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Policy Evaporation in the Himalayas: Climate Adaptation Gaps in Nepal's Karnali Basin

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Abstract

Background: The Upper Karnali River Basin in Nepal is highly susceptible to climate-related hazards. Despite the existence of national adaptation policies such as the National Adaptation Programme of Action (NAPA) and the Local Adaptation Plans of Action (LAPA), a persistent gap remains between policy design and local-level implementation.

Objectives: This study examines the adaptation policy–implementation gap across three municipalities representing the upstream (Pachaljharana), midstream (Bhairavi), and downstream (Jagannath) sections of the basin. It identifies the key barriers to effective adaptation and explores spatial variations in hazard exposure, impacts, and participatory responses.

Methods: A mixed methods approach was employed, incorporating household surveys, key informant interviews, focus group discussions, and policy document analysis to assess adaptation practices, governance processes, and community participation across the three municipalities.

Findings: The results reveal significant spatial variation in climate hazard exposure: water scarcity dominates upstream, landslides in the midstream, and flooding downstream. Agricultural loss and livestock decline are the most severe economic impacts, while water scarcity and erosion of traditional livelihoods are the dominant social impacts. Traditional coping strategies remain widely practiced, but participation in formal adaptation activities—such as early warning systems, data recording, and training—is very low. Governance barriers

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include weak inter-administrative coordination, inadequate financing, elite capture, and the exclusion of Dalits, women, and landless households. National policies are well designed but poorly implemented locally.
Conclusion: Bridging the adaptation gap requires spatially targeted planning, integration of traditional knowledge, investment in community-based early warning systems, and institutional reforms that ensure marginalized groups actively participate in decision-making rather than merely contributing labour.
Novelty: This study is the primary municipality-level comparison across a Himalayan basin to quantify participatory exclusion and explicitly link hydropower development to local adaptation failures.
Keywords: Climate change adaptation; policy implementation gap; socio-ecological systems; Karnali River Basin; community participation; Nepal

1. Introduction

The Karnali River Basin in western Nepal is a typical Himalayan socio-ecological system, characterized by steep elevation differences, fragile geology, and a monsoon-driven hydrology. As the country's longest river system, it supports more than 40% of the population of Karnali and Sudurpashchim provinces (Sharma et al., 2020; Acharya & Paudel, 2020). It is also one of Nepal's most climate-vulnerable regions. Over the past two decades, rising temperatures, erratic rainfall, and glacier retreat have altered its hydrology (Khatiwada et al., 2016; Lamichhane et al., 2024). Average annual precipitation ranges from 1000 to 1200 mm, but with extreme spatial variation – from less than 300 mm in rain-shadow areas to nearly 1900 mm in monsoon-exposed catchments. This has increased the frequency of floods, landslides, droughts, and forest fires (Pradhananga et al., 2025).

These impacts vary considerably across the basin. In upstream Pachaljharana (Kalikot), reduced snowfall and declining base flows cause seasonal water shortages. In midstream Bhairavi (Dailekh), irregular river discharge triggers landslides and damages the Karnali Highway. Downstream Jagannath (Bajura) faces greater flood risk, riverbank erosion, and shifting river courses, compounded by sediment that reduces irrigation efficiency and damages micro-hydropower infrastructure (Roy et al., 2024; Mitra & Das, 2025). The basin is therefore transitioning from a relatively stable hydrological system to an unpredictable, extreme environment.

These changes have produced severe socio-economic hardships. Most households depend on rainfed subsistence farming and livestock rearing. Agricultural loss is the most serious economic impact (reported by >80% of surveyed households), followed by livestock decline (39%), increased food prices (30%), and higher disaster recovery costs (27%) (field survey, 2025). Socially, water scarcity and loss of traditional livelihoods (45% each) disrupt daily life, erode indigenous skills, and place disproportionate burdens on women and children. Educational disruption affects nearly one-third of households. Seasonal and permanent male migration to India has increased, leaving women to manage farms under growing climatic

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pressure (Gautam, 2017). Access to resources and equity vary across the basin: upstream communities lack irrigation and markets; midstream areas have persistent land-ownership inequalities; downstream populations face repeated loss of land and housing. Marginalized groups – Dalits, landless households, and women – are disproportionately affected but remain excluded from formal adaptation planning (Paudel et al., 2025). Climate change thus functions as a threat multiplier, deepening existing social and economic marginalisation.
In response, Nepal has developed progressive policies. The National Adaptation Programme of Action (NAPA, 2010) and Local Adaptation Plans of Action (LAPA, 2011) shifted from centralized disaster response to decentralized, community-based adaptation, mandating local planning, prioritising vulnerable groups, and allocating 80% of international climate finance to local levels (Ghimire & Chhetri, 2022). Municipalities in the Upper Karnali have prepared LAPAs, often with support from the World Food Programme and the Adaptation Fund. Yet a persistent gap remains between policy intentions and on-ground implementation, driven by weak institutional capacity, insufficient and unpredictable financing, limited technical expertise, and poor coordination among federal, provincial, and local governments (Darjee et al., 2021; Suhardiman et al., 2018). Monitoring and evaluation are largely absent.

Large-scale hydropower projects – Upper Karnali (900 MW), West Seti (750 MW), Phukot Karnali (480 MW) – proceed with limited climate risk assessment and local ecological knowledge, altering river flows and sediment dynamics while rarely addressing downstream vulnerability. Project benefits are unevenly distributed, with elite caste groups (Bahun, Chhetri, Thakuri) receiving a disproportionate share, while Dalits and other marginalized groups are excluded from decision-making and employment (JYAKHWO, 2012). Consequently, communities rely on traditional coping strategies – agro-pastoral diversification, kulo irrigation, parma labor exchange, and mutual support networks – which, though valuable, cannot substitute for effective state-led adaptation.

Research gap and study objectives

Most existing studies focus on national-level policy analysis or localized vulnerability assessments, giving limited attention to vertical and horizontal linkages across different geographical sections of a single basin (Vij et al., 2018; Stock et al., 2021). Few systematically compare adaptation performance across upstream, midstream, and downstream municipalities. The role of community participation and institutional capacity as mediators remains underexplored, and marginalized groups are rarely centered in empirical assessments. Furthermore, traditional coping strategies are seldom analyzed in relation to formal policies. To address these gaps, this study employs a socio-ecological systems framework and a mixed-method approach to critically examine the alignment between climate policies and local realities in the Upper Karnali Basin. The objectives are:

1. To assess the impacts of climate change on environmental, socio-economic, and living conditions across Bhairavi, Pachaljharana, and Jagannath municipalities.

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2. To evaluate the performance of NAPA and LAPA in addressing climate risks and strengthening community resilience.
3. To identify governance, institutional, and community-level factors that mediate the policy-implementation gap and recommend context-specific strategies.

Novelty Statement

This study provides four novel contributions: (i) spatially disaggregated analysis across a river basin, showing that basin-wide adaptation plans are ineffective unless tailored to local hazard profiles; (ii) empirical measurement of "participatory exclusion", quantifying that marginalized groups participate at 40–60% in labour-intensive activities but at <10% in decision-making; (iii) direct comparison of traditional coping strategies (61% usage) with formal LAPA activities (e.g., early warning at 5%), demonstrating that traditional practices need policy support rather than replacement; and (iv) linkage of large hydropower projects to local adaptation gaps at the municipality level, documenting exclusionary benefit-sharing and missing climate risk assessments.

2. Literature Review

2.1 Climate Hazards and Environmental Change in Himalayan Basins

The Himalayan region is recognized as a climate change "hotspot" and is warming faster than the global average. This trend has significant implications for water security and livelihoods (Bolch et al., 2012; IPCC, 2022). Within Nepal, the Karnali River Basin is particularly vulnerable because of its steep terrain, fragile geology, and monsoon dependent hydrology. A growing body of research documents increasing floods, landslides, droughts, and erratic rainfall across the basin (Khatiwada et al., 2016; Panthi et al., 2019; Lamichhane et al., 2024). However, a critical review of the literature reveals three key analytical challenges.

First, there is a persistent inconsistency between basin wide hydrological projections and local hazard experiences. Studies such as Pradhananga et al. (2025) project increased seasonal flow variability using regional climate models. In contrast, municipal disaster data show that the frequency and intensity of hazards vary significantly across upstream, midstream, and downstream areas (Government of Nepal, 2025). Upstream areas experience declining base flows and seasonal water shortages. Midstream regions face irregular river discharge and unstable slopes. Downstream areas are exposed to higher flood risk and greater riverbank erosion (Roy et al., 2024; Mitra & Das, 2025). Despite these differences, most studies treat the basin as a single, uniform unit. As a result, the adaptation recommendations they produce are neither spatially targeted nor appropriate to local contexts.

Second, the causal mechanisms linking climate change to specific hazard outcomes remain contested. Although the relationship between rainfall intensity and floods and landslides is well established (Lamichhane et al., 2024), non climatic drivers such as road construction, deforestation, and unplanned settlement receive insufficient attention. The Karnali Highway has been repeatedly damaged by landslides. However, few studies distinguish the effects of

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climate change from those of poor engineering or inadequate drainage (Regmi & Dahal, 2024). This conflation creates a risk of attributing all increases in hazards to climate change, which diverts attention from practical interventions, such as improved road design and land use zoning, that fall outside climate policy.

Third, theoretical frameworks remain under specified. The socio ecological systems (SES) framework (Ostrom, 2009; Everard, 2019) is often used to highlight the interconnections among hydrology, governance, and communities. However, McGinnis and Ostrom (2014) argue that SES analysis requires clearly defined spatial and institutional boundaries, a condition that is rarely met in studies focused on Nepal. Most research treats the entire Karnali Basin as a single SES and overlooks the nested subsystems, including upstream grazing, midstream agriculture, and downstream floodplains, which operate at different scales and under distinct institutional arrangements. Political ecology provides a corrective by focusing on power imbalances and historical marginalisation (Adger et al., 2013; Ribot, 2014). However, few studies integrate these two perspectives. Consequently, comparative municipality level analyses of hazard patterns remain limited, and the translation of climate projections into locally relevant adaptation planning is still underdeveloped.

2.2 Socio-Economic Vulnerability and Local Adaptation

Climate impacts in the Karnali Basin are severe, unevenly distributed, and shaped by existing social hierarchies. Sharma et al. (2020) demonstrate that livelihood and cultural water requirements differ significantly across caste and gender groups. Gautam (2017) finds that male out-migration, itself a coping strategy, increases the workload and vulnerability of women as they assume responsibility for agriculture and water collection under worsening climatic conditions. Paudel et al. (2025) report that Dalit and landless households face greater barriers to accessing adaptation resources. These findings align with political ecology, which argues that vulnerability is jointly shaped by environmental change and pre-existing inequalities (Adger et al., 2013).

A notable contradiction exists between policy objectives and actual outcomes. National policies (NAPA, LAPA) explicitly prioritize vulnerable groups. However, studies consistently report that these groups remain excluded from adaptation benefits (Stock et al., 2021). Some studies attribute this gap to weak implementation capacity (Darjee et al., 2021). Others identify elite capture of local institutions as the main cause (Suhardiman et al., 2018). Additional research argues that participatory processes are shaped by NGOs and donors, resulting in what Sapkota (2018) describes as "participatory exclusion."

Research on traditional coping strategies provides detailed descriptions but offers limited analytical depth. Agro pastoral diversification, community based resource management through kulo irrigation and parma labour exchange, and mutual support networks are widely practiced (Paudel et al., 2025; Sagar et al., 2024). However, few studies assess their effectiveness under changing hazard conditions, and there is considerable disagreement regarding their long term viability. Ramya et al. (2023) argue that the increasing frequency of hazards is making these strategies maladaptive. In contrast, Sagar et al. (2024) contend that

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they remain resilient when supported by appropriate policies. Furthermore, most economic impact assessments are static and cross-sectional in nature. They measure agricultural losses, livestock declines, and rising food prices (Panthi et al., 2019; Pokhrel et al., 2021) but rarely capture cumulative impacts, including how repeated shocks reduce household assets, increase debt, and push families into poverty traps. Static assessments suggest the need for one-time compensation, whereas dynamic assessments indicate the need for asset rebuilding, social protection, and sustained livelihood diversification.

2.3 Governance Gaps and Infrastructure Challenges in Federal Nepal

Nepal's transition to a federal system in 2015 was expected to strengthen local autonomy; however, implementation challenges continue to persist. Darjee et al. (2021) identify weak institutional capacity, inadequate financing, and poor coordination as the primary obstacles. Suhardiman et al. (2018) demonstrate that federal institutions continue to dominate decision-making, limiting the roles of provincial and local governments. Vij et al. (2018) and Stock et al. (2021) describe a phenomenon of policy evaporation, in which donor-driven adaptation policies are poorly aligned with local priorities.

Adaptive governance theory (Folke et al., 2005) has been applied mainly in a descriptive rather than a diagnostic manner. The Karnali Basin demonstrates few of the core characteristics of adaptive governance, including learning, flexibility, and multi level coordination. However, studies rarely explain the reasons for this. It remains unclear whether these limitations result from structural factors such as constitutional ambiguities, behavioural factors such as bureaucratic resistance, or resource constraints.

The relationship between large-scale infrastructure and adaptation remains underexplored. Hydropower projects such as the Upper Karnali (900 MW), West Seti (750 MW), and Phukot Karnali (480 MW) are promoted as drivers of climate mitigation (Jyakhwo, 2012). However, critical studies highlight several adverse local impacts, including altered river flows, increased sedimentation, displacement, and unequal benefit-sharing (Baral et al., 2022; Ranjitkar et al., 2026). Research on adaptation governance and hydropower development has largely been conducted in isolation, despite their strong interconnections, as hydropower projects can simultaneously generate climate risks and attract adaptation investments.

Community participation is often treated as a binary concept, defined simply as present or absent, rather than as a continuum. Evidence shows high participation in labour intensive activities, such as reforestation and slope stabilization, but low participation in decision making, including planning, budgeting, and monitoring. Sapkota (2018) describes this as "participatory exclusion," but the concept remains underexplored. From a political ecology perspective, participation should be examined as a process shaped by power, including who speaks, who is heard, and whose priorities receive funding.

2.4 Summary and Linkage to the Current Study

In summary, the Upper Karnali Basin is highly vulnerable to climate hazards, which lead to severe and varied socio economic impacts. National policies promote decentralized and participatory adaptation. However, weak governance, insufficient resources, and exclusionary practices limit their implementation. Several gaps remain in the existing literature. These include the absence of comparative municipality-level analysis across different basin segments, limited critical examination of why policy commitments to vulnerable groups are not fulfilled, and insufficient analytical treatment of the effectiveness of traditional coping strategies. The literature also lacks dynamic economic assessments, adequate integration of hydropower and adaptation governance, and theorisation of participation as a process shaped by power dynamics. This study addresses these gaps by applying an integrated socio ecological systems and political ecology framework. It uses a comparative mixed method design across three municipalities, centres marginalized groups, and analyses participation as a process shaped by power dynamics.

3. Conceptual Framework

This study is guided by an integrated conceptual framework that draws on socio-ecological systems theory (Everard, 2019), adaptive governance theory (Folke et al., 2005), and political ecology (Ribot, 2014). The framework posits that climate change adaptation outcomes in the Upper Karnali River Basin are determined by the interplay among biophysical hazards, socio-economic vulnerability, governance structures, and community participation, with the gap between policy design and implementation serving as the central analytical focus.

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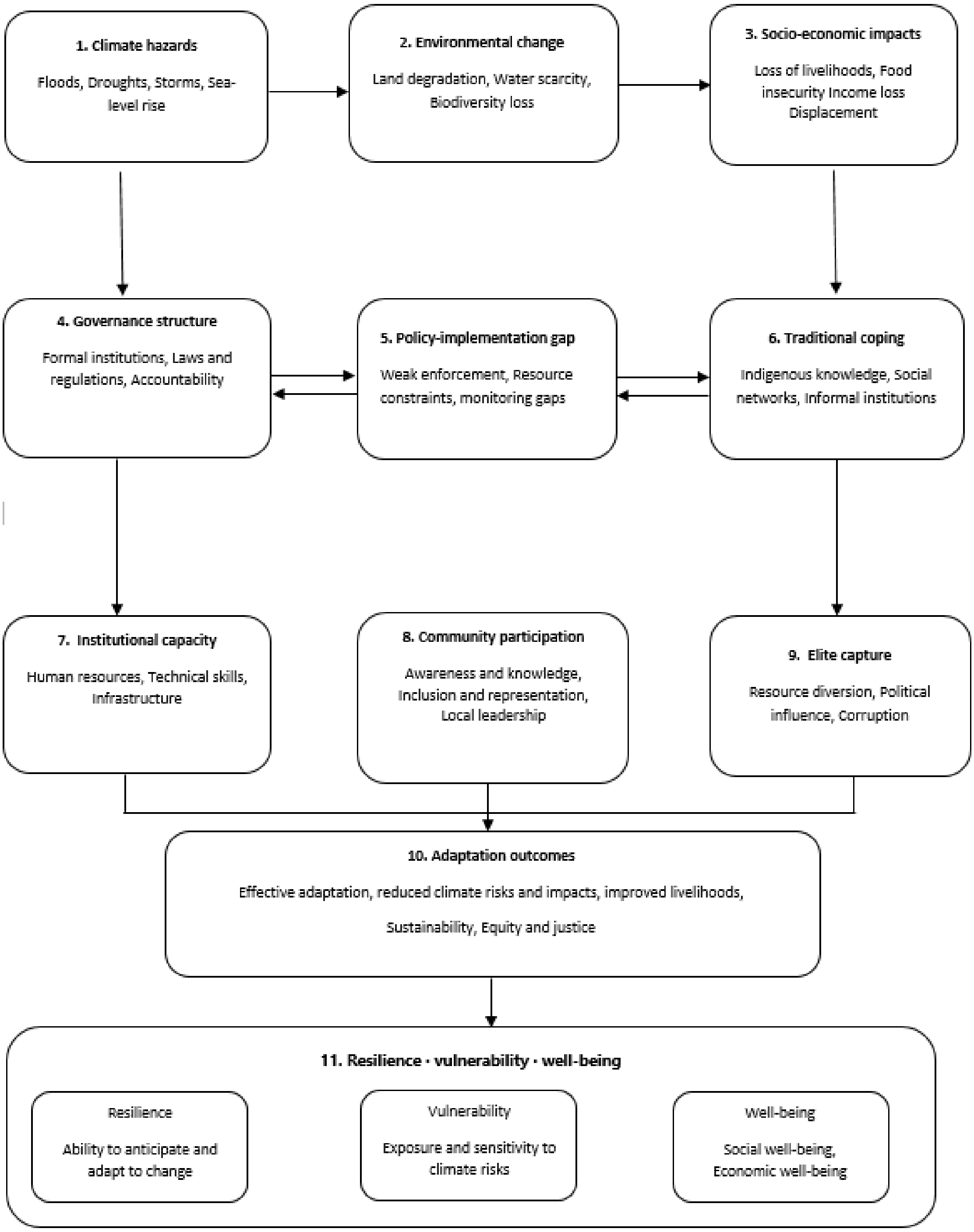

Figure 1. Conceptual framework showing relationships among biophysical drivers, the policy-implementation gap, mediating factors, and adaptation outcomes.

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4. Methodology

4.1 Study Area

The study was conducted in the Upper Karnali River Basin in Nepal, which is recognized as one of the country's most climate-vulnerable regions. Three municipalities were purposively selected to represent distinct geographical sections of the basin. Pachaljharana in Kalikot District represents the upstream area, Bhairavi in Dailekh District represents the midstream area, and Jagannath in Bajura District represents the downstream area. These municipalities vary in terms of topography, hazard exposure, and socio-economic conditions, making them well-suited for a comparative analysis of climate change impacts and the implementation of adaptation policies.

4.2 Research Design and Approach

The study employed a mixed-method research design that combined descriptive and exploratory approaches to examine climate hazards and socio-ecological vulnerabilities. This design enabled the integration of quantitative data obtained from household surveys with qualitative information gathered through key informant interviews, focus group discussions, and document analysis, thereby strengthening the validity and reliability of the findings.

4.3 Target Population and Sampling

The target population comprised farmers, fisherfolk, forest users, and women from marginalized Dalit communities residing in the three municipalities. A purposive sampling method was applied to ensure adequate representation of socio-economically vulnerable groups, particularly those most exposed to climate-related hazards.

A total of 180 households were selected, with 60 households drawn from each municipality. This sample size was determined based on the principle of data saturation and the need to ensure sufficient representation across caste, gender, and landholding categories within each municipality.

4.4 Data Collection

4.4.1 Semi-Structured Household Surveys

A semi-structured questionnaire was administered to 180 household heads (60 per municipality). The survey gathered information on demographic characteristics, livelihood assets, experienced climate variability and impacts, access to information, institutions and financial services, awareness of climate policies (NAPA, LAPA), and adoption of adaptation practices.

4.4.2 Key Informant Interviews

A total of 18 KIIs (six per municipality) were conducted with elderly farmers, local leaders, user group members (including women), agricultural input providers, and local extension officers. These interviews provided detailed insights into governance processes, institutional coordination, and historical changes in climate conditions and livelihoods.

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4.4.3 Focus Group Discussions

Nine mixed FGDs (three per municipality) were conducted, each comprising 10–15 participants. Discussions explored community perceptions of climate hazards, traditional coping strategies, access to resources and equity considerations, and experiences with local adaptation programs (LAPAs). FGDs also served to validate survey findings.

4.4.4 Secondary Data

Secondary data were collected from government sources including the BIPAD Portal, the Central Bureau of Statistics Nepal, and municipal profiles, as well as from organizations such as the World Food Programme, UNDP, and USAID. Policy documents including NAPA, LAPA, and the National Climate Change Policy were also reviewed.

4.5 Ethical Considerations

Formal ethical approval was not required for this study according to the guidelines of the authors' institutions. The study did not involve clinical interventions, the collection of biological samples, or sensitive personal data beyond voluntary opinions related to climate and livelihood issues. However, strict ethical standards were followed throughout the research. Prior informed verbal consent was obtained from all participants following a clear explanation of the study's purpose, procedures, and their rights, including the right to withdraw at any time without consequence. Anonymity and confidentiality were ensured through the use of pseudonyms and the removal of all personal identifiers. Participation was entirely voluntary, and no incentives were offered. Local cultural norms and protocols were respected throughout the fieldwork.

4.6 Data Analysis

Document analysis of policies including NAPA, LAPA, and the National Adaptation Plan (NAP) was conducted through content analysis to identify key provisions related to hazard mapping, community participation, financial allocation, and monitoring mechanisms.

Household survey data were entered into Microsoft Excel and analyzed using descriptive statistics. No inferential statistical tests were performed, as the study is primarily descriptive and exploratory. All results are reported as frequencies and percentages.

KII and FGD transcripts were transcribed verbatim and translated from Nepali into English. Thematic analysis was conducted manually (without specialized software) following the six-phase reflexive thematic approach (Braun & Clarke, 2006). Themes were developed deductively based on the research objectives and conceptual framework and inductively from patterns emerging directly from the data.

4.7 Validity and Reliability

To ensure research rigour, the study employed data triangulation by comparing findings across household surveys, key informant interviews, focus group discussions, and policy documents. Methodological triangulation was applied through the integration of quantitative and qualitative methods, and investigator triangulation was achieved by involving multiple researchers in both data collection and analysis. through the combination of quantitative and qualitative methods. In addition, investigator triangulation was incorporated by engaging multiple researchers in both data collection and analysis. Fieldwork was conducted in Nepali

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by researchers familiar with the local socio cultural context. Continuous field engagement and reflexive journaling were used to reduce bias and improve the credibility of the findings.

5. Results

This section presents findings from the household survey (n = 180), key informant interviews (n = 18), focus group discussions (n = 9), and secondary data analysis conducted across three municipalities of the Upper Karnali River Basin, namely Pachaljharana (upstream), Bhairavi (midstream), and Jagannath (downstream). The results are organized around three thematic areas: (A) climate hazards and environmental change, (B) socio-economic impacts and local adaptation, and (C) governance gaps and community participation.

5.1 Climate Hazards and Environmental Change

5.1.1 Hydrological Change and Hazard Frequency

Respondents across all three municipalities reported considerable changes in hydrological patterns. In the upstream municipality of Pachaljharana, reduced snowfall and irregular rainfall have resulted in seasonal water shortages, particularly during the pre-monsoon period. In the midstream municipality of Bhairavi, irregular river flow has contributed to a higher frequency of landslides and sediment movement, which has also caused damage to sections of the Karnali Highway. In the downstream municipality of Jagannath, the cumulative effects of upstream changes have led to elevated flood risk, increased riverbank erosion, and shifts in river courses. Analysis of data from the BIPAD Portal covering the period from 2012 to 2025 indicates an overall increase in rainfall up to a peak around 2018, followed by a fluctuating but slightly declining trend toward 2025. As shown in Figure 1, landslide and flood incidents increased with rising rainfall, peaking in 2017–2019 before declining slightly thereafter. The estimated average annual rainfall across the basin ranges between 1,000 and 1,200 mm. Considerable spatial variation exists, however, ranging from less than 300 mm in rain-shadow areas to nearly 1,900 mm in monsoon-exposed regions. During this period, floods occurred approximately two to three times in every five years, while landslides were recorded as an annual and recurring hazard, particularly during periods of intense monsoon rainfall. Drought also emerged as a frequent slow-onset hazard occurring at a comparable rate. In addition, emerging risks such as glacial retreat and potential glacial lake outburst floods (GLOFs) have been observed, although these events occur with less frequency.

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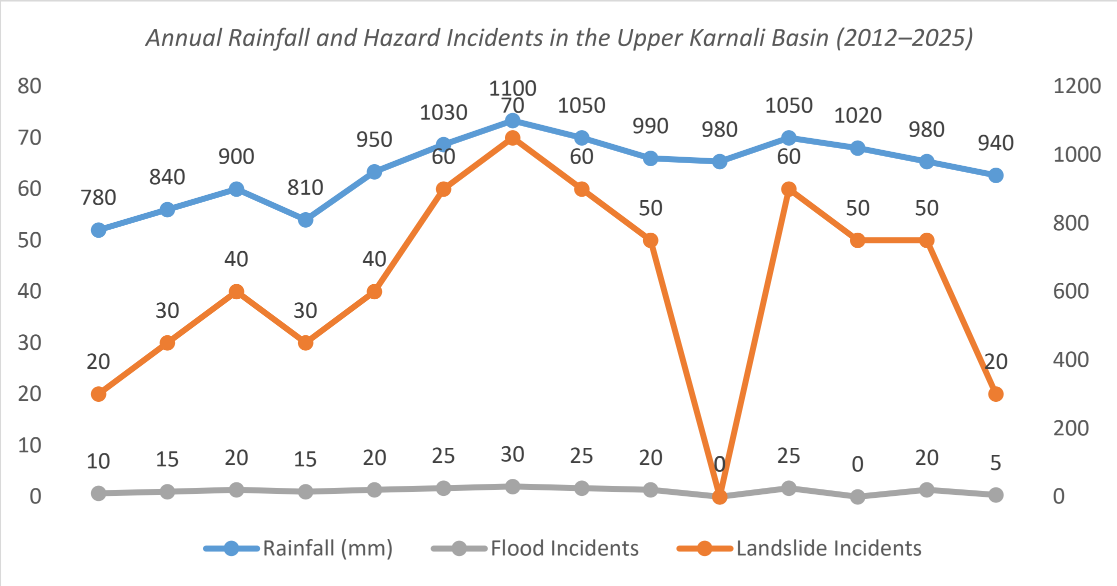

Figure 2. Annual rainfall (mm) and reported landslide and flood incidents in the Upper Karnali Basin (2012–2025). Source: BIPAD Portal.

5.1.2 Environmental Impacts

Survey respondents reported several environmental effects associated with climate change. Table 1 presents the frequency of the perceived environmental impacts.

Table 1

Impact of Climate Change on Environmental Aspects (n = 180)

Category	Frequency	Percentage (%)
Loss of biodiversity	48	26.7
Extreme weather events	37	20.6
Pollution of ecosystem	34	18.9
Deforestation	30	16.7
Rising temperature	22	12.2
Soil degradation	15	8.3

Note. Loss of biodiversity was reported as the most frequently cited impact (48 respondents), followed by extreme weather events (37 respondents) and ecosystem pollution (34 respondents). Soil degradation was reported the least frequently (15 respondents).

5.2 Socio-Economic Impacts and Local Adaptation

5.2.1 Economic Impacts

Climate change has severely affected household economies. Table 2 presents the economic consequences reported by respondents.

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Table 2

Impact of Climate Change on Economic Condition (n = 180)

Category	Frequency	Percentage (%)
Agricultural loss	59	32.8
Livestock decline	39	21.7
Increased food prices	30	16.7
Higher disaster recovery cost	27	15.0
Job loss	18	10.0
Infrastructure loss/damage	7	3.9

Note. Agricultural loss was the most commonly reported impact (59 respondents, 32.8%), followed by livestock decline (39 respondents, 21.7%) and increased food prices (30 respondents, 16.7%). Infrastructure loss and damage was reported the least frequently (7 respondents, 3.9%).

5.2.2 Social Impacts

Climate change has also disrupted social systems. Table 3 shows the reported social impacts.

Table 3

Impact of Climate Change on Social Aspects (n = 180)

Category	Frequency	Percentage (%)
Water scarcity	45	25.0
Loss of traditional livelihood	45	25.0
Resource scarcity for local crafts	39	21.7
Education disruption	31	17.2
Migration and displacement	20	11.1
Increased inequality	7	3.9

Note. Water scarcity and loss of traditional livelihood were equally the most severe impacts (45 each, 25%). Increased inequality was reported least frequently (7, 3.9%).

5.2.3 Water-Related Crises and Conflicts

Water scarcity has triggered cascading effects. Table 4 summarizes water-related crises.

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Table 4

Water-Related Crises and Conflicts (n = 180)

Category	Frequency	Percentage (%)
Impact on agriculture	67	37.2
Drying up water source	39	21.7
Wildlife migration due to water scarcity	30	16.7
Reliance on distant tap water	23	12.8
Human-wildlife conflict	21	11.7

Note. Impact on agriculture was the most frequently reported (67 respondents, 37.2%), followed by drying up water sources (39, 21.7%) and wildlife migration (30, 16.7%). Human-wildlife conflict was reported by 21 respondents (11.7%).

5.2.4 Traditional Coping Strategies

Communities employ a range of traditional coping strategies. Table 5 presents their reported usage.

Table 5

Traditional Coping Strategies in the Upper Karnali River Basin (n = 180)

Category	Frequency	Percentage (%)
Agriculture practice (agro-pastoral diversification)	61	33.9
Community-based resource management	32	17.8
Mutual support system	25	13.9
Use of traditional medicine and local resources	28	15.6
Mobility and livelihood diversification	22	12.2
Spiritual and cultural practice	12	6.7

Note. Agro-pastoral diversification was the most widely adopted strategy (61 respondents, 33.9%), followed by community-based resource management (32, 17.8%) and use of traditional medicine (28, 15.6%). Spiritual and cultural practices were least used (12, 6.7%).

5.3 Governance Gaps and Community Participation

5.3.1 Comparative Climate Hazards and Human Casualty by Municipality

The spatial distribution of hazards and casualties varied across the three municipalities. Table 6 summarizes hazard types and reported human casualties.

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Table 6

Comparative Climate Hazards and Human Casualty by Municipality

Municipality	Hazard Type	Human Casualty
Bhairavi (midstream)	Flood	2
	Landslide	5
	Drought	1
	Forest fire	2
Pachaljharana (upstream)	Flood	3
	Landslide	6
	Drought	2
	Forest fire	1
Jagannath (downstream)	Flood	2
	Landslide	1
	Drought	1
	Forest fire	3

Note. Pachaljharana recorded the highest casualties from landslides (6) and floods (3). Bhairavi showed strong landslide-related casualties (5), while Jagannath had the highest forest fire casualties (3). Drought caused the fewest casualties across all municipalities (1–2 each).

5.3.2 Community Participation in Climate Adaptation

Respondents reported varying levels of participation in adaptation and disaster risk reduction activities. Table 7 presents participation frequencies.

Table 7

Community Participation to Overcome Climate Change Hazards (n = 180)

Category	Frequency	Percentage (%)
Identification (hazard mapping, risk assessment)	50	27.8
Slope stabilization	40	22.2
Watershed management	32	17.8
Evacuation	25	13.9

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Training related to climate resilience and agriculture	12	6.7
First-aid volunteers	10	5.6
Data recording	6	3.3
Early warning	5	2.8

Note. Participation was highest in identification activities (50 respondents, 27.8%), slope stabilization (40, 22.2%), and watershed management (32, 17.8%). Participation was notably low in early warning (5, 2.8%), data recording (6, 3.3%), and first-aid volunteering (10, 5.6%).

5.3.3 Documented Policy Gaps

Analysis of key policy documents, including NAPA, LAPA, and the National Climate Change Policy, combined with findings from key informant interviews, revealed consistent gaps in implementation. Identified gaps include weak coordination among federal, provincial, and local levels of government, insufficient financial and technical resources at the municipal level, and limited monitoring and evaluation of LAPA activities. Furthermore, the systematic exclusion of marginalized groups such as Dalits, women, and landless households from decision-making processes represents a critical and recurring barrier to effective implementation.

6. Discussion

The findings demonstrate that climate hazards in the Upper Karnali Basin vary considerably across space. The upstream area primarily experiences water scarcity, the midstream area is predominantly affected by landslides, and the downstream area faces the greatest exposure to floods. This pattern is consistent with earlier studies (Khatiwada et al., 2016; Panthi et al., 2019). However, the present study makes a further contribution by providing disaggregated evidence at the municipality level. This spatial variation challenges the assumption that basin-wide adaptation plans such as LAPA can be applied uniformly and remain effective across diverse contexts. Adaptation measures therefore need to be tailored to local topographic and hydrological conditions.

The high levels of agricultural loss (59%) and livestock decline (39%) corroborate earlier findings on economic vulnerability (Pokhrel et al., 2021; Sharma et al., 2020). At the same time, the continued reliance on traditional coping strategies, particularly agro-pastoral diversification (61%), even under conditions of increasing hazard exposure, indicates that indigenous practices remain significant. Nevertheless, these practices are under growing pressure and may be approaching their functional limits.

A critical contradiction exists between policy intent and ground reality. Although NAPA and LAPA explicitly prioritise vulnerable groups, Dalits, women, and landless households participate far less in formal adaptation activities (early warning 5%, data recording 6%) compared to labour-intensive tasks (slope stabilization 40%, watershed management 32%).

This “participatory exclusion” aligns with political ecology perspectives (Adger et al., 2013; Ribot, 2014), but elite capture is not the sole explanation. Constitutional ambiguity over federal, provincial, and local roles (Schedules 5–8 of the 2015 Constitution) creates accountability gaps, and donor-driven project cycles prioritise short-term visible outputs over long-term institutional strengthening. These structural factors interact with local power relations to produce “policy evaporation” (Vij et al., 2018).

Hydropower projects such as Upper Karnali (900 MW) and West Seti (750 MW) are being implemented with limited integration of climate risk assessment and inadequate benefit-sharing mechanisms. These processes frequently exclude local communities, particularly Dalits, which underscores an important yet underexplored tension between large-scale infrastructure development and community-based adaptation.

How these findings extend previous research

This study makes four key contributions to the existing literature. First, it provides the first municipality-level comparison across a Himalayan basin, demonstrating that Local Adaptation Plans of Action (LAPAs) are ineffective unless spatially tailored to local conditions. Second, it quantifies participatory exclusion by showing that marginalized groups participate in 40 to 60% of labour activities but in less than 10% of decision-making processes. Third, it directly compares traditional coping strategies, recorded at 61% usage, with formal adaptation measures such as early warning systems, recorded at only 5%, demonstrating that traditional strategies require policy support rather than replacement. Fourth, it establishes a documented link between large-scale hydropower projects and local adaptation gaps at the municipal level, a connection that has not been previously examined in the literature.

Theoretically, this study shows that socio ecological systems (SES) in the Himalaya function as nested governance units that require polycentric coordination across municipalities within the same basin. This dimension is largely absent from current SES applications in Nepal. Practically, addressing the policy implementation gap requires spatially targeted revisions of LAPAs, integration of traditional knowledge, investment in community based early warning and data systems, and institutional reforms such as quotas and social audits to ensure that marginalized groups participate in decision making rather than only in labour activities.

7. Conclusion

This study shows that the Upper Karnali River Basin experiences different climate hazards across different areas. Water scarcity is mainly concentrated in the upstream region, landslides are most common in the midstream region, and floods pose the greatest threat in the downstream region. These hazards create serious economic impacts, including agricultural losses and livestock decline. They also cause significant social impacts, such as water scarcity and the loss of traditional livelihoods. Although national policy frameworks, including NAPA and LAPA, are well designed, their implementation at the local level is weakened by poor coordination between governments, inadequate funding, limited technical capacity, and elite capture that excludes marginalized groups such as Dalits, women, and landless households.

Traditional coping strategies continue to be valuable, but they are facing increasing pressure as climate hazards become more severe. Effective adaptation requires spatially targeted planning, stronger integration of traditional knowledge into local frameworks, investment in community based early warning systems, and institutional reforms that ensure meaningful participation of marginalized communities in decision making. Future research should examine how these governance gaps can be systematically addressed across similar mountain regions within the broader Hindu Kush Himalaya, where comparable adaptation challenges continue to exist.

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Appendix A

Table B1. Summary of research gaps in the existing literature and how the current study addresses them

Gap	Description	How Current Study Addresses It
Spatial heterogeneity	Most studies treat the basin as homogeneous.	Compares three municipalities across upstream (Pachaljharana), midstream (Bhairavi), and downstream (Jagannath) segments.
Vertical governance	Limited analysis of multi-level coordination.	Conducts KIIs with federal, provincial, and local officials; analyzes policy documents.
Marginalized groups	Dalits, women, landless rarely centered.	Purposively samples these groups (60 households per municipality).
Traditional vs. formal adaptation	Unclear relationship between indigenous practices and LAPA.	Compares self-reported traditional strategies with LAPA-prescribed activities.
Hydropower-adaptation nexus	Few studies examine infrastructure impacts on local adaptation.	Assesses climate risks to hydropower and benefit-sharing mechanisms.
Static economic assessments	Most studies capture climate impacts at one point in time, missing cumulative vulnerability.	Uses retrospective recall to track repeated shocks and their effects on household assets, debt, and livelihoods.
Participation as binary	Community participation is often treated as present/absent rather than as a continuum.	Disaggregates participation into labour-intensive activities (e.g., slope stabilization) vs. decision-making activities (e.g., planning, budgeting, monitoring).

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Appendix B: Major themes and sub-themes from qualitative analysis

Major Theme	Sub-themes
Climate hazards	Floods, landslides, droughts, forest fires, erratic rainfall, glacial retreat
Environmental change	Loss of biodiversity, deforestation, water scarcity, soil degradation, ecosystem pollution
Economic impacts	Agricultural loss, livestock decline, food price rise, disaster recovery costs, job loss, infrastructure damage
Social impacts	Water scarcity, loss of traditional livelihood, education disruption, migration and displacement, resource scarcity for local crafts, increased inequality
Water-related crises	Impact on agriculture, drying up water sources, wildlife migration, reliance on distant tap water, human-wildlife conflict
Traditional coping strategies	Agro-pastoral diversification, community-based resource management (*kulo*, *parma*), mutual support systems, use of traditional medicine, mobility/livelihood diversification, spiritual/cultural practices
Formal adaptation activities (LAPA)	Hazard identification, slope stabilization, watershed management, evacuation, training, first-aid, data recording, early warning
Governance gaps	Weak multi-level coordination (federal-provincial-local), inadequate financing, limited technical capacity, poor monitoring and evaluation, elite capture, exclusion of Dalits/women/landless
Community participation	Labour-intensive activities (high engagement) vs. decision-making activities (very low engagement)