

Political Ecology of Water Security in the Indian Western Himalaya: A Critical Review

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Abstract

Consideration of water security in the Indian Western Himalaya (IWH) is dominated by discussions of glaciers, snow and river discharge. While these are important, they do not explain for instance why some villages, located on rivers, do not have dependable sources of drinking water, or why hydropower projects can redirect and alter the flow of water and energy. This critical review examines the literature on Jammu and Kashmir, Ladakh, Himachal Pradesh and Uttarakhand through political ecology and the concept of hydro social relations. It employs a narrative synthesis of 26 sources on the Himalaya, and a range of water security and hydro social literature, to examine the body of evidence. Five primary themes are presented: scarce water resources, weakening of springs and irrigation commons, hydropower and the shift of risk, urban water institutions and gendered burdens. In all, insecurity is manifest in the intersection of environmental change and unequal control of natural resources. The evidence is skewed towards Himachal Pradesh and Uttarakhand, and one of the key focal points of the study is drawn from a single site. Evidence from Jammu and Kashmir is limited to Dal Lake. The review concludes with six policy suggestions and an agenda for further study, focused on Ladakh and Jammu and Kashmir.

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1. INTRODUCTION

1.1 Water security as a contested concept

Water security has become a major frame of reference for water policies at the local, national and international levels. The term, in general, refers to the ability of people and ecosystems to gain access to safe and reliable water and to be protected from water-related extreme events, including floods and droughts (Sadoff et al., 2020) [31]. The concept is wide enough to encompass different fields including health, agriculture and ecosystems, as well as energy and development; hence, different institutions can use the same term to describe very different phenomena and, in the process, ignite debate on what is being secured, for whom and by whom (Cook & Bakker, 2012) [11]. A government can define security through the build-up and management of water supply and infrastructure, while a household in a mountainous area can define it as the flow of a spring that is maintained during the dry season. Hence, the term water security is more appropriately described as fluid and multidimensional (Marcal et al., 2021) [23]. Although the link between water security and sustainable development is apparent, this relationship cannot be considered social or politically neutral (Mishra et al., 2021) [24].

1.2 Water Security in Mountain Regions

Mountains affect water security well beyond their local populations. They store water in many forms and release it at different times to meet the needs of people and ecosystems downstream (Viviroli et al., 2011) [44]. This role does not secure mountain communities. Communities at the top of mountain ranges are often the first and hardest hit by climate change. These communities often live in vulnerable conditions and depend on small mountain streams and glaciers for their livelihoods (Sharma and Choudhury, 2021) [37]. During glacier retreat and reduced snowfall, local conditions can affect the availability of household water, agriculture and livestock, and also impact the health of the community. Using the phrase "water tower" to describe the role of mountains often provides an inadequate and misleading account of the stress and inequality occurring at the source.

1.3 The Indian Western Himalaya

For the sake of ease and practicality, this review groups Jammu and Kashmir, Ladakh, Himachal Pradesh and Uttarakhand as the Indian Western Himalaya (IWH). This is a pragmatic grouping, not a claim of hydrological similarity. In fact, the Himalayan arc spans from the cold, arid, winter-precipitation area of Ladakh to the monsoon-influenced areas of Uttarakhand and Kumaon and Garhwal. The former feeds the Indus basin (including upper Indus in Ladakh, Jhelum and Chenab in Jammu and Kashmir and the Ravi, Beas and Sutlej in Himachal Pradesh), while Uttarakhand supplies the headwaters of the Ganga and Yamuna. According to a recent review, the Western Himalaya has been called the "Water Tower of Asia" for its importance to the Indian plains. The review also states that warming in the range is between 0.2-0.5°C per decade and that some basins have experienced significant loss of glaciers, as well as declining snow cover since 2000. Such changes can impact dry season flow, river health and increase the frequency and intensity of peak flows. The review covers the Western Himalaya as a whole, and, therefore, the statistics it presents represent the larger region to which the IWH belongs.

Physical abundance does not always result in social access. Research on a few towns in Uttarakhand and Nepal shows what has been termed as 'scarcity amidst plenty'. Water is plentiful in the landscape, but the supply systems are 'unreliable, inefficient and uncoordinated' (Ojha et al. 2020, p. 522) [26]. Climate change and increasing population in the Beas basin is expected to drastically reduce future per-capita water availability (Li et al., 2015) [21]. In rural areas, households depend more on springs and groundwater and not on large rivers that dominate regional policy discourse (Sen & Kansal, 2019) [35]. As a result, the location and everyday use of land (recharge areas and land use) is central to water security.

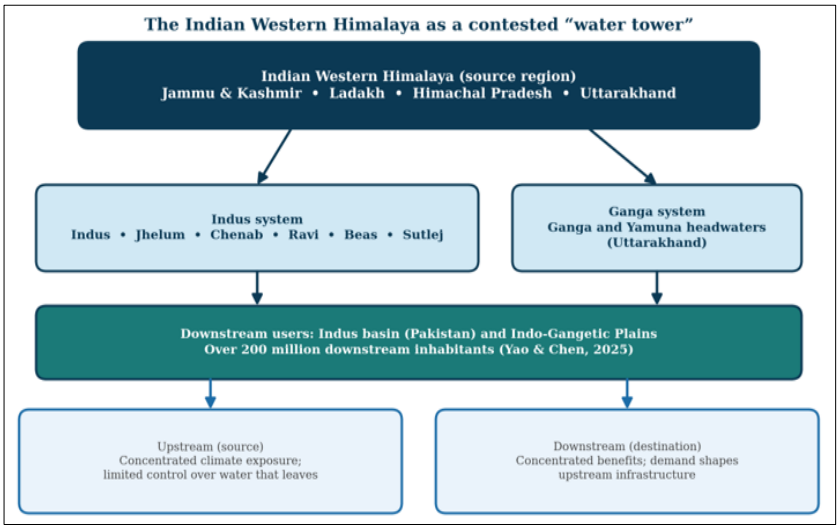


Fig 1: The Indian Western Himalaya as a contested "water tower." The source region drains to the Indus and Ganga Systems and provides downstream users in Pakistan and on the Indo-Gangetic Plains. Meanwhile, upstream communities have high climate exposure, while downstream users enjoy the benefits, what the scalar-political asymmetry developed in Section 6, refers to. The figure for the downstream population is from Yao and Chen (2025) [45].

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1.4 Political ecology as an analytical lens

Political ecology treats environmental degradation as social relations, and power structures as essential. It studies the relationships between different social groups and the environment, and how shifts in the environment impact various groups. It also studies what policy-related knowledges are accepted and why (Rodríguez-Labajos & Martínez Alier, 2015) [30].

Disputes over water are often assumed to be about supply and demand. However, other issues can also generate water conflicts. For instance, water can be polluted, water infrastructure (dams, canals) can change a community's livelihood, and communities may have disputes over land and/or water rights. Further, some communities may have the right to participate in making decisions, while others do not. The right to participate in making decisions and the right to access natural resources are key elements of community justice (Rodríguez-Labajos & Martínez Alier, 2015) [30].

Political ecology has the potential to deepen understandings of water-related conflicts, degradation and social injustices in the Himalaya. Earlier debates on environmental degradation in the Himalaya put the blame for downstream environmental problems on upstream populations. However, these statements were made selectively by different states and development actors. More recent geopolitical analyses of the Himalaya argue that the western part of the Himalaya is dominated by borders, rivers, national security and ice (Davis, 2022) [12]. With a political-ecological lens, the author connects concerns of local water issues with the state's energy and development policies and transboundary water politics.

1.5 THE RESEARCH GAP

Research on the Western Himalaya is growing, but uneven. A lot of recent review work focuses on temperature, glaciers, snow, river flows and hydrological extremes. One key regional review recognizes social impacts and policy responses but has no developed framework for analyzing power, inequality and governance and advocates for research that links change in the cryosphere and social and institutional aspects (Yao & Chen, 2025) [45]. Wider debates suggest that water security tends to shift towards issues of infrastructure and human (demand) aspects and focus less on the ecosystems and equity aspects (Saito et al., 2026) [32]. Here, the main issue is less about the lack of data on water changes and more about the absence of a sustained Political Ecology synthesis that shows how environmental changes and political choices combine to create insecurity in the IWH.

1.6 OBJECTIVES

This review has three objectives. First, it provides a Political Ecology of water security in the IWH that integrates concepts of access, power, hydrosocial relations, and environmental justice. Second, it synthesizes the main lines of literature on water and related systems, including hydropower, urban water supply, local institutions and gendered livelihoods. Third, it identifies knowledge gaps and suggests research and policy priorities. Its main objective is to consolidate and integrate existing, mainly case study-based, literatures on gender, hydropower and urban politics, as well as spring hydrology, into a single political ecology account.

Table 1: Roadmap linking the review's three aims to the sections that address them.

Aim	Addressed in	Focus
(1) Develop a political-ecological framework	Sections 2–3	Review design and the hydrosocial-production framework
(2) Synthesise the literature on water systems, springs, hydropower, governance and gender	Sections 4–6	Biophysical baseline, five-theme synthesis with its evidence base, and critical appraisal
(3) Identify weaknesses and propose priorities for research and policy	Sections 7–8	Policy implications, limitations and research gaps

2. METHODOLOGY

2.1 REVIEW DESIGN

This is a critical, political-ecology-informed narrative review. It is not intended to be exhaustive in the sense of reporting every study or article on Himalayan water. Its intention is to engage critically with already diverse literature on the subject using a single mode of analysis and to evaluate what is missing in that literature. A narrative type of review is most appropriate for bodies of work that span diverse disciplines, methods and source types that are often too varied to bring together or meta-analyze (Grant & Booth, 2009; Snyder, 2019) [18, 41]. Because it does not have the formal safeguards of a systematic review, the manuscript follows the reporting logic of the SANRA criteria for narrative reviews (Baethge et al, 2019) [4] and provides evidence that supports the claims made (Table 2).

2.2 Identifying Sources

Scopus, Web of Science and Google Scholar were searched for the terms "water security," "political ecology," "hydrosocial," "Himalaya," "Western Himalaya," "Uttarakhand," "Himachal Pradesh," "Ladakh," "Jammu and Kashmir," "hydropower," "spring depletion" and "water governance." "Spring depletion" and "hydropower" were excluded for the searches conducted in 2015 and later. Earlier, more foundational sources, were retained. Searches favored publications from 2015 onwards and were limited to English. Forward and backward citation tracking of key regional reviews was also done. Institutional and grey literature published by ICIMOD and other Himalaya focused institutions was searched. Searches were updated in month and year of last search.

2.3 Screening and Corpus

Records were kept if they were relevant to water security, water governance or water-related conflicts in the IWH, or if they included materials that were comparative or theoretical and related directly to the IWH. Baruah (2012) [6], Dukpa et al. (2019) [15] and Huber (2019) [20] on the eastern Himalaya, Nepal and Bhutan were included only for the second reason above.

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The review has identified two bodies of literature. The corpus of literature focused on the Himalaya comprises 26 sources. Of these, 12 are sources focused at the state level of the IWH, nine are regional and Himalaya-wide sources and five are comparative sources from outside the IWH (Appendix A). This body of literature includes 18 journal articles, two books, two book chapters, two PhD dissertations, and two research reports (both from ICIMOD). The second, framing body of literature focuses on water security, political ecology and hydrosocial relations, and provides the concepts and ideas used in other sections of this review. Each source in the corpus of literature was read in full.

2.4 ANALYSIS

Sources were coded based on four main questions from Section 3. The four questions were who defines water security, what infrastructures and institutions are authorized to provide water security, how are water access rights distributed among different social groups, and how are costs and risks associated with water security distributed. The codes were then organized based on an inductive grouping frame, and the five themes from Section 5. The analysis has two elements which respond to the limits of the narrative review. First, in order to show where a claim is well supported and where a claim is borrowed from other parts of the Himalaya, evidence is reported in Table 2, distinguishing state-level IWH sources from regional and comparative sources. Second, figures based on a single study are identified as such (Fig. 4). The sources and the coding were done by the same reviewer, a limitation discussed in Section 8.1. A record-level was not previously tracked.

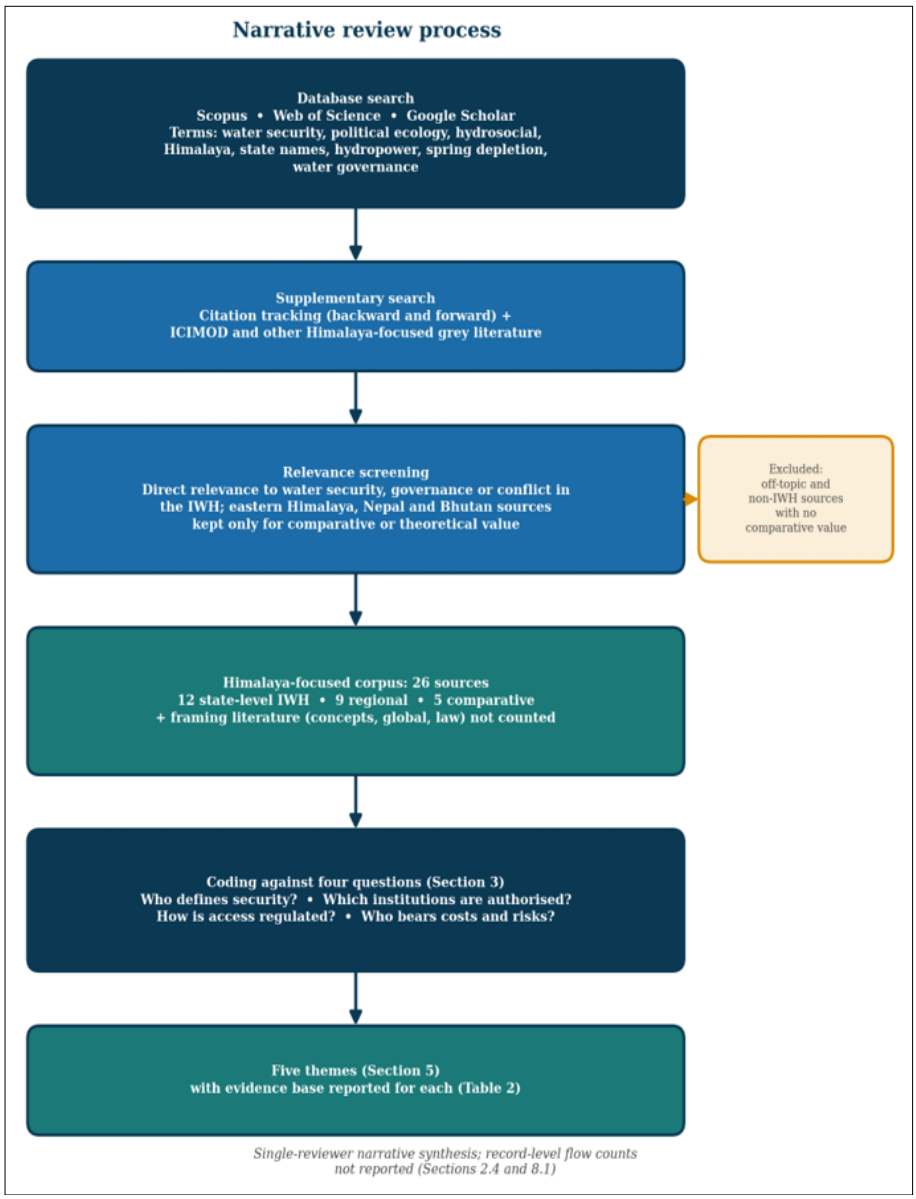


Fig 2: The narrative review process, from database search through relevance screening to coding and the five themes of Section 5. Counts refer to the Himalaya-focused corpus listed in Appendix A.

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3. Conceptual Framework: The Hydrosocial Production of Water Security

Political ecology considers water to be a social relationship as well as a material substance. However, the flow of water is not just a natural state, but is affected by dams, canals, pipes, as well as legislation, markets, land use, labour choices and political choices. A study on "apolitical" water governance demonstrates how technical language can conceal choices regarding whose needs are prioritised and whose risks accepted (Sayan, 2016) [34]. In India, for instance, scarcity is a socially constructed condition that can be achieved through caste, class, historical marginalization and unequal institutional power (Ranjan et al., 2026) [27].

The term "hydrosocial relations" is an umbrella term for this literature in this review. It includes the hydrosocial cycle, the concept of water and society mutually shaping each other in material and social interaction (Linton & Budds, 2014; Swyngedouw, 2009) [22, 42], and the more specific concept of hydrosocial territory, whereby water and social control, infrastructure and law, as well as cultural meaning are combined in contested spatial arrangements (Boelens et al., 2016) [9]. Various groups have different water worlds. A river can serve a variety of functions for various institutions; as an energy source for one, an irrigation source for another, and a part of a cultural landscape for yet another; and each use of the river carries its own claims, infrastructures and forms of authority (Feldblum, 2025) [16]. Conflict does not, then, indicate just that the governance system has failed to work. It can expose conflicting imaginations of water and, at times, create room for other institutions and water-justice movements (Rodríguez-Labajos & Martínez Alier, 2015) [30]. This review is a working one, addressing the questions of who sets the agenda for the problem, who holds the control over the solution, who has access to it and who bears the risks.

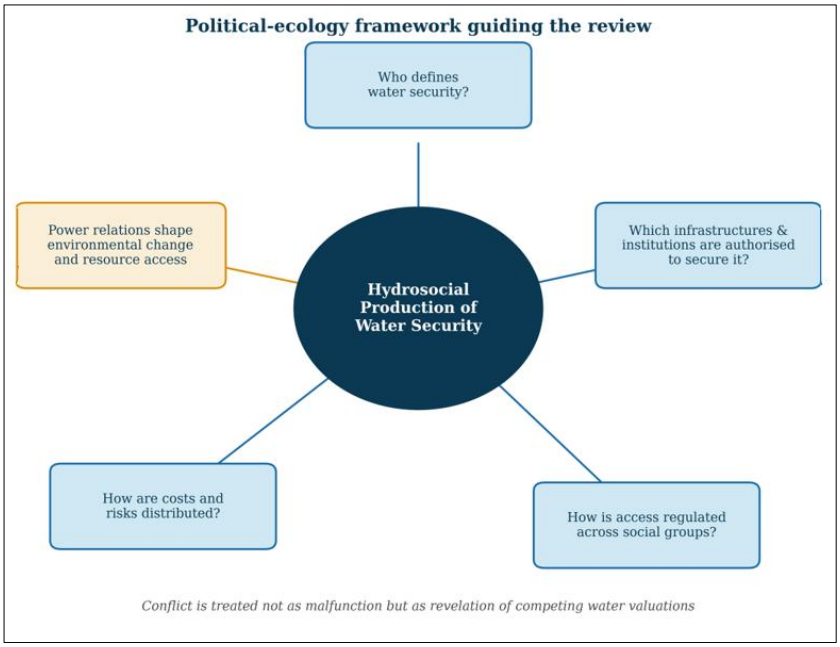


Fig 3: The political-ecology framework guiding the review. The four questions around the hydrosocial-production hub structure the thematic synthesis in Section 5 and the critical appraisal in Section 6.

4. The Biophysical Baseline: Water Stress in the Indian Western Himalaya

Physical changes in western Himalaya are well documented. A recent systematic review of the Western Himalaya as a whole reveals warming of 0.2-0.5°C per decade, glacier mass loss of up to 20-30% in some basins, and a 5-15% reduction in snow cover since 2000, along with less reliability of flows during the dry season and greater risk of more dangerous peak flows (Yao & Chen, 2025) [45].

Given that the Western Himalaya is being reviewed rather than the Indian part of the territory, the figures show direction and magnitude and not state-level measures for the IWH. The changes have implications for flood protection, irrigation, energy, drinking water and ecosystems. This evidence is not at odds with political ecology. It challenges how the risks are felt, and why some answers are considered more legitimate than others. The physical picture is also more complex than suggested by a scarcity narrative: Whereas glacier/snow melt is more relevant to the Indus basin than the Ganga, the projections for total runoff and seasonality are to increase until the 2050s with significant uncertainty (Azam et al., 2021) [3]. This is because in many areas the major challenge is not the volume but the timing and variability of the flow and its reliability in the near term.

A spring is the most important water source for many in the IWH, not a big river. The Indian Himalayan Region's (IHR) springs are crucial for domestic consumption, as well as for agriculture and local livelihoods, with estimates of almost 50 million to approximately 75 million people relying on these resources as their main livelihood, depending on counting practices (Ghimire et al., 2025; Sharma et al., 2024) [17, 38]. A study conducted in the Upper Kosi catchment in Kumaon

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(about 108 km2) reveals the impacts of spring decline: approximately 33% of natural springs in the catchment were found to be dry, while the majority of villages reported water scarcity for drinking, sanitation and agriculture purposes (Tiwari & Joshi, 2014) [43]. It is a single small catchment and acts as a mechanism and not necessarily a regional rate. These are not straightforward climate-damage figures. The future usability of a spring is also heavily influenced by land use changes, decreasing recharge rates, institutional neglect and changing demand.

There's another layer of water infrastructure. Hydropower operations have also spread throughout the Indian Himalaya and have created numerous conflicts. Participatory mapping in Himachal Pradesh identified 17 conflicts regarding hydropower projects, suggesting a regional trend and not local opposition to individual projects (Del Bene, 2018) [13]. The environment under review is therefore a mountainous environment that is under stress from an environment and water is being reallocated between households, farms, cities, industry and energy projects.

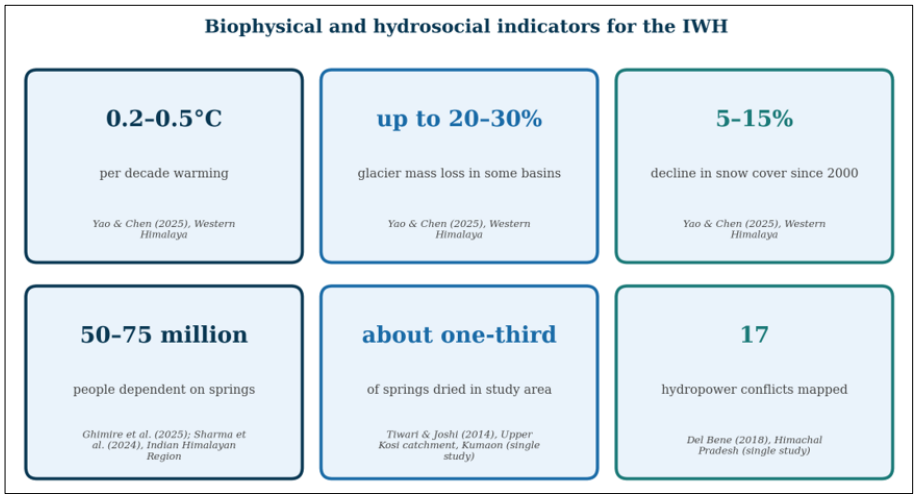


Fig 4: Key biophysical and hydrosocial indicators for the Indian Western Himalaya, with the source and spatial scope of each figure. The warming, glacier and snow figures come from a review of the whole Western Himalaya. The spring-drying and hydropower-conflict figures come from single-site studies and are indicative, not region-wide estimates (Section 8.1).

5. Thematic Synthesis: Political Ecologies of Water in the IWH

The reviewed literature converges on five recurring, interlinked themes (Fig. 5), developed below. Table 2 summarises the mechanism in each theme and the evidence behind it.

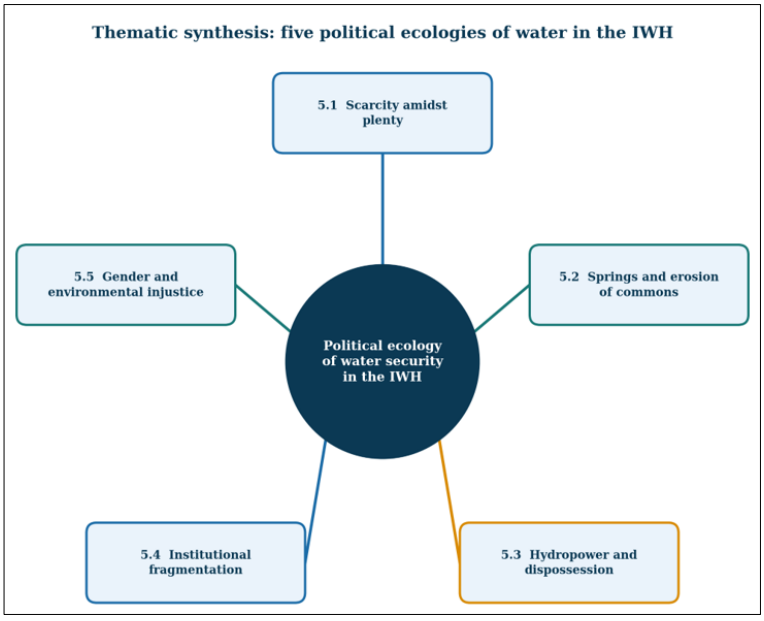


Fig 5: Five political ecologies of water security in the IWH identified through coding of the reviewed literature (Section 2.4).

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5.1 Scarcity Amidst Plenty: The Social Production of Water Insecurity

Institutions rather than water supply are the source of water insecurity in water-rich places, as is documented in literature. In five Himalayan towns, including two towns in Uttarakhand (Mussoorie and Haldwani) and three towns in Nepal, local institutions are weak while there is no strong system of water planning at the city level, especially in the context of urban growth and climate change (Ojha et al., 2020) [26]. In the eastern Himalaya, a study in Darjeeling indicates that formal supply and informal water markets can work in tandem without achieving a similar distribution of access to water (Shah & Badiger, 2018) [36]. Both studies converge in one direction: institutions determine who gets water and where the water comes from, who pays and who is deprived, who gets noticed and whose is ignored. The evidence from IWH itself is also limited, with only two towns in Uttarakhand, so this theme should be interpreted as a pattern that is well supported, but is only documented in a small number of IWH towns.

5.2 Springs, Shared Waters and the Erosion of Commons Institutions

The spring crisis is furthermore a crisis of institutions. Springs and streams in the western Himalaya have long been managed through community rules, customary labour and local irrigation arrangements. Drawing on the work of Baker (2005) [5] on the kuhls of Kangra, it is possible to understand why most of these community-managed irrigation systems have survived earthquakes, floods and socioeconomic changes so far, thanks to informal and interdependent relationships between the users. It can certainly be said that hydrogeological mapping is required but not enough, as inferred from current programmes of spring-revival. Increased awareness of recharge areas, community participation in restoration decisions, and post-restoration institutionalization of the community are found to be effective for rehabilitation (Ghimire et al., 2025) [17] and in Kangra, enhanced water levels after installation of recharge structures were reported. These are welcome results, but not sufficient to pass the buck to communities; if we have poor land use control, or large infrastructure, then local involvement is not enough.

5.3. Hydro Power, Enclosure and Accumulation by Dispossession

The political nature of water is apparent in hydropower. Large dams and run-of-the-river projects are often sold as renewables and as development and benefits for the region and the country. They can fence off a water commons, ship ecological, safety concerns over to the residents who are close to the project, and leave the electricity and the money elsewhere so much for their promises of clean energy and sustainable development. They can sequester water commons or shove ecological or safety concerns on to the people who live near the project while the electricity and the money are shipped somewhere else, as Critical studies have demonstrated. Baruah (2012) [6] takes up this argument on the eastern Himalayas in the context of river-basin hydropower. In addition, 17 hydro power conflicts in Himachal Pradesh have been documented through participatory mapping (Del Bene, 2018) [13] and a study of the Bajoli Holi project tells how the construction of dams is marketed using the dominant vision of a “new green India” (Asher & Negi, 2023) [1]. As much as the technical feasibility of a dam, who can determine the risk, and whose evidence counts.

The same exists in other settings, as is evident from comparative work conducted in the eastern Himalaya. In Sikkim, the communities had resorted to the Dzumsa system to resist proposed dams and assert their territorial rights (Dukpa et al., 2019) [46]. The study of the eastern Himalayan frontier of India demonstrates that power politics can be reduced by making hydropower projects appear inevitable, restricting dissent and using uncertainty as a justification for continuing instead of halting projects (Huber, 2019) [20]. Conservation can also take away. Work on Dal Lake in Kashmir refers to water conservation measures that are backed by the state and the displacement of the Hanji lake dwellers, which has created a sense of state control over water and made the lake dwellers think of themselves as those on the margins (Bhan & Trisal, 2017) [7].

The institutional dynamics and water governance in cities are becoming more complex. Institutional fragmentation and water governance in cities become more complex.

In IWH, urban water governance is frequently shared between a number of agencies that have overlapping mandates. A research in Nainital showed that this overlap brought accountability issues and decreased coordination between water supply, environmental management and resource protection (Singh et al., 2024) [40]. Previous research in the Indian Himalayas has come to the same conclusion: new participatory mechanisms have provided some actors with a voice, but not a voice without some distortion of power relations and without some inequity of distribution (see Saravanan, 2009) [33]. This makes it hard for households to understand. They may be responsible for local sources, and they might be responsible for paying for private supplies or having to deal with a shortage, and the responsibility might be spread across lots of departments that aren't easily held accountable.

5.5 Gender, Livelihoods and Environmental Injustice

Not all households and communities experience water insecurity. According to research conducted in Garhwal, the stress of water exacerbates women’s health and livelihood problems (Drew, 2015) [14]. Research on the impacts of run-of-the-river hydro power on livelihoods in Uttarakhand indicates gender and location-specific impact (Buechler et al., 2016) [10]. Previous women, energy and water programmes in the Himalayas have also stressed the importance of involving women in identifying needs and designing solutions to those needs, rather than leaving them as beneficiaries of the plan (Sharma & Banskota, 2005) [39]. It is not a social category tacked on at the end of a technical report, but rather a component of the system of water, as in a political-ecological analysis.

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Table 2: Synthesis matrix of the five themes, the core mechanism and political-ecological implication of each, and the evidence behind it.

Theme	Core mechanism	Implication	Evidence base
5.1 Scarcity amidst plenty	Weak, uncoordinated urban institutions produce shortages despite physical abundance	Insecurity is produced institutionally as well as hydrologically	Two Uttarakhand towns (Ojha et al., 2020) [26]; Darjeeling comparator (Shah & Badiger, 2018) [36]. Thin in the IWH.
5.2 Springs and commons	Community spring and irrigation institutions weaken under land-use change and state intervention	Revival requires institutional recognition as well as hydrogeology	Kangra, Himachal Pradesh (Baker, 2005; Rawal et al., 2024) [5, 28]; programme evidence across the Indian Himalayan Region (Ghimire et al., 2025) [17]. Moderate.
5.3 Hydropower and dispossession	Infrastructure enclosure transfers risk locally while benefits move elsewhere	Risk and voice are unevenly distributed	Himachal Pradesh (Del Bene, 2018; Asher & Negi, 2023) [13, 1]; Kashmir (Bhan & Trisal, 2017, on conservation-led dispossession) [7]; eastern Himalayan comparators. Moderate in Himachal Pradesh, comparative elsewhere.
5.4 Institutional fragmentation	Overlapping agency mandates create accountability gaps	Decentralisation without redistribution of power reproduces inequity	Nainital (Singh et al., 2024) [40]; Indian Himalaya (Saravanan, 2009) [33]. Thin.
5.5 Gender and injustice	Water burdens and livelihood impacts fall unevenly by gender	Gender is a structural feature of the water system	Garhwal (Drew, 2015) [14]; Uttarakhand project areas (Buechler et al., 2016) [10]; programme-level (Sharma & Banskota, 2005) [39]. Thin; none from Jammu and Kashmir or Ladakh.

6. Critical Appraisal: The Limits of the Dominant Water-Security Frame

There are three drawbacks in the prevailing water security frame, as identified in the literature. The first is its approach of technicalizing water governance. There is limited discussion of how the four solutions (pipes, dams, reservoirs and supply targets) affect power and access (Sayan, 2016) [34]. The second is the inclination to view security as infrastructure. Whilst infrastructure can enhance access, it can also lead to new exclusions and degrade recharge areas or push the risk to those with limited influence over decision making (Saito et al., 2026) [32]. There are two examples from Ladakh. However, one recent contribution raises questions about how well the political institutions at local, union and national level have been able to ensure accountability, equity and participation in the governance of water in the region (Awasthi, 2026) [2], while the "artificial glaciers" encouraged as adaptation to the retreat of glaciers are either not effective as a climate response, or not suited to the local conditions, as climatic variability, hazards and limited integration with local socioeconomic arrangements diminish their effectiveness (Nüsser et al., 2019) [25].

The third weakness is scale of water security that is typically conceptualized. The term 'Water Tower of Asia' refers to the significance of the region's hydrology but also serves to limit the scope of the Western Himalaya to the service of populations in the downstream regions. Much of the earlier discussion of the mountain–upstream–downstream issue demonstrates the capacity of narratives to attribute issues to the actions of mountain users when these issues are also the result of state policy, land-use change and development planning (Blaikie & Muldavin, 2004) [8]. For the western Himalayas, these questions are linked to borders, geopolitics, and local access (Davis, 2022) [12]. A critical approach asks the question, will a project create a sense of security for people who live by the water or does it benefit the more powerful users for more distant purposes?

While climate science is important, it can't account for the fact that two communities facing the same climate event – such as a drought or a flooding event, or a drop in spring runoff – can be very different in their ability to adapt. If volumes are counted but access, labour, institutions and risk transfer are ignored, the social reality of water insecurity will be missed.

7. POLICY IMPLICATIONS AND RECOMMENDATIONS

In addition to the research priorities discussed in Section 8.2, the synthesis and evaluation highlight six policy implications for water and infrastructure policies in the IWH.The synthesis and appraisal reveal six policy implications for water and infrastructure policies in the IWH, apart from the research priorities discussed in Section 8.2. They are based on a limited body of evidence (Table 2) and should be evaluated at the local level prior to implementation.

First, groundwater and spring governance should be part of the water security planning at the state level, and not seen as a community-only responsibility. The sustainable funding lines and legal recognition of spring-user committees following the completion of the project, as suggested in the study, are important conditions for the successful management of springsheds (Ghimire et al., 2025; Rawal et al., 2024) [17, 28].

Secondly, the process of approval for hydropower projects should encompass cumulative basin-level impact assessment, as projects are often clustered together and a history of conflicts exists in Himachal Pradesh (Del Bene, 2018) and should provide open avenues for communities affected by projects to provide evidence regarding the stability of the land upon which their project is being built, and the impact of the project on their livelihoods. Models of community empowerment like Dzumsa in Sikkim suggest that, beyond serving as a delaying measure, supporting existing self-governance institutions could enhance project monitoring. (Dukpa et al., 2019) [15].

Third, there is a need for urban water governance to be managed by a single accountable body or at least a statutory coordination mechanism that helps address the gaps in governance of urban water when water supply, environmental management and resource protection are fragmented between related agencies with overlapping mandates (Singh et al., 2024; Saravanan, 2009) [40, 33].

Fourth, gender-oriented design must shift from the consultation to shared decision making authority in water and energy planning as earlier studies have found that taking part in problem definition and solution making in water and energy programmes is more effective when women are involved in the process (Sharma & Banskota, 2005; Drew, 2015) [39, 14].

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Fifth, water schemes for high-altitude and border regions like Ladakh and Jammu and Kashmir should be designed with respect to the ecological and political context of the region and not be copies of water schemes designed in other countries.Fifth, water schemes for high altitudes and border regions like Ladakh and Jammu and Kashmir require schemes that are tailored to their ecological and political conditions, and not schemes transferred from other planning contexts that are lower in elevation. Lastly, reporting on distributional outcomes is needed, including who is able to have reliable access to water, who shares the risk of construction and operation, and how benefits and risks are shared between the upstream and the downstream side, in addition to the traditional reporting on households connected and megawatts installed.

Table 3: Summary of policy recommendations by domain.

Domain	Recommendation	Primary responsible actor(s)
Springs and groundwater	Integrate springshed management into state planning with durable funding and legal recognition of user groups	State irrigation and public health engineering departments; technical partners (e.g., ICIMOD)
Hydropower governance	Require cumulative, basin-level impact assessment; create accessible community evidence channels	State pollution control boards; project developers; judiciary
Urban water governance	Establish a single accountable authority or statutory coordination mechanism	Urban local bodies; state water departments
Gender-responsive planning	Move from consultation to shared decision-making authority	Implementing agencies; women's self-help groups and user committees
High-altitude and border regions	Adapt schemes to high-altitude ecological and political conditions	Union Territory administrations (Jammu and Kashmir; Ladakh)
Monitoring and evaluation	Report distributional outcomes (who gains, who bears risk) alongside coverage and capacity metrics	National and state water mission secretariats

8. LIMITATIONS, RESEARCH GAPS AND FUTURE DIRECTIONS

8.1 Limitations of this review

There are five restrictions to the analysis. First, the small number of items in the corpus (26 sources) as well as some of the central concepts, such as the extent of spring drying in Kumaon and the number of hydropower conflicts faced in the state of Himachal Pradesh, are based on a single study. These refer to specific patterns and not to exact or generalisable numbers for the entire IWH (Fig. 4). Second, the biophysical baseline is based on one recent regional review (Yao & Chen, 2025) [45] which is for the whole Western Himalaya, so it would be good to cross check with other hydrological and cryospheric sources for further confidence in the numbers.

Third, coverage is unevenly distributed geographically (Table 4). The political-ecological work clusters in the state of Himachal Pradesh and Uttarakhand, while Ladakh is covered by two sources, the river and the Dal, there are no sources retrieved directly from the area of Jammu and Kashmir, which is represented by its hydropower. This pattern is also a finding (Section 8.2), but searches conducted in English in indexed databases and institutional repositories may mean that material exists in local language, administrative and unpublished which this review did not reach. Fourth, there are heterogeneous and substandard types and quality of the corpus. It contains doctoral dissertations, institutional reports, and peer-reviewed articles, with several articles published in journals that don't have a high visibility. If a theme is dependent on such sources, then that evidence is marked as thin or moderate in Table 2.

Fifth, the source identification and coding was performed by a single reviewer with no double screening, thus with selection and interpretive subjectivity, as would be lessened by a multi-reviewer protocol.

Table 4: Geographic focus of the 26 Himalaya-focused sources in the corpus (Appendix A).

Scope	Sources	n
Himachal Pradesh	Asher & Negi (2023) [1]; Baker (2005) [5]; Del Bene (2018) [13]; Li et al. (2015) [21]; Rawal et al. (2024) [28]	5
Uttarakhand	Buechler et al. (2016) [10]; Drew (2015) [14]; Singh et al. (2024) [40]; Tiwari & Joshi (2014) [43]	4
Ladakh	Awasthi (2026) [2]; Nüsser et al. (2019) [25].	2
Jammu and Kashmir	Bhan & Trisal (2017) [7] (Dal Lake only)	1
Regional or Himalaya-wide	Blaikie & Muldavin (2004) [8]; Davis (2022) [12]; Ghimire et al. (2025) [17]; Saravanan (2009) [33]; Sen & Kansal (2019) [35]; Sharma & Banskota (2005) [39]; Sharma & Choudhury (2021) [37]; Sharma et al. (2024); Yao & Chen (2025) [45]	9
Comparative (outside the IWH)	Baruah (2012) [6]; Dukpa et al. (2019) [15]; Huber (2019) [20]; Ojha et al. (2020) [26]; Shah & Badiger (2018) [36]	5

8.2 PRIORITY RESEARCH GAPS

This review leads to five research priorities. First, greater place-based political-ecological efforts are required in Ladakh and Jammu & Kashmir, in particular, with much less literature available compared to Himachal and Uttarakhand, where rivers, springs and hydropower are major topics under consideration. Second, there is a need to study gender in conjunction with caste, class, indigeneity, age and family income rather than in isolation. Third, the evolving status of kuhls, naulas, springs etc., as vernacular institutions, should be explored in greater depth, especially in areas where state schemes and hydropower projects are intruding into preexisting commons (Baker, 2005) [5]. Finally, social researchers and local institutions should be involved right from the beginning and social impacts should not be added on after the hydrological analysis is finished (Yao & Chen, 2025) [45]. Last, water missions and hydropower programmes should be evaluated on distributional results: Who benefits, who pays, and who is at risk for future losses are more important than who benefits and how many megawatts are generated.

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9. CONCLUSION

The water security of the IWHs is tied to the retreat of glaciers and to variations in precipitation, but is also affected by the availability of springs that are less predictable to draw water from, as well as poorly coordinated institutions, water systems that carry water and risk across space, and households that differ in their power to influence development decisions. Those connections are made visible from a holistic political-ecological perspective, but do not supplant hydrology; it clarifies the differential impacts of hydrological change. This review brings together these three areas of spring hydrology, hydropower conflict and urban governance and gender, and proposes that there is a logic in bringing them together. Insecurity can be created when environmental change intersects decision-making power asymmetries and these forces are not mutually responsible.

The results are based on a bounded, narratively reviewed corpus where the representation of the regions of Uttarakhand and Himachal Pradesh is much stronger than that of Ladakh and Jammu and Kashmir (Section 8.1). They provide a synthesis and an agenda, but do not claim to be an exhaustive account. To ensure a more equitable water security for the region, recharge area protection and ecosystem safeguarding, increased accountability of water infrastructure, support of local water institutions, and meaningful engagement of communities most directly relying on mountain water will be needed

10. DECLARATIONS

Author Contributions: Anzar Ahmed Khokhar conceived the review, carried out the literature search and synthesis, and wrote the manuscript.

11. FUNDING

This research received no external funding."

12. ETHICS STATEMENT

Not applicable. This is a literature review that involved no human or animal participants.

13. DATA AVAILABILITY

No new data were generated. The Himalaya-focused sources synthesised are listed in Appendix A and all sources are cited in the References.

14. Use of generative AI

Claude AI tool has been used to Rewrite the work to make it more readable and understandable

15. iCompeting Interests

The author declares no competing interests.

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47.

Appendix A. Himalaya-Focused Sources in the Corpus

Table A1: Type, geographic scope and use of each source. "Used in" lists the sections of this review where the source is cited.

Source	Type	Geographic scope	Used in
State-level focus in the IWH			
Asher & Negi (2023) [1]	Journal article	Himachal Pradesh	5.3
Baker (2005) [5]	Book	Himachal Pradesh (Kangra)	5.2, 8.2
Del Bene (2018) [13]	Doctoral dissertation	Himachal Pradesh	4, 5.3, 7
Li et al. (2015) [21]	Journal article	Himachal Pradesh (Beas basin)	1.3
Rawal et al. (2024) [28]	Journal article	Himachal Pradesh (Kangra)	5.2, 7
Buechler et al. (2016) [10]	Journal article	Uttarakhand	5.5
Drew (2015) [14]	Journal article	Uttarakhand (Garhwal)	5.5, 7
Singh et al. (2024) [40]	Journal article	Uttarakhand (Nainital)	5.4, 7
Tiwari & Joshi (2014) [43]	Journal article	Uttarakhand (Kumaon)	4
Awasthi (2026) [2]	Journal article	Ladakh	6
Nüsser et al. (2019) [7]	Journal article	Ladakh	6, 7
Bhan & Trisal (2017) [7]	Journal article	Jammu and Kashmir (Dal Lake)	5.3, 8.1, 8.2
Regional or Himalaya-wide			
Blaikie & Muldavin (2004) [8]	Journal article	Himalayan region	1.4, 6
Davis (2022) [12]	Book	Himalaya (geopolitics)	1.4, 6
Ghimire et al. (2025) [17]	Institutional report	Indian Himalayan Region	4, 5.2, 7
Saravanan (2009) [33]	Journal article	Indian Himalaya	5.4, 7
Sen & Kansal (2019) [35]	Journal article	Rural Indian Himalaya	1.3
Sharma & Banskota (2005) [39]	Institutional report	Himalaya (programme-level)	5.5, 7
Sharma & Choudhury (2021) [37]	Book chapter	Himalaya	1.2
Sharma et al. (2024) [38]	Book chapter	Indian Himalayan Region	4
Yao & Chen (2025) [45]	Journal article	Western Himalaya	1.3, 1.5, 4, 8
Comparative (outside the IWH)			
Baruah (2012) [6]	Journal article	Eastern Himalaya	5.3
Dukpa et al. (2019) [15]	Journal article	Sikkim	5.3, 7
Huber (2019) [20]	Doctoral dissertation	Eastern Himalayan borderland	5.3
Ojha et al. (2020) [26]	Journal article	Nepal (3 towns); Uttarakhand (2 towns)	1.3, 5.1
Shah & Badiger (2018) [36]	Journal article	Darjeeling	5.1

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