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A Governance-Based Analysis Of The Policy-Practice Gap In Glacial Flood Risk Management In Uttarakhand

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Abstract
Uttarakhand is a predominantly Himalayan state with extensive snow and glacier cover, which increases exposure to glacial floods. Experience from Kedarnath in 2013, Chamoli in 2021, and reported incidents near Dharali in 2025 shows a rising risk as climate change accelerates glacier retreat. Although national bodies like the National Disaster Management Authority have issued detailed guidance, a constant gap remains between policy and practice. This paper argues that this gap reflects systemic governance shortcoming. Using a framework which combines policy implementation and multi-level governance, the study reviews India's glacial disasters policies and their application in Uttarakhand. The analysis identifies a pattern of public safety conflicts with powerful economic interests in hydropower and tourism. Four linked drivers emerge: ambiguous mandates and unfunded local responsibilities; project-based, response-heavy risk management that sidelines prevention; weak coordination, including slow data sharing and procurement; and incentives that favour short-term growth over risk reduction. The paper suggests practical steps: setting up clear land-use rules with strict no-build zones in dangerous areas; making hazard maps for river basins; building effective early warning systems and running regular community drills; keeping maintenance budgets and independent audits. Learning from international case studies, India can build a forward-looking, and resilient system to manage Glacial disaster risks.
Keywords: *Glacial lake outburst floods; Disaster governance; Multi-level governance; Early warning systems; Uttarakhand; Policy implementation.*

1. INTRODUCTION

The Hindu Kush Himalaya (HKH) region is identified as the "Third Pole"-the highest accumulation of snow and ice outside the polar regions. It is the source of ten major Asian river systems, including the Indus, Ganga, and Brahmaputra, which provide water to more than a billion people (Azam et al., 2021). This region is highly sensitive to changes in climate, thus placing it at the critical forefront of climate change studies. The Intergovernmental Panel on Climate Change (IPCC) has conclusively stated that human activities have warmed the planet, which has led to rapid and irreversible changes in the climate system (IPCC, 2021).
Rising temperatures, changes in precipitation patterns, decrease in snowfall, widespread glacier mass loss, and an increase in glacial lake number and size are among those observed changes associated with the warming trend, especially in high mountain areas such as the Himalayas (IPCC, 2022). This scientific consensus lends strength to the rationale for the growing threat of Glacial Lake Outburst Floods (GLOFs). This view is further

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strengthened by the research of Azam et al. (2021), who state that glacier melting is non-uniform across the HKH region. Their model indicates that river runoff and glacier melt will keep increasing at least till the 2050s, a direct factor in the enhancement of glacial lakes and hence the higher risk of devastating floods.

Vulnerability of Uttarakhand

Within the HKH region, the Indian state of Uttarakhand is particularly vulnerable. Due to its particular mixture of fragile geology and high earthquake risk (being in Seismic Zones IV and V), northern Indian areas hosting high population densities in narrow river valleys create a high-risk environment (Rautela et al., 2020). The scale of the hazard is enormous. Uttarakhand has nearly 1,200 glaciers and a glacial lake inventory of 1,266, many situated in remote and hard-to-reach areas (Government of India, 2025a; Allen et al., 2016).

Many lakes have been declared potentially hazardous by national-level bodies such as the National Disaster Management Authority (NDMA) and categorized based on the level of risk, with several ranked at the highest risk mainly in the districts of Pithorgarh and Chamoli (Government of India, 2025b; NDMA, 2020). The rapid growth of many such lakes, as recorded from long-term monitoring, greatly increases the huge potential energy available for GLOF, highlighting the dynamic and intensifying nature of the hazard (Worni et al., 2013).

The history of the state is filled with the tragic instances connected with this vulnerability. One of the worst natural disasters in India during the 21st century was the disaster that struck Kedarnath in 2013, wherein extreme rains led to an outbreak of the Chorabari glacial lake, resulting in more than 6,000 casualties (Allen et al., 2016). The Chamoli disaster in 2021, on the other hand, was a mixed rock-ice avalanche that metamorphosed into a highly destructive flood killing over 200 individuals and obliterating crucial infrastructure (Shugar et al., 2021). The recent flash flood in Dharali in August, 2025 was triggered by intense rainfall, leading to debris-laden flows that destroyed homes, buildings, bridges, roads, and resulted in loss of life (Indian Space Research Organisation, 2025). These events forewarn of the destructive capability of the hazards in the high mountainous terrains of Uttarakhand.

Research Problem

Despite a scientifically informed national framework for managing Glacial Lake Outburst Floods (GLOFs), a serious gap remains between policy intent and practice in Uttarakhand. This study argues that the gap is not simply due to difficult terrain or scarce resources; it reflects a systemic governance failure. Well-articulated policies, such as the National Disaster Management Authority's (NDMA) 2020 guidelines, do not consistently translate into effective, life-saving action, as seen in Kedarnath (2013) and Chamoli (2021). The core problem is to identify the political, institutional, and structural barriers that block the local implementation of national GLOF guidance. The study moves beyond technical explanations to examine the governance dynamics that sustain this policy–practice gap.

Rationale and Significance

The rationale is urgency and relevance. As climate change accelerates glacier melt, risks to downstream communities, infrastructure, and local economies in Uttarakhand are increasing. While research has advanced hazard identification and modelling, far less explains why available knowledge and national guidance do not translate into prevention and preparedness on the ground. This study addresses that gap by shifting attention from the physical hazard to the workings of disaster governance. Using a policy-implementation lens it offers a detailed account of how mandates, incentives, and institutions shape outcomes in a high-stakes Himalayan setting. The contribution is practical: by pinpointing where implementation fails within existing structures, the study provides a foundation for targeted, evidence-based measures to reduce the policy–practice gap and strengthen the safety and resilience of vulnerable communities in Uttarakhand and similar high-mountain regions.

2. A Framework for Analyzing Implementation Failure in Disaster Risk Governance

To face complex and growing risks like GLOFs, we need a way of thinking that goes beyond basic emergency response. This concept would provide the framework for disaster governance. Tierney (2012) defines disaster governance as being a system with multiple centers of decision-making that operate at multiple levels simultaneously and have the presence of so many governmental and non-governmental actors. Effective disaster governance is not only for a crisis situation; rather, it demands joint action throughout the disaster life cycle: mitigation, preparedness, response, and recovery. One of the key points of this framework is that disaster governance is "nested within and influenced by overarching societal governance systems" (Tierney, 2012). This means that weaknesses found in the broader public administration system such as lack of transparency, weak accountability, or corruption will inevitably translate as problems in a system set for specific types of disaster governance. In this regard, the failures of GLOF management should never be viewed alone but rather be seen as symptoms of the broader governance context within which they occur.

Why Policies Fail: Implementation Theory

Pressman and Wildavsky (1973) provide a foundation for the theory behind why well-intentioned policies often fail to meet their goals. Studying the Oakland Project, a federally funded project that failed despite adequate funding and political support, they posed the "complexity of joint action." Pressman and Wildavsky's contention was that the success of implementation of a given policy decreases with every additional decision point and clearance demanded from competing, often disjointed actors. Each actor acts in its own interest, with its priorities and ways of doing things, creating an excessively long and fragile chain of dependencies. Yet, a single point of disagreement or delay can bring the process to a complete stop. Such a model is especially relevant in GLOF risk management in India, which demands coordinated action among many national, state, and local agencies, scientific institutions, and community groups. It would further predict that such a system is prone to delay and failure if not strongly coordinated with clear lines of authority (Pressman & Wildavsky, 1973).

While Pressman and Wildavsky make a good case for explaining the structural nature of implementation difficulties, the Ambiguity-Conflict Model presented by Richard Matland (1995) offers a strong tool for thinking about the politics of implementation failure. Matland proposes that two variables shape implementation processes: policy ambiguity (how clear goals and methods are) and policy conflict (how much disagreement there is among stakeholders over said goals and methods). This produces a fourfold matrix of implementation situations (Matland, 1995). The first, Administrative Implementation, occurs when conflict and ambiguity are low, so implementation is a technical job contingent upon resources; the second, Political Implementation, occurs when ambiguities are low, but conflict is high, thus turning implementation into a power struggle among competing interests. The third, Experimental Implementation, arises out of high ambiguity and low conflict circumstances where local actors have great leeway in adapting the policy to their needs. The final one, Symbolic Implementation, turns both ambiguity and conflict to the highest grade, such that implementation becomes a battleground over interpretation of meaning in terms of local groups. This framework enables a more fine-grained understanding of why a policy is failing to be implemented as intended, to distinguish between failures caused by capacity, consensus, or clarity (Matland, 1995).

Multi-Level Coordination Challenges

The final part of the analytical framework analyzes coordination challenges that come up under a decentralized system. Hooghe and Marks's (2003) theory of Multi-Level Governance (MLG) gives a way to address the relationships between different levels of government, both vertically (national-state-local) and horizontally (between departments). They identify two main types of MLG. Type I MLG comprises general-purpose, non-overlapping jurisdictions organized in a few levels nested together, designed for stability with clear responsibilities attached. On the other hand, Type II MLG consists of numerous task-specific jurisdictions overlapping with one another by design, allowing for more flexibility in response to concrete needs, thereby giving way to a more fluid and fragmented system.

The disaster management structure in India has been constitutionally envisaged as being of Type I, having clear levels from the national to the district. This paper will argue, that in practice, the system has a large number of agencies that act like a Type II system, but one in which management of competing interests has broken down. To paraphrase, there is an ever-growing number of agencies with overlapping responsibilities, unclear lines of authority, and informal arrangements for coordination. This creates confusion and competition for resources and mutual blame. This structural fragmentation does nothing to curtail the "complexity of joint action" identified by Pressman and Wildavsky but further exacerbates the problem, creating an environment where consistent and effective implementation of GLOF risk management policies becomes almost impossible (Hooghe & Marks, 2003).

3. India's GLOF Risk Management Policy Framework

National Guidelines and Programs

At the highest level of India's disaster management structure, GLOF risk policy is detailed and based on scientific knowledge. The most important document remains the NDMA Guidelines on Management of Glacial Lake Outburst Floods (2020). These guidelines designed a clear plan for the central and state agencies with a pan-disaster management cycle approach. It recommends for the identification and mapping of potentially dangerous lakes in a systematic manner through field observations and technical data, coupled with the use of newer technologies such as Synthetic-Aperture Radar (SAR) imagery to monitor changes in water bodies. The guidelines suggest both structural and non-structural interventions.

Structural interventions relate to engineering interventions to reduce risk, for example, lowering the lake water levels by controlled means. The non-structural approaches consist of strict enforcement of land-use planning to avoid development in zones where hazards are high, which is considered to be a very effective means of risk reduction (NDMA, 2020; Joshi et al., 2022). Capacity building for the preparation of teams at the local level for emergency response is deeply stressed, along with the creation of strong End-to-End Early Warning Systems (EWS) in vulnerable localities, with alarm systems and evacuation procedure being a part of the program (NDMA, 2020; Government of India, 2025b).

To take these guidelines into operation, the central government sanctioned the National GLOF Risk Mitigation program (NGRMP). It serves as the main body to fund and assist the program, with a total allotment of Rs. 150 crore for all four Himalayan states, which includes Rs. 30 crore for Uttarakhand (Government of India, 2025a; Government of India, 2025b). The objectives of the NGRMP are straightforward: prevent loss of lives, minimize economic damage, strengthen EWS with the ability to reach the last person, and develop scientific and technical capabilities at the local level (Government of India, 2025a; Government of India, 2025b). In an effort to improve coordination, NDMA initiated the Committee on Disaster Risk Reduction (CoDRR), bringing representatives from various central and state agencies in an all-inclusive "whole-of-government" approach to encourage sharing of information, technology, and scientific resources (NDMA, 2024; Government of India, 2025a).

Supporting Agencies and Technical Framework

The national framework of policies is further supported by a web of specialized central agencies that provide the scientific and technical backbone in GLOF risk management. Their function differs, though it may be inter-linked. The Central Water Commission (CWC) uses remote sensing technology to monitor glacial lakes and water bodies (more than 902) in the Indian Himalayas with several noteworthy publications such as "Criteria for Risk Indexing of Glacial Lakes," which suggest the standard methods to rank lakes for hazard level and downstream damage potential (Central Water Commission, n.d.; Government of India, 2025a). The Geological Survey of India (GSI) undertakes long-term glacier retreat monitoring and glaciological studies of glacier mass balance and is involved in detailed geological and technical investigations; hence, GSI plays an important post-disaster technical advisory role regarding safe reconstruction (Government of India, 2025a; Government of India, 2025c). The last agency in this linkage is the NRSC under ISRO, which facilities the agencies with satellite data and the inventory of glacial lakes, which all agencies use for monitoring, risk analysis, and modeling (NRSC, 2023; Government of India, 2025a).

State Implementation Structure

The power to implement national policies and guidelines at the ground level is vested in the state government. The Uttarakhand State Disaster Management Authority (USDMA), which has the Chief Minister as its Chairperson, is the apex body responsible for disaster management in the State. According to the Uttarakhand State Disaster Management Plan, some of its functions are the formulation of policies at the State level, coordination of different departments, overseeing training programs, and implementation of Early Warning Systems (EWS) (USDMA, 2020; Rautela et al., 2020). These responsibilities are transferred down to the District Disaster Management Authorities (DDMAs) at the district levels that are entrusted with district-level planning and implementation, community awareness programs, and coordination of initial responses for any disaster. This structure is meant to provide an unambiguous, vertical chain of command allowing the free flow of policy, finance, and directions from NDMA at the national level to USDMA at the state level to DDMAs for local implementation.

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Table 1. The Multi-Level GLOF Governance Matrix in Uttarakhand

Governance Level	Institution/Actor	Mandated Role/Responsibility	Key Policy/Legal Instrument
National	National Disaster Management Authority (NDMA)	Policy formulation, guideline issuance, NGRMP oversight, inter-agency coordination through CoDRR.	Disaster Management Act 2005, NDMA GLOF Guidelines 2020.
	Central Water Commission (CWC)	Monitoring of glacial lakes, development of risk indexing criteria, issuing dam safety guidelines.	CWC Technical Guidelines.
	Geological Survey of India (GSI)	Glacier monitoring, post-disaster geological assessment, site-specific hazard analysis.	GSI Mandate.
	National Remote Sensing Centre (NRSC)	Provision of satellite data, preparation of glacial lake inventories.	NHP Mandate.
State	Uttarakhand State Disaster Management Authority (USDMA)	Preparation and implementation of State DM Plan, coordination of state agencies, EWS implementation, capacity building.	Uttarakhand State DM Plan 2020.
	State Line Departments (e.g., Forest, PWD, Irrigation)	Integration of DRR into sectoral planning, execution of mitigation works, providing technical support.	State DM Plan.
District	District Disaster Management Authority (DDMA)	Preparation and implementation of District DM Plan, first response coordination, community awareness, local EWS dissemination.	Disaster Management Act 2005.
Local	Panchayati Raj Institutions (PRIs) / Urban Local Bodies	Participation in planning, information dissemination, management of community shelters, first responders.	NDMA GLOF Guidelines 2020.
	Community / Local Teams	First responders (search & rescue), participation in drills, providing local knowledge, monitoring local conditions.	NDMA GLOF Guidelines 2020.

4. A Critical Assessment of GLOF Management in Uttarakhand

Risk Assessment Challenges

Traditional GLOF risk assessment in Uttarakhand has largely centered on creating and working through lists of glacial lakes (Worni et al., 2013). Such lists, constructed mostly with satellite imagery, have the merit of providing a first impression of which lakes may harbor danger, but one major weakness is that they do not wholly represent the dynamic and intricate processes that may result in a disaster. Many GLOFs result from a chain of occurrences: rock or ice avalanches, thawing of frozen ground that weakens moraine dams, and so on, with extreme weather frequently featuring as the final trigger. These triggers do not appear on a simple list describing a lake's size and volume (Gurung et al., 2023).

In fact, even in the current framework, slow response from the state to identified risks can be seen. Based on this, the NDMA identified high-risk lakes for on-site assessment by expert teams commissioned by the erstwhile Uttarakhand government, which reinforced the stated deficiencies in governance and protracted procedural delays concerning some identified risks, where nothing could have prevented a timely risk reduction effort (Rautela et al., 2020).

Disaster Case Studies: 2013 and 2021

The 2013 disaster was the major turning point for disaster management in Uttarakhand, where a GLOF from Chorabari glacial lake broke its moraine dam following a bout of extreme rainfall and rapid snowmelt (Allen et al., 2016; Worni et al., 2013). Sudden flooding with large volumes of debris destroyed the town of Ram Bada and wrought such large-scale destruction in Kedarnath that around 6,000 lives were lost (Allen et al., 2016).

A later performance audit by the Comptroller and Auditor General (CAG) of India castigated the preparedness and response of the state government with harsh words. According to the CAG report, in the initial few days, "government machinery remained virtually clueless" and its response was "grossly inadequate given the scale of destruction" (Comptroller and Auditor General of India, 2015). Further, it alleged that State Disaster Management Authority (USDMA) has been "virtually non-functional since its inception" and important warnings of heavy rainfall given by the India Meteorological Department were disregarded by district officials (Comptroller and Auditor General of India, 2015).

These governance failures passed well into the post-disaster recovery and reconstruction stages. A separate CAG audit of the reconstruction found many problems, including diversion of funds meant for disaster-hit areas to other projects, inefficient utilization of centrally allocated funds despite their timely release, and unexplained delays in completion of projects (Comptroller and Auditor General of India, 2018). According to the report, monitoring and controlling the quality of reconstruction works was not centrally organized (Comptroller and Auditor General of India, 2018). This is evidence of very deep-rooted systemic governance, accountability, and financial management problems, which far exceed the initial disorder caused by a disaster.

The 2021 Chamoli disaster offered one more major lesson on how the state remains vulnerable to the complex and cascading hazards beyond simple GLOFs (Shugar et al., 2021; ICIMOD, 2021). It is a clear-cut demonstration of this instance. This was not an ordinary GLOF where a moraine dam fails. Instead, it resulted from a huge rock and ice avalanche from Ronti Peak (Shugar et al., 2021). The kinetic energy from the avalanche induced melting of ice and snow, giving rise to a debris flow which obliterated everything in its path downstream (ICIMOD, 2021). Hazards of this variety, which are initiated by a high-altitude slope failure rather than an existing lake, are not covered through traditional GLOF lists, pointing to a major blind spot in the state's hazard assessment approach. Moreover, examination of satellite imagery before the collapse indicated that the slope had been moving for a number of years. This shows that a more dynamic monitoring system might have given a warning (Jacquemart et al., 2022).

The detachment of about 27 million cubic meters of rock and ice from Ronti Peak caused a high-velocity debris flow that obliterated the Rishiganga and Tapovan Vishnugad hydropower projects, thus highlighting the extreme threat faced by critical infrastructure erected in these volatile river valleys (Shugar et al., 2021).

Although the immediate response comprised of national level forces such as NDRF and Indo-Tibetan Border Police (Government of India, 2025b), serious questions about the lacunae in the pre-emptive mitigation and monitoring are once again raised by this event. The disaster brought out the reactive nature of the state's disaster management system. This modus operandi of being reactive to the last disaster instead of proactively preparing for a host of future risks provides for a systemic inability to learn and adapt. Due to seismic hazards, the state is heavily invested in an earthquake EWS but the same level of proactive push for monitoring cryospheric hazards like slope instability and GLOFs is still wanting (Mittal et al., 2024). This gives rise to a "hazard-of-the-month" problem where the institutional focus keeps moving according to the latest disaster compromising the development of a genuinely integrated multi-hazard risk management system that foresights and mitigates the complex threats of a changing climate.

Early Warning System Gaps

The NDMA guidelines 2020 rightly stress the importance of an effective EWS as a vital lifesaving measure (NDMA, 2020). However, the initiation of GLOF-specific EWS in Uttarakhand has been very slow. The problem is not just installing sensors and sirens; it is also about solving the "last-mile connectivity" problem. The last-mile concept is not linked only to the technology used to send a warning but indeed concerns the whole chain of communication to ensure an alert message is received, interpreted correctly, and acted upon by the most remote and vulnerable communities (Dash & Jagirdhar, 2022; Huggel et al., 2012).

This last mile now stands as a major gap in Uttarakhand, with very few attempts being made to repair it. The reports and experts' opinions keep pointing to this prolonged gap where there is a total absence of meaningful community engagement in the entire disaster management process (Joshi et al., 2022; Rautela et al., 2020). The communication infrastructure in high-altitude villages is subpar, and in worse cases, hardly existent. It has never been thought essential to develop local capacity for disaster response (Kumar et al., 2024). The resources and focus of the state institutions remain overly oriented toward post-disaster response, as can be seen in the well-equipped State Disaster Response Force (SDRF). Alongside its impressive capabilities, the existence of SDRF buys into the reactive approach where the preparedness begins mostly after disaster has struck (Kumar et al., 2024). This focus on centralized, top-down response has come at the cost of forgetting to inject resources into a decentralized, community-based preparedness approach, which is crucial for last-mile connectivity in those initial minutes and hours after a GLOF events.

5. An Application of Implementation and Governance Theories

Implementation Complexity

Applying Pressman and Wildavsky's (1973) framework to the multi-level governance setup (as shown in Table 1) reveals the immense procedural complexity of GLOF risk management in Uttarakhand. Hence, even the implementation of one simple measure-say the installation of an EWS for a high-risk lake-requires a long and highly complicated chain of "decision points" and "clearances" from actors who have diverging responsibilities and priorities.

Typically, the process would begin with an instruction from the NDMA (a national-level decision point) pertaining to funding realized through the NGRMP, and this will require technical inputs of the CWC alongside geological survey by the GSI. At the state level, the USDMA would have to grant administrative approval and interact with several departments, such as the Forest Department for environmental clearances and the Public Works Department for access. Then the DDMA would be in charge of local implementation concerning tendering, procurement, and the actual work on-site. At the end of the day, the local community would have to consent and partake in social acceptance; otherwise, the project will not fare well in perpetuity. Thus, at each stage, the project can get terminated or delayed significantly. This "complexity of joint action" hence explains why things continue to be implemented at a snail's pace, with an enormous number of necessary inter-agency agreements causing procedural gridlock (Pressman & Wildavsky, 1973).

Political Conflict vs. Safety Goals

If procedural complexity explains the failure, Matland's (1995) Ambiguity-Conflict theory presents a very telling comment on why this is so. An analysis of GLOF management in Uttarakhand reveals an insurmountable policy conflict to be defining factors in the policy-practice gap rather than ambiguity. The GLOF threat's nature is scientifically well-founded, and the NDMA guidelines (2020) are straightforward, specifying exactly what needs to be done (NDMA, 2020). Hence, the level of policy ambiguity is low. However, a high degree of conflict exists between the policy's declared aim of disaster risk reduction and the often unspoken but very powerful policy objectives of economic development through massive hydropower projects and the furtherance of tourism infrastructure in an unregulated way. The ongoing construction of hydropower projects in highly vulnerable river valleys, two of which were destroyed in the 2021 Chamoli disaster, is proof of this conflict (ICIMOD, 2021; Shugar et al., 2021). Likewise, the non-enforcement of land-use regulations and the promotion of construction in flood plains stand for safety being ferry prioritized (Joshi et al., 2022; Rautela et al., 2020).

Low ambiguity-high conflict status therefore places GLOF risk management in Uttarakhand squarely in the "Political Implementation" area of Matland's framework (Matland 1995). Here, implementation is no longer a rational, technical process guided by evidence and resources but rather a political contest in which outcomes are decided by the relative power and influence of competing interests. The persistent failure to implement key safety measures, such as land-use zoning, demonstrates that the interests of development and infrastructure lobbies have consistently prevailed over the policy mandate for risk reduction.

Table 2. Diagnostic of Implementation Challenges via the Ambiguity-Conflict Model

GLOF Management Component	Policy Ambiguity Level	Policy Conflict Level	Resulting Implementation Type	Evidence/Justification
Hazard Zonation & Land-Use Planning	Low	High	Political	NDMA guidelines are clear on restricting development. However, this directly conflicts with powerful tourism and infrastructure development interests, leading to widespread non-enforcement and continued construction in vulnerable areas (Joshi et al., 2022; Rautela et al., 2020).
EWS Installation for High-Risk Lakes	Low	Low	Administrative	The goal and technology are clear, and there is little political opposition to EWS. Delays in this area are primarily administrative failures: slow fund release, bureaucratic hurdles, and logistical challenges, rather than active opposition (Comptroller and Auditor General of India, 2015).
Community Capacity Building & Drills	High	Low	Experimental	NDMA guidelines call for community involvement but are vague on the specific methods. This ambiguity, combined with low conflict, results in an "experimental" approach where implementation is inconsistent and depends on the initiative of individual DDMAs or local NGOs, leading to varied outcomes (Kumar et al., 2024; NDMA, 2020).
Dam Safety Reviews for GLOF Impact	Low	High	Political	CWC mandates GLOF studies for new and existing dams. This is a clear directive but creates high conflict with the hydropower industry due to the potential for costly retrofitting or operational changes. Implementation is a political negotiation between regulators and powerful project proponents (Government of India, 2025a; Government of India, 2025b).

The Hooghe-Marks framework (2003) shows how the structural design of governance in Uttarakhand facilitates the continuance of this problematic political implementation situation. While India's disaster management system is Type I MLG nested system, its functioning is deeply flawed. There is a major disconnect and lack of effective vertical coordination between the national level, which lays strong, science-based policy, and state-district levels responsible for implementation (Hooghe & Marks, 2003).

State and district authorities often have limited resources, lack in-house technical expertise, and are more influenced by local political-economics concerns that run counter to national disaster risk reduction objectives (Kumar et al., 2024). One of the primary flaws lies with the absence of a dedicated, permanent disaster management apparatus in the state. Higher-level officials fill key posts on a temporary basis, an arrangement that has perpetually compromised the retention of institutional memory and an absence of long-term, special expertise for handling complex risks in this regard, mainly GLOFs (Kumar et al., 2024). This state-level institutional weakness then ruptures the implementation chain. It creates a fractured system where national policies are heard but never effectively translated into ongoing action, leaving in control the high-conflict dynamics of "political implementation" on the ground.

6. Lessons from Global Practices and Recommendations for Uttarakhand

International Models

To bridge the policy-practice gap, Uttarakhand can learn important lessons from international experiences concerning managing similar hazards. There are several countries with mature, integrated systems that can act as models for a more proactive and seamless approach. Switzerland exemplifies a long and successful history of integrated risk management concerning different natural hazards in mountainous regions. It is a holistic model that pairs advanced scientific hazard mapping with legally binding land-use zoning, structural measures for protection, and institutional arrangements with clear responsibilities across all government levels. This is a proactive and mature model where risk assessment directly influences decisions on development (Huggel et al., 2005).

Given Norway's substantial landslide risk compounded by extreme weather, it has developed its own sophisticated national Landslide Early Warning System (LEWS). A highlight of the Norwegian model is its combination of weather forecasts at the national level with data collection from local instruments. This multi-level method effectively fills the void between national- and local-level information systems and offers more precise and practical warnings for specific sites-a model that is very relevant given Uttarakhand's diverse terrain (Krøgli et al., 2018). Bhutan, as a Himalayan country facing similar GLOF threats, is especially relevant in teaching Ush-term lessons. Initiating the lowering of the Thorthormi Lake, essentially manual digging of a channel to reduce the water level of a dangerously poised glacial lake, stands out as an example of constructive, structural mitigation in a remote, high-altitude environment (UNDP, 2011; NCHM, 2019). Meanwhile, Bhutan has simultaneously invested in community-based risk reduction programs in order to build capacity at the local level, organize local disaster management committees, conduct awareness campaigns, and carry out evacuation drills. These steps are addressing the last-mile connectivity issue by empowering those communities that are at greatest risk (Gurung et al., 2023; UNDP, n.d.)

Reforms for Uttarakhand

Based on the diagnostic analysis and lessons learned from global best practices, many steps can be taken to deal with the systemic failures in GLOF risk management in Uttarakhand. To deal with systemic weaknesses, serious institutional strengthening and accountability measures are required. Basically, it may be recommended that a State Disaster Management Cadre be constituted. Upon instituting a permanent, professional cadre for the USDMA and DDMAs, this severe institutional problem of loss of institutional memory, lack of specialized knowledge will be resolved, and continuity shall be maintained while the state is able to develop a long-term technical capacity in cryospheric risk management. There would also be a clear career path for disaster managers, shielding them from politically motivated transfers (Kumar et al., 2024).

Along with this, the USDMA must be accorded greater financial and administrative autonomy to facilitate independence of execution of its mandate from any undue political influence. Consideration may be given for amending the legislation to confer on the USDMA the clear prerogative in relation to enforcement of the State Disaster Management Plan and NDMA guidelines within all line departments. To ensure respect for such prerogative, provision should be made for establishment of an independent third party audit mechanism, perhaps to be anchored under the aegis of the CAG, to periodically audit the implementation status of GLOF mitigation projects and hold responsible agencies accountable for delays in implementation and blatant non-compliance.

The risk assessment framework of the state should evolve from static inventories of glacial lakes and adopt an integrated multi-hazard approach that utilizes dynamic, process-based modeling for various cryospheric hazards, including rock-ice avalanches, debris flows, and potential cascading events. This will also mean forming deeper, more long-term partnerships with key scientific institutions like Wadia Institute of Himalayan Geology, GSI, and NRSC to prepare an integrated multi-hazard zonation map for the state, which is regularly updated.

To directly target the "political implementation" problem arising out of the conflict between safety and development, the state government must make GLOF and other cryospheric hazard impact assessments compulsory and non-negotiable as part of the environmental clearance of all major infrastructure projects such as hydropower projects, highways, and big tourism projects in high-altitude zones. The USDMA backed by independent scientific experts should be vested with the legal power to review and veto assessment reports of projects where the risk posed to downstream communities is considered unacceptably high.

Lastly, operationalizing last-mile connectivity requires operating a paradigmal change to a community-focused "first mile" approach (Kelman & Gaillard, 2018). The state must move away from an exclusive top-down, techno-centric perception of EWS and actively engage at-risk communities in the co-designing and co-implementation of the warning systems. This requires using participatory approaches such as to combine local and indigenous hazard knowledge, identify culturally suitable and trusted communication channels, and co-develop evacuation plans and routes. This must be complemented by mechanisms to empower local response teams: dedicated resources to train and equip community-based disaster response teams in each vulnerable village should be earmarked, as recommended in the NDMA guidelines (NDMA, 2020; Joshi et al., 2022). Comprising local volunteers, these teams will be responsible for local monitoring; disseminating warnings; managing community shelters; and conducting regular evacuation drills-consequently creating a robust and resilient local response capacity that can act in those critical first few moments.

7. CONCLUSION

This study set out to explain why strong national guidance on Glacial Lake Outburst Floods (GLOFs) does not turn into steady, local action in Uttarakhand. Looking at the Kedarnath (2013) and Chamoli (2021) events, and reading policies and official reports, the findings are clear. The main problem is not a lack of knowledge or difficult terrain alone. It is an implementation gap rooted in how governance works day to day. Four linked drivers stand out: roles and responsibilities are unclear and local tasks are often unfunded; risk work is organised as short projects that focus on response after disasters rather than prevention; coordination across departments and levels is weak, with slow data sharing and slow procurement; and incentives favour short-term economic gains in hydropower and tourism over long-term safety. In short, Uttarakhand faces a low-ambiguity, high-conflict setting where clear safety goals contrast with powerful growth interests.

The paper points towards practical measures already within the existing policy frame. These include: risk-informed land-use rules with enforceable no-build zones in hazardous areas; basin-wide hazard mapping that is kept up to date and used in approvals; layered early-warning systems linked to simple community protocols and regular drills; open checks of the combined impact of projects before clearances; dedicated budgets for operation and maintenance; and independent audits to track delivery. Lessons discussed from Switzerland, Norway, and Bhutan show that such approaches can work in mountain regions when roles, funding, and routines are clear.

Taken together, these steps can narrow the policy–practice gap without inventing new institutions. They ask the state to do common tasks reliably: define who does what, fund it, share data on time, and practice plans with communities. If these basics are in place, Uttarakhand can move from reacting after floods to preventing avoidable losses, strengthening the safety and resilience of people and infrastructure in the valleys at risk.

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