for translation, community notification, and real-time alerts varies significantly. In Gilgit-Baltistan specifically, the GLOF-II Project has enhanced community-based flood early warning systems, with documented effectiveness in alerting communities – yet the roundtable noted that "while institutions may possess some level of capacity, there is considerable room for improvement in their readiness to address climate change effectively" and that "institutions are not yet working in a fully coordinated manner," with "the absence of data-driven policies and initiatives" limiting effective decision-making across levels. Effective early warning requires not only technical monitoring capacity but also communication systems that can reach all community members and the social institutions that can translate warnings into protective action. Climate finance and resource mobilization are critical challenges that limit Pakistan's ability to implement necessary adaptation and resilience measures, despite policy frameworks and international commitments. The consultation noted that Pakistan's "annual investment needs for a comprehensive response to the country's climate and development challenges are estimated to range from USD 30 billion to USD 60 billion by 2030"[283] with "adaptation and resilience comprising 45% of these investment needs". However, accessing and effectively utilizing climate finance also requires institutional capacity for project development, implementation, and monitoring that exceeds current systems in many areas.

Effective institutional resilience requires innovation in governance arrangements that can address the scale, complexity, and urgency of climate challenges while building upon existing institutional foundations and social capital. The consultation findings revealed examples of institutional innovation, including "alternative dispute resolution methods, such as community-led mediation" and "community-based disaster risk management (CBDRM) programs" that combine traditional and modern governance approaches. ADR methods, particularly community-led mediation, represent a documented institutional innovation with demonstrated impact. Rather than relying solely on protracted court proceedings, mediation centres have been established at high court levels, with plans to extend to district courts, and community-based dispute resolution committees have been established at police station levels in some provinces. However, scaling these innovations requires policy environments that support institutional experimentation and adaptation. First, effective ADR requires targeted capacity-building for mediators, as not all officials trained in traditional conflict resolution possess competencies specific to climate-related disputes, which often involve technical aspects (e.g. water allocation during scarcity, land use under changing soil conditions) alongside social negotiation. Second, tailoring responses to the context is critical: mediation worked in a case concerning road expansion because it involved a specific, bounded dispute between identifiable parties; in contrast, water distribution disputes affecting multiple communities across elevation gradients require different institutional structures with broader participation frameworks. Third, replication of ADR mechanisms from urban to rural areas must account for institutional capacity gaps, as establishing mediation centres in remote mountain districts requires investment in infrastructure, personnel training, and communication systems that have not been uniformly available.

283 Asian Development Bank. (n.d.). *58054-001 technical assistance special allocation: Thematic Assessment (Summary): Climate Change and Disaster Risk Management.* https://www.adb.org/sites/default/files/linked-documents/58054-001-tsa.pdf

CBDRM programs similarly demonstrate institutional innovation combining traditional and modern governance. In Gilgit-Baltistan, the GLOF-II Project has enhanced community-based flood early warning systems that integrate community caretakers (traditionally appointed by villages) with scientific monitoring equipment and formal alert protocols, creating hybrid governance that leverages both customary authority and technical capacity. Experience suggests that, traditionally, governance following disasters (where elders organize community response) functions at scales aligned with kinship or settlement patterns, typically 500-5000 people. Scaling CBDRM to regional levels requires that institutional bridges are made between community-level governance and district/provincial authorities, which are currently absent or weakly coordinated. Furthermore, the 2022 Reshun flood case study documented that CBDRM programs, while improving alert mechanisms, remain vulnerable when they lack gender-specific adaptation: women received less training in evacuation procedures, despite research showing they comprise disproportionate casualties in flood events. This suggests that proposed institutional innovations require analysis for intersectionality, as mechanisms designed for a "generic community response" will reproduce the existing vulnerabilities unless explicitly tailored to the needs of different population groups. Lastly, a critical constraint is governance readiness to action any or all of the above institutional innovations. The roundtable noted that "institutions possess some level of capacity, but there is considerable room for improvement," and specifically identified that "institutions are not yet working in a fully coordinated manner" and suffer from the "absence of data-driven policies," limiting the ability to implement even proven institutional models. This suggests that institutional innovation cannot succeed through design alone, and effective replication requires simultaneous investment in data systems, inter-institutional coordination mechanisms, and capacity development.

6.4.8 REGIONAL COOPERATION AND TRANSBOUNDARY DIMENSIONS UNDER POLITICAL CONSTRAINTS

Pakistan's position within major transboundary river basins and migration systems creates interdependencies where climate adaptation requires regional cooperation while political tensions and sovereignty concerns limit the development of coordinated responses to shared climate challenges. The consultation findings emphasized that "regional cooperation is critical for managing transboundary risks" while noting that "practical models should align national plans and policies for collective action." However, the consultation also revealed the complexity of transboundary cooperation under conditions of political tension and competing national interests.

Water resource management represents the most critical area for transboundary cooperation, with the Indus River system originating in and flowing through multiple countries where climate change is altering flow patterns, seasonal timing, and the frequency of extreme events. The Indus Waters Treaty, enacted 65 years ago, provides a framework for water sharing between India and Pakistan but "was designed before climate change had been recognized as an issue" and faces increasing stress from changing hydrological conditions and political tensions.[284] Recent conflicts have led India to suspend its obligations under the treaty, threatening "the long-term future of the treaty" precisely when climate change makes cooperative water management most essential for regional stability. The consultation noted specific transboundary tensions, including disputes over "sharing of Kabul River" where "the source of river is in Pakistan, but it flows to Afghanistan before it reenters Pakistan," illustrating how climate impacts on shared water resources can create or exacerbate political tensions between neighbouring countries. However, the consultation also identified opportunities for cooperation, noting that "successful collaboration between countries on water resources could shift from being a technical challenge to a peace-building opportunity, fostering broader regional cooperation."

Climate-induced migration creates additional transboundary dimensions where population movement across borders requires coordinated policy responses that address both humanitarian needs and regional security concerns. Pakistan's position as both origin and destination for climate-related migration creates opportunities for developing innovative approaches to mobility governance, but political tensions with neighbouring countries may limit cooperation on migration management despite shared interests in addressing climate displacement. Disaster risk reduction represents an area where regional cooperation has shown some success and could

284 https://climate-diplomacy.org/case-studies/water-conflict-and-cooperation-between-india-and-pakistan

provide models for expanded cooperation on aspects of climate adaptation. The consultation noted examples of regional cooperation on disaster preparedness and response, including early warning systems that operate across borders and coordinated emergency response protocols. The framework suggests that building upon existing cooperation mechanisms while developing new institutional arrangements, could address shared climate challenges through coordinated planning, resource sharing, and joint implementation of adaptation measures. The consultation emphasized that effective transboundary cooperation requires that both technical challenges and political constraints are addressed through approaches that build trust while delivering concrete benefits to all parties. Examples of successful cooperation include technical collaboration on shared environmental challenges, humanitarian cooperation on climate-related disasters, and economic cooperation on renewable energy development that could provide the foundations for broader regional frameworks for cooperation on climate. However, realizing this potential requires political will and institutional innovation that can operate despite current constraints.

6.4.9 ECONOMIC TRANSFORMATION AND LIVELIHOOD ADAPTATION UNDER CLIMATE STRESS

The impacts of climate change interact with economic systems to create both constraints and opportunities for transformation that could enhance resilience while supporting development objectives. Pakistan's economy faces particular vulnerability to climate change due to the country's high dependence on climate-sensitive sectors including agriculture (24% of GDP),[285] water-intensive industries, and hydropower generation (7,320 MW capacity)[286] that are all directly affected by changing temperature and precipitation patterns. The consultation findings revealed the economic dimensions of climate impacts through specific case studies, noting that single events can create massive economic losses, with the Reshun Village flash flood causing "an estimated USD 20 million in economic losses" through destruction of agricultural land, livestock, and infrastructure. The 2022 floods created national economic losses of USD 30-40 billion while pushing "nine million people into poverty" and causing "a 4-percentage point increase in the national poverty rate," demonstrating how climate disasters can reverse development gains and increase economic vulnerability.[287]

Traditional economic systems based on agriculture and natural resource extraction face unprecedented challenges under climate change, with consultation participants noting that "traditional farm-based livelihoods are declining" while climate hazards create "risks such as glacier lake outburst floods (GLOFs) that threaten mountain livelihoods". However, the consultation also revealed significant adaptation occurring at household and community levels, with examples including "fruit trees" cultivation replacing traditional crops that are "no longer viable" and communities developing "water-efficient irrigation technologies" and "drought-resistant crop varieties" that help maintain agricultural productivity under changing conditions. Livelihood diversification represents a critical economic adaptation strategy that requires supportive policy environments and institutional capacity to be effective at scale. The consultation noted examples of successful diversification including "local fruit processing and market linkages" and "preserving indigenous medicinal knowledge" that can "create sustainable economic opportunities". However, participants also emphasized constraints on diversification, including limited market access, inadequate technical support, and social barriers that prevent some populations from accessing new economic opportunities. Renewable energy development represents a significant economic opportunity that could simultaneously enhance energy security, reduce climate vulnerability, and create new employment opportunities. Pakistan has achieved substantial growth in renewable energy capacity, reaching over 5,100 MW of installed capacity,[288] but consultation participants noted that realizing the full potential for renewable energy requires institutional, financial, and technical barriers to be addressed. The consultation noted particular

285 Syed, A., Raza, T., Bhatti, T. T., & Eash, N. S. (2022). Climate Impacts on the agricultural sector of Pakistan: Risks and solutions. *Environmental Challenges, 6,* 100433.

286 Sheikh, A. I., & Inayat (2023, September 13). *Hydropower generation in Pakistan, province Punjab*. Paper presented at the International Water Resources Association Congress, Beijing, China. https://iwra.org/proceedings/congress/resource/IWRA2023_Beijing_China_20230913_SE11_ORAL_5_Abid_Inayat_Sheikh_HYDROPOWER_GENERATION_IN__PAKISTAN_PROVINCE_PUNJAB.pdf

287 Knippenberg, E., Amadio, M. & Meyer, M. Poverty Impacts of the Pakistan Flood 2022. *EconDisCliCha 8*, 453–471 (2024). https://doi.org/10.1007/s41885-024-00155-3

288 https://www.weforum.org/stories/2025/08/pakistan-energy-affordable-reliable-electricity/

potential for “micro-hydropower projects that could improve irrigation systems, promote the construction of climate resilient infrastructure, protect land and people from recurrent flooding and improve access to electricity as alternative to wood for cooking and heating during winter months.”

Women’s economic participation is currently constrained but represents an opportunity for economic transformation under climate stress. The consultation findings emphasized that women face barriers to accessing economic opportunities, including limited access to credit, restricted mobility, and exclusion from decision-making processes, while simultaneously noting that “women SHGs can emerge as water entrepreneurs” when supported through appropriate policies and financing mechanisms. Addressing these barriers could simultaneously enhance gender equity and increase overall community adaptive capacity. The consultation revealed the importance of addressing economic stress factors that may drive communities toward unsustainable livelihood strategies under climate pressure. Participants noted that economic constraints can force communities to engage in environmentally destructive practices, including unsustainable resource extraction, while debt burdens from repeated climate disasters can trap households in cycles of vulnerability that limit their ability to invest in adaptation measures.

6.4.10 POLICY INTEGRATION AND SYSTEMIC TRANSFORMATION REQUIREMENTS

Pakistan’s experience demonstrates the urgent need for transformation from sectoral approaches toward integrated system-wide responses that can address the compound nature of climate impacts while building adaptive capacity across multiple scales and sectors simultaneously. The consultation findings emphasized that addressing climate challenges requires “governance and policy interventions that go beyond siloed approaches” while advocating for “interdisciplinary frameworks to analyse nexus elements within socio-ecological systems”. The framework’s emphasis on threshold analysis proves particularly relevant for policy prioritization in Pakistan’s context, enabling identification of approaching tipping points where proactive intervention can prevent system collapse at much lower cost than post-crisis reconstruction and humanitarian response. Priority areas for immediate intervention include water security systems approaching sustainability limits, agricultural systems facing unprecedented climate stress, and urban systems that lack the infrastructure needed to manage current climate risks, much less projected future conditions.

Climate finance represents a critical policy priority requiring innovative approaches that can operate despite political constraints while ensuring equitable access for the most vulnerable populations. The consultation noted that Pakistan’s climate finance needs of “USD 30 billion to USD 60 billion by 2030” far exceed current international commitments and national resources. New approaches are required for climate finance that can leverage private investment while ensuring that adaptation benefits reach vulnerable communities. However, accessing climate finance requires institutional capacity for project development, implementation, and monitoring that may exceed current systems in many areas. Gender-responsive programming represents an essential policy priority that must address structural barriers to women’s participation in climate adaptation while building upon women’s knowledge, skills, and leadership capabilities. The consultation findings revealed constraints to women’s participation, including limited mobility and decision-making authority, and opportunities, including potential leadership roles in water management and sustainable agriculture.

Effective gender-responsive climate policy requires these structural constraints are addressed while creating supportive environments for women’s climate leadership. Institutional coordination represents a fundamental policy challenge, and requires new governance arrangements that can integrate across sectors, levels of government, and time scales while maintaining democratic accountability and local participation. The consultation emphasized the need for “blended governance models” that combine traditional and modern governance approaches while noting that “institutions are not yet working in a fully coordinated manner, which is essential for tackling climate change in a meaningful way”. The consultation findings emphasized that effective policy integration requires understanding of local contexts and building upon existing knowledge and institutional foundations rather than imposing external solutions. Participants noted that “localized solutions and indigenous practices” provide crucial foundations for climate adaptation but emphasized that “while communities have their

own way of adapting to the changing climate" these local approaches require supportive policy environments and resource allocation to be effective at scale.

Most critically, Pakistan's experience demonstrates that human security under climate stress requires unprecedented forms of integration across sectors, scales, and time frames that exceed traditional governance approaches, while building upon existing institutional foundations, social capital, and cultural knowledge systems. The country's substantial human and institutional resources provide opportunities for innovation that could benefit not only Pakistan's own adaptation needs but also contribute to regional and global efforts to build human security under accelerating climate stress. However, realizing this potential requires addressing fundamental governance challenges including sectoral coordination, multi-level planning, resource allocation, the building of authority and capacity at decentralized levels of governance, and inclusive participation that ensure adaptation benefits reach the most vulnerable populations who face the greatest climate risks while having the least access to adaptation resources.

7. Regional Perspective: Cooperation Imperatives and Frameworks

Tunnel Farming. Photo: UNDP Nepal

The transboundary nature of climate impacts in the Hindu Kush Himalaya creates imperatives for regional cooperation that transcend traditional approaches to international relations and development assistance. The impacts of climate change ramify through biophysical systems including watersheds, atmospheric circulation patterns, and ecosystem networks that cross political boundaries without regard for national sovereignty or diplomatic relations. The effective management of climate risks therefore requires coordination mechanisms that can address shared environmental challenges while respecting national interests and institutional constraints. Regional cooperation imperatives in the Hindu Kush Himalaya are particularly urgent due to the interconnected nature of water systems, the transboundary effects of extreme weather events, and the potential for climate-induced migration and conflict to destabilize entire regions.

Regional cooperation in the HKH represents not merely developmental coordination but a strategic imperative for maintaining human wellbeing and institutional stability under accelerating climate stress. The transboundary nature of water systems, migration flows, and disaster risks means that unilateral national responses prove insufficient for addressing challenges that routinely cross political boundaries through shared hydrological connections and population movements. Climate-induced resource competition, particularly around water allocation in glacier-fed river basins, creates conditions where cooperative frameworks could either prevent escalating tensions or allow localized stresses to propagate into wider institutional breakdowns affecting multiple countries simultaneously. The urgency for regional cooperation is that the region is approaching environmental thresholds (irreversible glacial retreat, aquifer depletion, agricultural system collapse) which compress the timeframe within which coordinated action can prevent cascading disruptions across national boundaries. This chapter examines how existing cooperation frameworks can be strengthened and new mechanisms developed to address the distinctive challenges climate change poses for regional human security outcomes.

Water resource management represents the most immediate and tangible area for regional cooperation as the major river systems of the Hindu Kush Himalaya cross multiple national boundaries and support the livelihoods of nearly two billion people. The glacier and snow-fed Ganges, Indus, Brahmaputra and other major rivers originate in mountain areas that are experiencing rapid changes due to climate warming. These changes affect the timing and magnitude of river flows in ways that create both opportunities and challenges for downstream water users across multiple countries. Effective regional water management requires coordinated approaches to dam operation, flood management, drought response, and ecosystem conservation that can optimize benefits while minimizing negative transboundary impacts. Existing water cooperation frameworks including the (now suspended) Indus Waters Treaty between India and Pakistan, provide precedents for transboundary water management, but these agreements were negotiated under historical climate conditions that may no longer be representative of future hydrological regimes. Climate change introduces new sources of uncertainty and variability that may require adaptive management approaches and flexible institutional arrangements that can respond to changing conditions. The development of climate-informed, water cooperation frameworks requires technical cooperation on hydrological monitoring, climate impact assessment, and water management modelling that can support evidence-based decision making across national boundaries.

Transboundary water governance in the HKH region extends beyond the technical allocation of water to encompass the foundational dimensions of institutional relationships and human security outcomes across the region. The dependence on shared glacier-fed river systems of downstream populations in multiple countries, creates inherent interdependence. Upstream climate-driven changes in glacier retreat, monsoon timing, and extreme precipitation patterns directly determine downstream water availability affecting agriculture, hydropower generation, and domestic water security for billions of people. Institutional frameworks that enable transparent information-sharing, coordinated adaptation planning, and equitable benefit allocation, whether through formalized water-sharing agreements, joint commission mechanisms, or regular expert consultation, demonstrate how technical cooperation can reinforce mutual understanding and reduce misperceptions during periods of resource stress. Conversely, where institutional mechanisms for coordinated water management are absent or weakened, climate-induced water variability creates conditions where unilateral actions in one basin can trigger cascading effects across borders, potentially undermining confidence in multilateral cooperation at broader scales.

Disaster risk management cooperation is increasingly critical as extreme weather events become more frequent and severe throughout the region. Major disasters, including floods, landslides, and glacial lake outburst floods, regularly affect several countries simultaneously or trigger cascading impacts that cross borders through transportation networks, supply chains, and population movements. Effective disaster risk management requires coordinated early warning systems, joint emergency response capabilities, and shared approaches to disaster risk reduction that can address hazards at appropriate scales. The development of regional early warning systems requires technical cooperation on meteorological and hydrological monitoring, data sharing protocols, and communication systems that can provide timely information to vulnerable populations across national boundaries. Joint emergency response capabilities could include shared expertise, equipment, and resources that can be rapidly deployed to support disaster response in any affected country. Regional approaches to disaster risk reduction might encompass coordinated land use planning, infrastructure standards, and ecosystem management practices that reduce vulnerability to transboundary hazards.

Climate-induced migration creates both a humanitarian challenge and a security concern, that requires regional cooperation to be addressed effectively. Large-scale displacement due to environmental changes can overwhelm the capacity of individual countries to provide adequate assistance and protection to displaced populations, while creating potential sources of tension between origin and destination areas. Regional cooperation on climate migration could include coordinated policies for managing cross-border movements, shared approaches to integration and protection of climate migrants, and collaborative efforts to address the root causes of climate-induced displacement. The development of regional migration frameworks requires balancing humanitarian concerns about displaced populations with legitimate security and economic concerns about rapid population movements. Such frameworks might include regional agreements on temporary protection for climate migrants, coordinated labour mobility programs that can provide legal pathways for climate-induced migration, and cooperative programs for addressing climate vulnerabilities in origin areas to reduce displacement pressures.

Scientific and technical cooperation provides essential foundations for effective regional climate responses through shared research programs, data sharing initiatives, and technology transfer mechanisms. The complex mountain environments of the Hindu Kush Himalaya require sophisticated monitoring and analysis capabilities that may exceed the resources of individual countries, while the transboundary nature of climate impacts means that effective understanding requires regional-scale research and monitoring programs. Regional research cooperation could encompass coordinated climate monitoring networks, joint research programs on climate impacts and adaptation strategies, and shared facilities for climate modelling and impact assessment. Technology transfer mechanisms might include programs for sharing climate adaptation technologies, joint development of climate-resilient infrastructure systems, and collaborative training programs for climate professionals and practitioners. Economic cooperation frameworks could support regional climate responses through coordinated investment programs, shared financing mechanisms, and integrated approaches to sustainable development that address climate change as a regional challenge rather than a collection of national problems. Regional climate finance initiatives might include shared adaptation funds, coordinated approaches to accessing international climate finance, and joint investment programs in climate-resilient infrastructure and economic systems. The development of effective economic cooperation requires addressing the political and institutional barriers that have historically limited regional integration in South Asia. Such barriers include security concerns, trade disputes, and institutional mistrust that may be exacerbated by climate stress conditions. Overcoming these barriers may require innovative institutional arrangements that can address climate cooperation as a distinct domain that transcends broader political tensions, while building trust and cooperation that can eventually extend to other areas of regional relations.

Institutional frameworks for regional climate cooperation must balance the need for coordination and integration with respect for national sovereignty and diverse political systems. Such frameworks might include formal treaty arrangements that establish binding commitments for specific areas of cooperation, informal coordination mechanisms that can facilitate information sharing and joint planning without requiring formal agreements, and multi-stakeholder platforms that can include non-governmental organizations, private sector actors, and civil society groups in regional climate responses. Such partnership approaches may be more feasible than formal treaty arrangements in contexts where political tensions limit government-to-government cooperation, while providing platforms for building the technical relationships and shared understanding that may eventually support more formal cooperation agreements.

8. Policy Recommendations and Strategic Entry Points

Panjshir valley, Afghanistan
Photo: Alex Treadway/ ICIMOD

The transformation of human security policy frameworks to address climate stress conditions in the Hindu Kush Himalaya requires fundamental shifts from reactive crisis management to proactive system transformation that addresses the root causes of vulnerability while building adaptive capacity for uncertain futures. The country analyses of India and Pakistan, and the regional consultation findings, reveal that effective climate adaptation in the HKH region demands policy approaches that transcend traditional sectoral boundaries and address the interconnected nature of FWE systems, livelihood security, systemic resilience, and human mobility. Policy recommendations must operate across multiple scales from local community-level interventions to regional governance mechanisms, with particular attention to the coordination challenges that arise when climate impacts cross sectoral, jurisdictional, and temporal boundaries.

The manner in which countries articulate climate risks in their policy frameworks, particularly Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs), reflects how different contexts frame and regulate the relationship between climate change and human security. Notably, countries across the region have begun recognizing these interconnections explicitly in their national climate commitments, though with different strategic emphases. Pakistan's NDC and NAP documents explicitly link climate risks to peace and security, recognizing that water scarcity, agricultural disruption, and resource competition threaten social stability and can exacerbate existing tensions, particularly in conflict-affected regions. This framing prioritizes climate adaptation as a stabilization mechanism within broader security governance. Nepal's policy framework similarly connects climate to human security, but frames adaptation through the lens of post-conflict recovery and livelihood security, emphasizing food and water access as foundations for social cohesion and economic reintegration in conflict-affected communities. Afghanistan's national climate policies approach the nexus from a stabilization perspective, targeting climate resilience for water and food security as mechanisms for reducing community grievances and resource-driven conflict that threaten state capacity and fragile peace gains. In contrast, India's national climate frameworks emphasize development and ecological stability rather than explicitly addressing human security; India's NDC prioritizes energy transitions, ecological restoration, and agricultural productivity without framing these outcomes explicitly as human security measures, reflecting its position as both a significant emissions actor and a developing economy with ongoing energy and food security deficits, where reframing development outcomes as 'security' risks undermining equity-based climate negotiations. This variation in policy framing, from Pakistan and Nepal's explicit security-climate linkage, through Afghanistan's stabilization lens, to India's development-focused approach, demonstrates that national governments recognize climate impacts extend beyond environmental concerns to social stability, though the conceptual frame through which they articulate this connection varies substantially based on each nation's geopolitical context and security challenges. The framework advanced in this report validates this policy-level recognition while providing analytical specificity on how climate impacts cascade through institutional, livelihood, and migration systems to undermine human security outcomes.

Strategic entry points for policy transformation should prioritize interventions that can generate immediate benefits while contributing to long-term system resilience. While addressing urgent humanitarian needs it must be recognized that climate adaptation requires sustained commitment over decades. The consultation findings from Pakistan emphasized that "climate change is a multifaceted, multi-sectoral issue" requiring "multi-sectoral and integrated approach" that goes beyond traditional "siloed approaches". Similarly, the India consultation stressed the need for "blended governance models" and noted that "there is no coordination among government departments, and no integrated policy to address this challenge". These insights, validated through extensive stakeholder engagement, provide the foundation for policy recommendations that are both technically sound and politically feasible within the complex governance environments of the HKH region. The framework's four-pillar approach provides a systematic basis for identifying policy leverage points where strategic interventions can create cascading positive effects across multiple systems. Each pillar represents both a domain of vulnerability and an entry point for transformation, with policy recommendations designed to strengthen the interdependencies that create systemic resilience rather than addressing isolated problems. The consultation findings consistently emphasized that successful policy interventions must recognize the intersectional nature of climate vulnerabilities, with participants noting that "interlinked climate risks are further affected by the intersectionality of various identities of mountain communities."

Most importantly, the transformation of human security in the Hindu Kush Himalaya region requires moving beyond the sectoral fragmentation that currently characterizes institutional responses to climate change. While numerous discrete actions, such as early warning systems for flood hazards, agricultural extension programs promoting climate-smart cropping practices, crop adaptation initiatives introducing climate-resilient varieties, and disaster resilience building through community-based disaster risk management, are underway across the region, these interventions largely operate in isolation from one another, preventing the development of systemic resilience that emerges when interconnected actions reinforce each other. In this regard, the primary purpose of this integrated framework is to equip policymakers with the analytical tools to recognize and operationalize these hidden synergies. When early warning systems integrate data from water and agriculture sectors, they create comprehensive risk assessment capabilities exceeding any single-sector system. When agricultural extension programs align with water security initiatives and energy planning, they enable livelihood transformations that build household adaptive capacity across multiple dimensions simultaneously. When disaster resilience-building efforts incorporate gender-responsive approaches and build upon existing institutional foundations, they strengthen the social cohesion and community trust that sustains collective adaptation through repeated climate shocks. The framework seeks to identify that these discrete actions, when driven through an integrated lens, generate positive feedback loops where investments in one domain create enabling conditions for success in others, multiplying the resilience benefits of equivalent resource investments across disconnected interventions.

Policymakers must therefore shift from sectoral planning approaches toward macro-level resilience targets, clarifying the overarching objectives that discrete actions at a micro-level should collectively advance. Building human resilience under climate stress requires identifying the specific outcomes, measured through Food-Water-Energy security, livelihood diversification, migration management, and systemic threshold indicators, that should guide resource allocation and policy design across sectors and governance levels. Rather than planning sectoral strategies independently and subsequently seeking coordination mechanisms, policymakers should reverse this approach by establishing integrated resilience targets first, then identifying which discrete actions contribute to these targets and how their coordination can enhance overall effectiveness. This approach recognizes that individual interventions possess limited impact when they address isolated problems within complex socio-ecological systems but can generate exponential resilience gains when designed as complementary elements of an integrated adaptation architecture. For example, basin-level resource councils coordinating water allocation, hydropower development, and agricultural planning create institutional arrangements enabling this integration. Early warning systems expanded to encompass multi-hazard threats rather than single-sector risks multiply their value for household and community decision-making. Livelihood diversification programs designed explicitly to support migration transitions, rather than prevent them, become components of comprehensive mobility governance. Each discrete action thus becomes a building block contributing to larger systemic transformation rather than an isolated project.

Operationalizing this integrated approach requires moving from conventional project-based implementation toward a building block methodology where individual interventions are systematically designed to generate learning, catalyse subsequent actions, and strengthen institutional capacity at each stage of scaling. Initial interventions should focus on establishing integrated climate risk monitoring capabilities and coordination mechanisms that enable subsequent sectoral investments to operate synergistically rather than in parallel. Foundation-level investments in basin-level councils, multi-sectoral coordination platforms, and data systems that track Food-Water-Energy interconnections and human migration patterns create the institutional infrastructure enabling more ambitious integrated initiatives. Pilot programs should be deliberately designed to demonstrate both the technical feasibility and the organizational mechanisms required for integrated implementation at scale, generating evidence and political support for larger investments. As pilot initiatives demonstrate success, scaling strategies should emphasize vertical integration, incorporating successful local approaches into higher-level policy frameworks, alongside horizontal replication, ensuring that local innovations are recognized and resourced as components of comprehensive adaptation strategies rather than isolated community initiatives. This building block approach acknowledges that effective systemic transformation requires sustained commitment across multiple implementation phases, with each phase creating conditions enabling subsequent advances.

Bangladesh represents one of the most substantive attempts at integrated macro-level resilience targeting in a Least Developed Country (LDC) context, though its experience illustrates both progress and ongoing challenges. Established in 2009, the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) represents a comprehensive six-pillar approach addressing food security, disaster management, infrastructure, research, mitigation, and institutional development. The strategy explicitly attempts to move beyond sectoral planning toward integrated objectives. The government established the Bangladesh Climate Change Trust Fund (BCCTF) in 2009 to support BCCSAP implementation, allocating approximately 6-7 percent of annual budget (approximately USD 1 billion annually) to climate adaptation, among the highest adaptation finance commitments by any LDC. Bangladesh established an inter-ministerial coordination structure that brings together representatives from different sectoral ministries under unified climate objectives. This coordination mechanism represents institutional infrastructure designed to overcome sectoral fragmentation.

More recent planning integrates long-term water resource management with agricultural development and urban planning, explicitly recognizing Food-Water-Energy interconnections across a century-long planning horizon. Despite these institutional frameworks, implementation challenges persist. Research on Bangladesh's experience indicates that while policy frameworks are comprehensive, coordination between implementing agencies remains incomplete, sectoral agencies continue to operate with significant autonomy, and integration at sub-national levels remains limited. The presence of coordinating institutions does not automatically overcome the sectoral interests embedded in ministry structures and budgeting processes.

8.1 Institutional Transformation for Integrated Risk Management

The development of threshold-based risk management institutions represents the most critical policy priority for climate adaptation in the Hindu Kush Himalaya region, building upon consultation findings that consistently identified institutional coordination as the primary barrier to effective climate action. Current institutional arrangements typically operate through sectoral mandates that address water, agriculture, energy, and migration issues through separate agencies with limited coordination mechanisms, creating what the Pakistan consultation characterized as institutional "silos" where "institutions are not yet working in a fully coordinated manner, which is essential for tackling climate change in a meaningful way". The human security framework demonstrates that climate change creates conditions where impacts propagate rapidly across sectors, rendering sectoral approaches inadequate for managing system-wide risks. The India consultation revealed this challenge through specific examples, noting that the "water mills of Uttarakhand that play a central role in local agri-based livelihoods are not running due to change in water flow" while "proven solutions based on distributed renewable energy for local processing, as well as early learning systems, are not getting scaled up". These cases illustrate how climate impacts on one system cascade through interconnected livelihood and energy systems, exceeding the capacity of single-sector institutions to provide effective responses. Effective climate adaptation requires institutional arrangements that can monitor cross-sectoral threshold indicators, coordinate response measures across multiple agencies, and implement interventions at appropriate scales and timing. The consultation findings revealed that successful institutional integration requires addressing both technical and political challenges, with participants emphasizing that "capacity for designing solutions at local level needs to be created but this can be constrained because of remoteness". However, they also noted positive examples where "landscape approach by GIZ" created conditions where "community institutions are ensuring that there is strong collective action."

Institutional transformation should begin with the establishment of integrated climate risk assessment capabilities that can monitor the Food-Water-Energy nexus indicators, livelihood security measures, and migration patterns that provide early warning of approaching system thresholds. Such assessment capabilities require technical infrastructure for data collection and analysis, institutional mechanisms for synthesizing information across sectors, and decision-making processes that can translate risk assessments into coordinated policy responses. The Pakistan consultation emphasized that "one of the most pressing issues is the absence of data-driven policies and initiatives" and that "without solid, accurate, and timely data, institutions are essentially operating without a clear direction". The development of these capabilities requires significant investments in monitoring infrastructure, analytical capacity, and institutional coordination mechanisms, but such investments are essential for moving from reactive to proactive climate risk management. The consultation findings revealed that effective monitoring systems must address the "digital divide in mountain regions" and ensure that early warning systems can overcome language barriers and "[the] asymmetry [in access] to disaster related early warning and dissemination [of] news."

Technical solutions alone are insufficient; institutional transformation requires building participatory monitoring systems that integrate community-based observation with scientific monitoring to create comprehensive risk assessment capabilities, while simultaneously developing institutional agility to enable rapid decision-making and implementation when climate emergencies require swift protective action. The consultation findings revealed that climate impacts, particularly GLOFs and flash floods, provide limited reaction time for protective responses, with early warning systems functioning effectively only when organizations can translate warning information into immediate protective action through pre-arranged protocols, rapid resource mobilization, and emergency response activation. Effective institutional agility requires establishing decision-making authority and clear chains of command that can operate rapidly during emergencies, pre-positioned resources and personnel capable of immediate deployment, trained and equipped emergency response teams operating at community and district levels, and regular simulation exercises that enable institutions to practice rapid response protocols before actual emergencies occur. Additionally, institutional agility requires building flexible coordination mechanisms that can operate across sectoral and jurisdictional boundaries during crises, supported by early coordination protocols that establish relationships and communication systems before emergencies occur, rather than attempting to coordinate for the first time during active disasters. The integration of participatory monitoring with agile decision-making and rapid implementation systems creates institutional capacity to convert early warning information into effective protective action that can save lives and reduce disaster impacts when communities have sufficient time between warning and impact.

Policy coordination mechanisms must address the reality that effective climate adaptation requires simultaneous interventions across multiple sectors and scales of governance. Watershed-scale coordination may be needed to address water resource management challenges that cross administrative boundaries, while regional coordination is essential for managing transboundary migration flows and extreme weather events. The India consultation noted that "systemic responses over water sharing" are essential, with particular need to improve "[the] capacity of local governments for negotiations." The framework analysis suggests that effective coordination requires the creation of new institutional arrangements that can operate across traditional sectoral and jurisdictional boundaries, while maintaining democratic accountability and local participation. The development of multi-scale coordination mechanisms requires institutional innovations that can maintain accountability and democratic oversight while enabling rapid response to emerging threats. The consultation findings revealed that successful coordination often requires combining formal institutional mechanisms with informal networks and traditional governance systems. The India consultation noted examples where "district action plans vs customary laws balance conservation with development," suggesting that effective coordination requires "blended governance models" that can integrate traditional and modern institutional approaches. Recent innovations in adaptive governance provide models for institutional transformation that can address the dynamic nature of climate risks. The Performance-Based Climate Resilience Grant mechanism[289] implemented in Bangladesh, Cambodia, Nepal, and other countries demonstrates how institutional arrangements can "strengthen their local planning and budgeting of climate change adaptation investments in a gender sensitive manner" while building direct

289 https://www.uncdf.org/local/performance-based-grants-for-climate-resilience

access to climate finance for local governments. These innovations suggest that institutional transformation requires creating flexible mechanisms that can adapt to changing conditions while maintaining core functions for risk management and service delivery.

8.2 Financial Architecture for Climate-Resilient Development

The mobilization of financial resources for climate adaptation in the Hindu Kush Himalaya requires innovative approaches that can address both the large scale of the needed investment and the limited fiscal capacity of national governments in the region., Consultation findings consistently identified access to climate finance as a major constraint for the implementation of adaptation measures. Pakistan's climate finance needs of "USD 30 billion to USD 60 billion by 2030" far exceed current national resources and international commitments, while consultation participants emphasized that "climate finance going for mitigation more than for adaptation, and, even for adaptation, access to finance is highly unequal for the poor because of institutions that have discriminating mechanisms". Climate adaptation investments encompass immediate needs for disaster risk reduction and emergency response capabilities, medium-term requirements for infrastructure adaptation and livelihood diversification, and long-term investments in system transformation that may take decades to fully implement. Traditional development financing approaches are inadequate for addressing the scale and urgency of climate adaptation needs, while also failing to address the risk characteristics that make climate adaptation investments unattractive to conventional financial institutions. The consultation findings revealed that "post-project sustainability of interventions" remains a critical challenge, while "access to finance is highly unequal for the poor" due to institutional barriers that limit financial inclusion.

Regional climate finance mechanisms could provide coordinated approaches to mobilizing resources for climate adaptation while addressing the transboundary nature of climate risks and opportunities. The Asia-Pacific region has demonstrated significant innovation in climate finance, with examples including Indonesia's green sukuk raising "over USD 10 billion" and Thailand raising "more than USD 800 million from Sustainability Linked Bond."[290] However, consultation participants noted that these innovations have not adequately reached mountain communities, where geographic isolation and institutional barriers limit access to formal financial services. Such mechanisms might include regional adaptation funds that can support coordinated investments across multiple countries, innovative financing instruments that can mobilize private sector resources for climate adaptation projects, and risk-sharing mechanisms that can make climate adaptation investments more attractive to financial institutions. The development of regional climate finance architecture requires that the political and institutional challenges that have historically limited regional financial cooperation are addressed, while building on existing initiatives, including multilateral development bank programs and international climate finance commitments. Cambodia's "Sub-National Climate Finance Fund" provides a model for creating dedicated financial mechanisms that can channel resources to local levels where adaptation investments are most needed.[291]

Local-level financing mechanisms are equally important for ensuring that climate adaptation investments reach vulnerable communities and support adaptation strategies at the grassroots. The consultation findings revealed both constraints and opportunities for local financial innovation, with participants noting that "with ease of access to credit for women SHGs, the positive aspect is that women SHGs can emerge as water entrepreneurs." However, they also emphasized that "access to finance is highly unequal for the poor because of institutions that have discriminating mechanisms." Microfinance institutions, community-based savings groups, and local government financing mechanisms may be better positioned than national or international institutions to support small-scale adaptation investments that are essential for building household and community resilience. However, local financial institutions may lack the technical capacity and risk management capabilities needed to support climate adaptation investments, the institutions first requiring capacity building and development support.

290 https://www.undp.org/asia-pacific/press-releases/asia-pacific-steps-momentum-climate-finance-resilience

291 https://www.uncdf.org/article/8968/asia-pacific-momentum-climate-finance-resilience

The consultation findings revealed examples of successful local financial innovation, including community-managed funds for natural resource management and local revolving loan funds for livelihood diversification. The integration of traditional and modern financial mechanisms represents a critical opportunity for expanding financial access while building upon existing social capital and institutional arrangements. The consultation participants noted examples where traditional institutions provide foundations for modern financial services but emphasized that successful integration requires addressing power imbalances and ensuring that financial innovations serve the needs of marginalized populations rather than exacerbating existing inequalities.

Digital financial technologies offer significant potential for expanding financial access in remote mountain areas while reducing transaction costs and improving transparency. The consultation findings noted challenges with the "digital divide in mountain regions" but also revealed examples where mobile money and digital platforms have improved financial inclusion. The framework suggests that digital financial innovations should be designed to complement rather than replace traditional financial arrangements, recognizing that technology alone cannot address structural barriers to financial inclusion. Risk-sharing mechanisms represent a critical component of climate finance architecture, enabling financial institutions to support adaptation investments despite the inherent uncertainties associated with climate change. Index-based insurance, weather derivatives, and catastrophe bonds can provide financial protection against climate risks while creating incentives for adaptation investments. However, the consultation findings revealed that these instruments remain inaccessible to most mountain communities due to high costs, complex procedures, and lack of local institutional capacity.

8.3 Technology Transfer and Development

The deployment of climate adaptation technologies throughout the Hindu Kush Himalaya requires innovation systems that can develop locally-appropriate solutions while accessing global knowledge and technology resources. Consultation findings consistently identified technology access and appropriateness as critical challenges for effective adaptation. The India consultation revealed both the potential and constraints of technology deployment, noting examples where "solar pumping at large scale can possibly lead to water crisis in future" due to "excess withdrawal of groundwater because of solar pumps," while also highlighting opportunities where "proven solutions based on distributed renewable energy for local processing as well as early learning are not getting scaled up". Climate adaptation technologies encompass both "hard" technologies including water storage systems, climate-resilient infrastructure, and renewable energy systems, as well as "soft" technologies, including early warning systems, climate information services, and adaptive management practices. The consultation findings revealed that effective technology deployment requires understanding the specific environmental and social conditions under which different technologies are appropriate, while building local capacity for technology operation and maintenance. The Pakistan consultation emphasized that "technology plays an important role in mitigating the impacts of climate change, particularly in agriculture-dependent economies" but noted that "communities still require sustained support to recover from climate-induced disasters". The framework analysis demonstrates that technology transfer is not simply a matter of moving equipment from developed to developing countries but requires building innovation systems that can adapt technologies to local conditions, while developing local capacity for innovation and improvement. The consultation findings revealed numerous examples where external technologies failed due to inadequate attention to local conditions and maintenance requirements, while successful technology adoption required extensive community engagement and capacity building support.

Regional mechanisms for technology cooperation could accelerate the deployment of adaptation technology through coordinated research and development programs, technology sharing initiatives, and joint procurement programs that can reduce costs and build regional technical capacity. The consultation participants noted examples of successful technology cooperation, including regional networks for sharing traditional knowledge and collaborative development of locally appropriate technologies. However, they also emphasized barriers to technology cooperation including intellectual property constraints, limited research capacity, and inadequate financing for technology development and deployment. Regional cooperation mechanisms might therefore include regional centres of excellence for specific adaptation technologies, coordinated research programs that can address region-specific adaptation challenges, and technology incubator programs that can support local innovation in climate adaptation solutions. The Adaptation at Altitude program's technology portal demonstrates how "systematic collection and analysis of information on implementation that is happening on the ground" can accelerate technology transfer by documenting "tried-and-tested adaptation solutions" and their effectiveness under different conditions. The SERVIR-HKH program, implemented by ICIMOD,[292] provides a model for regional technology cooperation that integrates satellite data, geospatial analysis, and local knowledge to "address critical challenges in climate change, food security, water and related disasters, land use, and air quality". This program demonstrates how technology cooperation can build regional capacity while addressing shared challenges, though consultation participants noted that such programs require sustained funding and institutional support to achieve their full potential.

Capacity building for technology adoption requires educational and training programs that can build local expertise in climate adaptation technologies while supporting innovation in locally appropriate solutions. The consultation findings revealed that successful capacity building requires that both technical and social dimensions are addressed, with particular attention to gender dynamics and power relationships that determine who has access to training opportunities and technology resources. The India consultation noted that "who gets access to trainings [is] often determined by who has the time and bandwidth [and] poor people and women [are] often excluded [as the] opportunity cost [is] much higher for daily wage workers". Such programs should encompass both formal educational institutions and informal learning networks that can transfer knowledge through farmer-to-farmer networks, community organizations, and professional associations. The consultation participants emphasized the importance of integrating traditional knowledge with modern technologies, noting examples where "indigenous knowledge, such as water conservation techniques and agricultural practices like traditional crop rotation, has always been climate-friendly and adaptable to changing conditions".

The development of regional capacity building networks could support knowledge sharing across national boundaries, while building the human resources needed for effective climate adaptation. However, the consultation findings revealed that successful capacity building requires addressing structural barriers including limited educational access, language barriers, and economic constraints that prevent participation in training programs. The framework suggests that effective capacity building must be designed to be inclusive and accessible, with particular attention to reaching marginalized populations who face the greatest climate risks but have the least access to capacity building resources. Indigenous innovation represents a critical component of technology systems that is often overlooked in conventional technology transfer approaches. The consultation findings revealed numerous examples of locally developed technologies and practices that provide effective climate adaptation while being culturally appropriate and financially accessible. The India consultation noted the "Ice Stupas of Ladakh" as "a nature-based solution with an integrated approach, but government recognition of this community initiative is absent". This example illustrates both the innovation potential within mountain communities and the institutional barriers that prevent recognition and scaling of indigenous innovations. The integration of indigenous and modern technologies requires institutional mechanisms that can document, validate, and scale local innovations while respecting intellectual property rights and cultural protocols. The consultation participants emphasized that successful integration requires addressing power imbalances between local communities and external technology providers, ensuring that local knowledge is valued and compensated appropriately rather than simply extracted for external use.

292 https://www.icimod.org/initiative/servir-hkh/

8.4 Social Protection and Human Mobility Governance

The development of comprehensive social protection systems that can address climate-induced vulnerabilities requires moving beyond traditional safety net approaches to create adaptive social protection that can respond flexibly to changing needs and circumstances. Consultation findings reported how climate change is transforming patterns of vulnerability and mobility across the HKH region. The Pakistan consultation emphasized that "climate-induced migration, both temporary and permanent, is expected to increase, with estimates suggesting nearly two million climate migrants within Pakistan by 2050," while noting that current social protection systems are inadequate for addressing the complex needs of climate-affected populations. Climate change creates new forms of vulnerability that may not be adequately addressed by existing social protection programs, while also increasing the variability and unpredictability of social protection needs. The consultation findings revealed that traditional social protection approaches often fail to address the intersectional nature of climate vulnerability, with participants emphasizing that "interlinked climate risks are further affected by the intersectionality of various identities of mountain communities" including gender, ethnicity, economic status, and geographic location.

Adaptive social protection systems must be able to scale up rapidly during climate emergencies while providing sustained support for gradual climate adaptation processes. The consultation participants noted examples of successful adaptive programming, including weather-indexed social protection systems that automatically trigger increased benefits during climate emergencies, and mobile transfer systems that can reach populations affected by displacement and mobility. The India consultation noted "One Nation One Ration" as "an example of social security for migrant labour," demonstrating how social protection innovations can address mobility-related vulnerabilities. However, participants also emphasized that social protection systems must address the underlying drivers of vulnerability rather than simply providing temporary relief, requiring their integration with broader development and adaptation strategies.

Appropriate governance of human mobility represents a particularly critical area for policy innovation as climate-induced migration increases throughout the region. The consultation findings revealed complex patterns of climate-related mobility, including both distress migration, due to livelihood failure, and strategic mobility, that enables household diversification and risk management. The Pakistan consultation noted that "migration patterns highlight inequities, as marginalized groups face discrimination and limited access to social services," while emphasizing that "migration can enhance resilience" when it occurs "through safe, regulated pathways". Existing legal and institutional frameworks for managing migration and displacement were not designed to address climate-induced mobility, creating protection gaps and institutional confusion about responsibilities and procedures. The consultation participants noted that most countries in the region lack comprehensive legal frameworks for addressing climate-induced displacement, while bilateral labour agreements often exclude the most vulnerable populations who engage in informal migration.

The development of comprehensive frameworks for the governance of human mobility requires athat both the rights and needs of climate migrants and the legitimate concerns of host communities about rapid population changes and resource competition are addressed. The consultation findings highlighted that successful mobility governance requires that the full migration cycle is addressed, from preventing forced displacement through supporting adaptation in origin areas, to facilitating safe migration pathways, to supporting integration and return migration processes. Regional frameworks for mobility governance could provide coordinated approaches for the management of climate-induced migration, and address the transboundary nature of climate displacement. The consultation participants noted examples of successful regional cooperation on labour mobility, including bilateral agreements that provide legal pathways for seasonal migration, and regional frameworks for mutual recognition of skills and qualifications. However, they also emphasized that existing regional cooperation mechanisms are inadequate for addressing the scale and complexity of climate-induced mobility. Future frameworks might include regional agreements on temporary protection for climate migrants, coordinated labour mobility programs that can provide legal pathways for climate-induced migration, and collaborative programs for addressing climate vulnerabilities in origin areas to reduce displacement pressures. The development of regional governance for mobility should be built on existing cooperative initiatives for migration while addressing the specific challenges posed by climate change. The consultation findings raised the important perspective that

successful mobility governance must address both the immediate humanitarian needs of displaced populations and the longer-term development challenges associated with large-scale population movements. This requires coordination between humanitarian, development, and migration governance systems that traditionally operate through separate institutional frameworks and funding mechanisms.

The governance of remittances represents a critical but often overlooked component of mobility governance that could significantly enhance the development outcomes from migration. The consultation participants noted that “remittances are rarely reinvested in climate adaptation or agriculture,” suggesting missed opportunities for linking migration benefits to origin area adaptation. Digital remittance systems that reduce transaction costs and provide incentives for investment in climate adaptation could significantly enhance the adaptive value of migration. The integration of mobility governance with broader climate adaptation planning represents an essential but challenging requirement for effective policy responses. The consultation findings suggested that migration is often treated as a failure of adaptation rather than a legitimate adaptation strategy, leading to policies that attempt to prevent migration rather than facilitate safe and beneficial mobility. Effective governance of human mobility therefore requires the recognition of migration as both a response to climate stress, and as a potential contributor to adaptation and resilience, when properly supported and managed.

8.5 Implementation Strategies and Sequencing

The implementation of comprehensive climate adaptation policies requires careful sequencing that can build institutional capacity and political support while addressing urgent needs and vulnerabilities. The consultations consistently emphasized the importance of building upon existing institutional foundations and social capital rather than creating entirely new systems. The Pakistan consultation noted that “localized solutions and indigenous practices” provide crucial foundations for climate adaptation, while emphasizing that “while communities have their own way of adapting to the changing climate” these local approaches require supportive policy environments and resource allocation to be effective at scale.

Initial policy interventions should focus on building the institutional foundations for integrated climate risk management, including monitoring systems, coordination mechanisms, and early warning capabilities that can support more comprehensive adaptation efforts. The consultation findings noted that effective implementation requires that both technical capacity constraints and political barriers that limit institutional coordination are addressed. The India consultation noted that “capacity for designing solutions at local level needs to be created but this can be constrained because of remoteness,” while emphasizing successful examples where the “landscape approach by GIZ” created conditions for “strong collective action”. These foundational investments may not provide immediate visible benefits but are essential for creating the institutional infrastructure needed for effective climate adaptation. The consultation participants emphasized that successful implementation requires building trust and demonstrating value through early wins that can build political support for larger investments. Framework analysis suggests that initial interventions should focus first on areas where coordination benefits are most visible and where institutional resistance is likely to be lowest.

Pilot programs and demonstration projects can provide opportunities for testing innovative approaches while building evidence and political support for scaled-up implementation. The consultation findings revealed numerous examples of successful pilot initiatives, including community-based adaptation projects that have demonstrated effective models for integrating traditional and modern approaches to climate risk management. Such pilots should be designed in future to generate learning about effective adaptation strategies while demonstrating the feasibility and benefits of integrated approaches to climate adaptation. The selection of pilot locations and approaches should balance the need for representative conditions with the likelihood of success, recognizing that failed pilots can undermine political support for broader adaptation efforts. The consultation participants emphasized that pilot programs should be designed with scaling in mind from the outset, rather than treating scaling as an afterthought. The Adaptation at Altitude program’s approach to pilot

project documentation provides a model for systematic learning from pilot initiatives.[293] Their methodology for assessing adaptation solutions includes evaluation of “scalability of change” and “sustainability” to identify approaches that have potential for replication and mainstreaming. This systematic approach to pilot evaluation can help prevent the common problem of successful pilots that cannot be scaled due to specific local conditions or resource requirements.

Scaling up successful pilot approaches requires attention to the institutional, financial, and political factors that determine whether small-scale successes can be replicated at larger scales. The consultation findings revealed that successful scaling requires addressing both horizontal scaling, that replicates successful approaches in new locations, and vertical scaling, that integrates successful local approaches into higher-level policy frameworks. The Pakistan consultation emphasized that successful scaling requires understanding that “not everything can be scaled” and that scaling strategies must be adapted to local contexts and conditions. Effective scaling up requires maintaining the key features that made pilot programs successful while adapting to different contexts and institutional environments. The consultation participants noted that successful scaling often requires policy reforms that address regulatory barriers and which provide supportive frameworks for innovation and adaptation. The development of monitoring and evaluation systems for climate adaptation policies poses significant methodological challenges due to the long-time horizons, uncertainty, and complex interactions that characterize climate adaptation outcomes. Traditional project evaluation approaches that focus on short-term, directly attributable outcomes may be inadequate for assessing climate adaptation effectiveness, which may require decades to fully evaluate and involve complex interactions

293 https://adaptationataltitude.org/knowledge-base/adaptation-in-mountains/adaptation-at-altitude-4-years-of-collaborative-action-in-the-mountains-synthesis-scroll/

9. Conclusion and Future Research Directions

Pakistan. Photo: Alex Treadway/ ICIMOD

The comprehensive analysis of human security under climate stress in the Hindu Kush Himalaya reveals a region at the epicentre of cascading climate-induced transformations that fundamentally challenge traditional security paradigms and demand unprecedented forms of integrated response. This assessment demonstrates that climate change operates not as an isolated environmental hazard, but as a systemic disruptor that propagates across the interconnected domains of food, water, and energy systems, livelihood structures, and human mobility patterns in ways that exceed the analytical and response capacity of conventional risk management approaches. The findings establish that the Hindu Kush Himalaya requires an integrated human security framework that recognizes how disruptions to any single component trigger cascading failures across the entire socio-ecological system, with implications that extend far beyond the immediate mountain areas to affect downstream populations across major river basins supporting nearly two billion people. The research validates the central proposition that human security under climate stress requires understanding of the dynamic interplay among four critical dimensions: the Food-Water-Energy nexus that provides material foundations for human wellbeing, livelihood systems that mediate between environmental changes and welfare outcomes, systemic resilience mechanisms that determine adaptive capacity, and migration dynamics that represent both adaptation strategies and indicators of system breakdown. The framework's emphasis on threshold analysis proves particularly relevant across all four focus countries, enabling identification of approaching tipping points where proactive intervention can prevent system collapse at much lower cost than post-crisis reconstruction and humanitarian response. The consultation findings from Afghanistan, India, Nepal, and Pakistan consistently validate this integrated approach while revealing the critical importance of understanding intersectional vulnerabilities where climate risks interact with existing social, economic, and governance inequalities to create compound threats that exceed the sum of individual stressors.

The theoretical contribution of this research lies in the development of an integrated analytical framework that bridges human security concepts with systems thinking approaches to address the unique challenges that climate change poses for mountain regions. The framework advances beyond traditional human security approaches that treat individual security dimensions in isolation, instead recognizing the systemic interdependencies that determine overall security outcomes under climate stress. The four-pillar framework provides a comprehensive analytical tool for understanding how climate impacts cascade through interconnected systems while identifying strategic intervention points where targeted investments can create positive effects across multiple security dimensions simultaneously. The methodological contribution encompasses the integration of multiple analytical approaches including comprehensive literature synthesis, stakeholder consultation processes, systems analysis techniques, and cross-country comparative analysis to examine complex climate-security linkages across diverse national contexts. The research demonstrates how participatory consultation methods can generate insights about local adaptation strategies and institutional innovations while providing validation for framework concepts across different geographic and institutional contexts. The threshold analysis methodology proves particularly valuable for policy prioritization, enabling identification of approaching system limits where proactive intervention becomes essential for preventing irreversible degradation or collapse.

The country-specific analyses reveal both common patterns and distinctive vulnerabilities that require differentiated, yet still coordinated, adaptation approaches. Afghanistan represents the most severe case, with all human security dimensions operating at threat levels where immediate humanitarian intervention is required alongside long-term efforts towards system transformation. Nepal exemplifies the challenges facing high-altitude nations with extreme dependence on glacial water resources and limited adaptive capacity, where imminent irreversible thresholds in glacier retreat, groundwater depletion, and agricultural system viability demand immediate proactive interventions. Pakistan confronts water security threats affecting over 35 million people through its dependence on glacier-fed river systems. It demonstrated both the devastating impacts of extreme events, like the 2022 floods, and the potential for innovative adaptation responses when supported by appropriate policy frameworks. India exhibits variable vulnerability patterns across its diverse Himalayan regions, illustrating both the complexity of addressing climate adaptation in large federal systems and the opportunities for leveraging substantial technical and institutional capacity to develop adaptation innovations that could benefit the broader region. The policy analysis reveals that effective climate adaptation in the Hindu Kush Himalaya requires fundamental transformation, moving from sectoral approaches toward integrated system-wide responses that address root causes of vulnerability while building adaptive capacity across multiple scales simultaneously. The

consultation findings consistently emphasized that current institutional arrangements operate through sectoral mandates with limited coordination mechanisms, rendering them inadequate for managing system-wide risks that propagate rapidly across sectors, jurisdictions, and temporal boundaries. Using examples of success, the research demonstrates that effective adaptation requires building upon existing institutional foundations and social capital rather than creating entirely new systems, while developing “blended governance models” that can integrate traditional and modern governance approaches to address both immediate needs and long-term transformation requirements.

The human mobility analysis establishes migration as both a critical adaptation strategy and an indicator of adaptation failure, requiring governance approaches that facilitate safe, voluntary movement while supporting adaptation in both origin and destination areas. The research demonstrates that climate-induced migration in the region encompasses both distress migration due to livelihood system failure and strategic mobility that enables household diversification and risk management. However, current legal and institutional frameworks for managing migration and displacement were not designed to address climate-induced mobility, creating protection gaps and institutional confusion that require comprehensive policy innovation at both national and regional levels. The analysis of technology and innovation revealed significant potential for developing locally appropriate adaptation technologies that integrate traditional knowledge with contemporary approaches, but identifies substantial barriers, including limited access to financing, inadequate institutional support, and insufficient recognition of indigenous innovations. The consultation findings consistently emphasized that successful technology adoption requires extensive community engagement and capacity building support, while technology transfer approaches must address both technical and social dimensions of innovation adoption to be effective at scale.

The experience of the Hindu Kush Himalaya region provides crucial insights for global climate adaptation efforts, particularly regarding the challenges of managing climate risks in complex mountain systems with transboundary implications. The region’s experience demonstrates that climate adaptation requires unprecedented forms of coordination across sectors, scales, and temporal horizons that exceed traditional governance approaches while building upon existing institutional foundations and cultural knowledge systems. The framework’s emphasis on understanding cascade effects and threshold dynamics proves relevant beyond the immediate regional context, offering analytical tools that could inform climate adaptation planning in other vulnerable regions facing similar challenges of systemic risk management under uncertainty. The research establishes that effective climate adaptation requires moving beyond incremental adjustments toward system transformation approaches that can create fundamentally new configurations of socio-ecological systems capable of thriving under changed environmental conditions. However, the analysis also demonstrates that such transformation must build respectfully upon existing social capital, traditional knowledge, and institutional arrangements rather than attempting to impose external solutions that may undermine local adaptive capacity. This insight has broad relevance for climate adaptation efforts globally, suggesting that successful transformation requires hybrid approaches that integrate innovation with existing strengths rather than wholesale replacement of traditional systems.

The scope of this research reveals multiple areas requiring continued investigation to advance understanding of human security under climate stress and support effective adaptation responses. Future research priorities encompass four primary domains: systemic risk assessment and early warning systems, transformation pathways and innovation mechanisms, regional cooperation and governance frameworks, and community resilience and adaptive capacity building. Each domain requires integrated research approaches that can address both technical and social dimensions of climate adaptation while building upon the theoretical and methodological foundations established through this analysis. The development of advanced risk assessment methodologies represents a critical research priority for enhancing predictive capacity and early warning systems across the Hindu Kush Himalaya region. Current risk assessment approaches typically address individual hazards or sectors in isolation, failing to capture the cascade dynamics and compound effects that characterize climate impacts in complex mountain systems. Future research should prioritize developing multi-hazard cascade modelling capabilities that can simulate how climate impacts propagate through interconnected Food-Water-Energy systems, livelihood networks, and human mobility patterns to create compound vulnerabilities that exceed the sum of individual risks.

Transboundary impact assessment represents another critical research area where improved understanding is essential for effective regional cooperation on climate adaptation. The current research demonstrates that climate impacts in one country frequently create consequences in neighbouring countries through shared river systems, migration flows, and economic relationships, but existing assessment methodologies inadequately capture these transboundary dimensions. Future research should develop integrated assessment frameworks that can quantify transboundary impacts while providing analytical foundations for regional coordination mechanisms and shared responsibility frameworks. Compound vulnerability mapping requires advancement through research that can understand how multiple stressors interact across different temporal and spatial scales to create vulnerability patterns that exceed linear risk accumulation. The consultation findings consistently emphasized the importance of intersectional analysis that addresses how climate risks interact with existing social, economic, and governance inequalities, but current mapping approaches lack the analytical sophistication needed for comprehensive compound vulnerability assessment. Priority research should develop integrated vulnerability assessment methodologies that can address both biophysical and social dimensions of climate vulnerability while identifying strategic intervention points for building resilience across multiple vulnerability dimensions simultaneously. Research on livelihood transformation models represents an essential priority for understanding how traditional livelihood systems can evolve to remain viable under changed environmental conditions while maintaining social cohesion and cultural continuity. The current research reveals that traditional mountain livelihoods face unprecedented challenges as environmental conditions exceed historical bounds, but successful transformation examples demonstrate the potential for developing hybrid approaches that integrate traditional knowledge with contemporary innovations. Future research should develop comprehensive transformation frameworks that can guide livelihood adaptation processes while maintaining essential cultural and social values that provide identity and community cohesion. Knowledge sharing platforms require research to develop effective mechanisms for transferring adaptation innovations and lessons learned across different contexts while respecting intellectual property rights and ensuring equitable benefit-sharing arrangements. The consultation findings revealed numerous examples of locally developed adaptation innovations that could benefit other communities, but current knowledge sharing mechanisms are inadequate for systematic transfer and scaling of successful approaches. Priority research should develop comprehensive knowledge sharing frameworks that can facilitate technology and innovation transfer while ensuring that knowledge holders receive appropriate recognition and compensation for their contributions.

Research on cross-border governance models represents a critical priority for developing institutional arrangements that can coordinate climate adaptation responses across multiple countries while respecting national sovereignty and addressing diverse development priorities. The current research reveals both opportunities and constraints for regional cooperation, with successful examples demonstrating the potential for coordinated action alongside political and institutional barriers that limit comprehensive coordination. Future research should develop innovative governance frameworks that can address transboundary climate challenges while building upon existing regional cooperation mechanisms and addressing political constraints that limit deeper integration. Climate finance mechanisms require substantial research to develop innovative financing approaches that can mobilize resources for climate adaptation at the scale and with the urgency required, while ensuring equitable access for the most vulnerable populations. The research demonstrates that current climate finance systems are inadequate for addressing the scale of investment needs. Additionally, they often exclude the populations and communities that face the greatest climate risks. Priority research should focus on developing regional climate finance architectures that can combine public and private resources while ensuring that financing mechanisms serve adaptation needs rather than creating new dependencies or inequalities. Frameworks for improved governance of migration and human mobility represent an essential research priority for developing comprehensive approaches to managing climate-induced mobility that protect migrants' rights while addressing legitimate concerns of destination communities about rapid population changes and resource competition. The research establishes that climate-induced migration is already occurring at substantial scale across the region, but existing legal and institutional frameworks are inadequate for addressing the complex needs of climate migrants. Future research should develop comprehensive migration governance frameworks that address the full migration cycle from prevention of forced displacement through facilitation of safe migration pathways to support for integration and potential return migration processes.

Future research in human security under climate stress requires methodological innovations that can address the complexity, uncertainty, and multi-scale nature of climate-security linkages while maintaining scientific rigor and policy relevance. The current research demonstrates the value of integrating multiple analytical approaches including systems analysis, participatory consultation, comparative case studies, and theoretical framework development, but each methodological approach requires further refinement and development to address the evolving challenges of climate adaptation research. Participatory research methodologies require advancement to ensure that community voices and traditional knowledge are meaningfully integrated into research processes while building local capacity for ongoing monitoring and evaluation of adaptation efforts. The consultation processes employed in this research demonstrate both the potential and challenges of participatory approaches, revealing the importance of cultural sensitivity, language accessibility, and awareness of power relationships in effective community engagement. Future research should develop enhanced participatory methodologies that can combine community knowledge with scientific analysis while building local capacity for sustained engagement in adaptation planning and implementation.

The comprehensive analysis of human security under climate stress reveals that effective climate adaptation requires sustained research efforts that can support adaptive management processes over decades while building enduring institutional capacity for ongoing learning and adjustment. Climate change represents a long-term challenge that will require continuous adaptation as environmental conditions continue to change and as societies develop new technologies, institutions, and social arrangements for managing climate risks. Sustainability of these efforts requires attention to building enduring research capacity within regional institutions that can support continuing climate adaptation efforts while maintaining their connection to global research networks and policy processes. The current research demonstrates the importance of regional research institutions like ICIMOD for understanding regional climate challenges, but sustained funding and institutional development are needed to maintain and enhance regional research capacity. Future efforts should focus on building sustainable regional research institutions that can support long-term adaptation efforts while maintaining high scientific standards and policy relevance. Capacity building requires systematic efforts to develop the next generation of climate adaptation researchers and practitioners while ensuring that capacity building efforts serve local and regional needs rather than simply extracting knowledge for external purposes. The consultation processes revealed extensive local expertise and innovation capacity that could be enhanced through appropriate capacity building support, but current capacity building efforts remain fragmented and limited in scope. A priority development, therefore, should be a focus on comprehensive capacity building programs that can develop regional expertise to help form enduring institutional capacity for climate adaptation research and implementation.

This analysis points toward four strategic dimensions essential for advancing human security in the HKH region under climate stress:

1. Climate-Responsive Livelihood Systems: Strengthening rural and urban livelihood diversification, agricultural innovation, and employment creation that reduces population vulnerability to climate-driven resource stress.

2. Transboundary Water Cooperation and Management: Developing and strengthening institutional mechanisms for coordinated water management across river basins, ensuring that upstream climate changes (glacier retreat, precipitation variability) do not create unilateral advantage or resource scarcity for downstream populations.

3. Institutional Adaptation and Governance Innovation: Building multi-level institutional capacity for coordinating adaptation across sectors and administrative boundaries, enabling formation of integrated responses to compound climate risks that exceed sectoral institutional competence.

4. Community-Led Resilience and Adaptive Capacity: Strengthening social networks, institutional participation, and local knowledge systems that enable communities to anticipate and respond to climate stress while maintaining social cohesion and cultural identity.

These dimensions are not sequential or hierarchical but deeply interconnected, as livelihood systems depend on water availability and institutional coordination; transboundary cooperation depends on community trust and institutional capacity; institutional innovation depends on livelihoods enabling populations to engage in governance processes. Effective human security strategies in the HKH must address all four dimensions simultaneously, recognizing that progress in any single area is constrained by deficits in others.

Advancing human security under climate stress requires differentiated but complementary roles across multiple stakeholder categories. National governments carry primary responsibility for designing and implementing adaptation policy within their territories, including livelihood support mechanisms, agricultural transformation, and inter-sectoral coordination. Research and knowledge institutions (such as ICIMOD) provide evidence-based analysis on climate projections, adaptation innovation, and best-practice documentation that enables governments to ground policy in scientific understanding while learning from regional experience. Regional and international cooperation mechanisms are required to facilitate transboundary coordination on shared water systems, climate impact assessment, and technology/knowledge transfer that exceed any single nation's capacity. Community organizations and civil society represent critical voices in ensuring that adaptation strategies reflect local knowledge, livelihood realities, and population priorities rather than imposing external prescriptions. Private sector and financial institutions provide innovation, investment capital, and market mechanisms that can accelerate livelihood diversification and technology deployment. Effective implementation requires these stakeholders operate within mutually reinforcing roles: governments setting policy and allocating resources; research institutions providing evidence and analysis; civil society ensuring accountability and community voice; regional mechanisms enabling coordination across borders; and private actors enabling innovation and scaling. The HKH region's human security challenges are too complex and too urgent for any single actor to address unilaterally; progress depends on institutional relationships that enable coordinated action while respecting the distinctive mandates and capacities of different stakeholders

The future of human security in the Hindu Kush Himalaya depends fundamentally on the region's capacity to develop and implement innovative approaches to climate adaptation that build upon existing strengths while addressing unprecedented challenges. The research framework and findings presented here provide essential foundations for such innovation, but realizing the potential for enhanced human security requires sustained commitment to integrated research, coordinated policy development, and collaborative implementation efforts that span sectors, scales, and national boundaries. The window for proactive adaptation is rapidly closing and makes urgent action essential. It is also recognized that effective adaptation to a continuing and possibly mounting threat requires long-term commitment and sustained investment in the research, innovation, and cooperation mechanisms needed to build resilience in one of the world's most climate-vulnerable and globally significant regions.

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