

AGENDA FOR CLIMATE ACTION

WATER

Linking the Vulnerability and Risk Assessment for
Uttarakhand with policy implications for the state



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1. OVERVIEW OF WATER SECTOR IN UTTARAKHAND

Uttarakhand's water resources, notably water from the Himalayan glaciers and rivers, provision both the State and India as a whole. However, despite the State's multiple water reserves including 17 rivers, several snow-fed glaciers, and 31 lakes, many districts of Uttarakhand face acute water scarcity. Water resources are diverted for activities in many sectors, including agriculture, energy, tourism and forestry. The agriculture sector is the greatest consumer of water in the State, accounting for 75% of the total demand. Increasing population and rising standards of living have also led to a greater demand for water.

The State's water scarcity is linked to the unsystematic distribution of water and poor management of water resources.ⁱ Many of the State's rural water supply systems no longer meet community needs, especially when frequent landslides damage water pipes and infrastructure. It can take weeks or months for technicians

Box 1: Observed trends linked to water sector vulnerability

Based on Participatory Rural Appraisals (PRAs) of five sample villages in Uttarakhand

- Villagers report that springs and naulas are being destroyed due to heavy rainfall. Changing patterns of snowmelt and rainfall are also impacting the quantity of water available in these sources.
- One village (Chameli in Tehri Garhwal) noted that road construction, particularly the unmanaged disposal of debris, was damaging streams, causing them to dry up.
- Three out of five villages have no irrigation facilities and are dependent on rainfall. One village (Bikkampur in Haridwar) has good irrigation facilities but the quality of drinking water is poor, causing illness.
- One village noted a gradual decrease in post monsoon rain, compared to the 1980s and 1990s. Four others noted a decrease in snowfall in recent years.

from State water agencies to reach remote villages.ⁱⁱ River management practices, including the management and release of dam water can also impact the seasonal availability of water. Moreover, the reduction in forest cover has led to soil erosion and loss of water storage capacity in the hills.ⁱⁱⁱ Finally, the quality of water seems to have deteriorated in some regions. These aforementioned factors have led to water shortages, frequent illnesses and drudgery for women and children, who spend several hours daily collecting water.^{iv} Communities in the hills are dependent on local springs, which periodically dry up due to lack of recharge during the summer months. Implementing pumping schemes is seen as costly and energy-intensive.

2. CLIMATE VULNERABILITY IN THE WATER SECTOR IN UTTARAKHAND

These existing developmental stresses will be exacerbated by climate variability and change. Higher temperatures and changes in extreme weather conditions are projected to affect distribution of rainfall, snowmelt, river flows and groundwater reserves, and negatively impact water supply and quality. Furthermore, demand for water in response to a changing climate, from people, ecosystems and key sectors such as energy and agriculture, is also expected to impact water availability in the future. In addition to these risks, climate change may also bring about positive changes and opportunities; for example through the availability of more water in certain places. Figure 1 presents the district-level composite water vulnerability in Uttarakhand. It is however important to note there is a degree of uncertainty linked to all projections, particularly on precipitation, and that there is limited information and data on flows from glacial melt and their impact on water resources. These uncertainties make it necessary to focus on policy options that are robust against multiple scenarios, and which take into account different sectoral priorities, given water's multiple uses.

Based on hydrological modelling, the Vulnerability and Risk Assessment (VRA) points to the following specific areas of future impact on water resources in the State:

- Seasonal changes in water availability
- Increased risk of flooding
 - Increased stress on dam infrastructure
- Potential improvement in stream flow

2.1. Seasonal changes in water availability

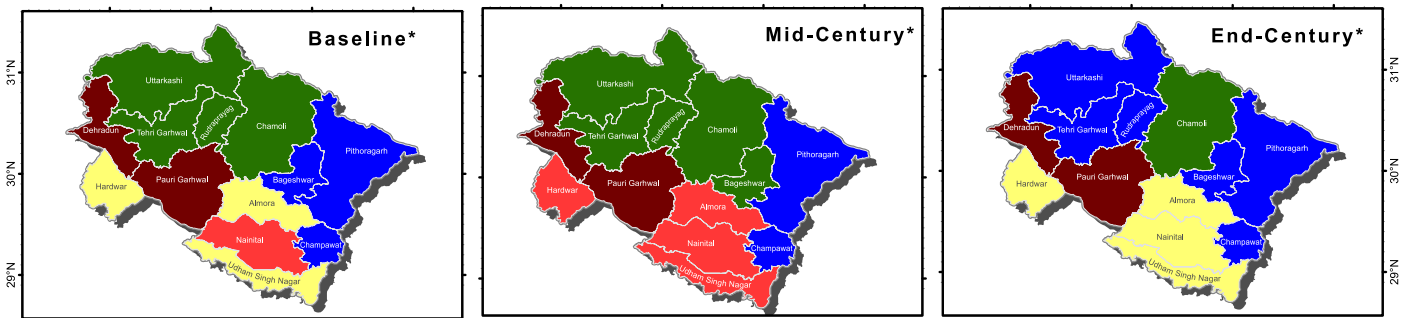
Under the moderate scenario, towards the middle of the century, water availability is not projected to change significantly, but its distribution is likely to change. Therefore, it is important to examine projected changes at the seasonal level to understand when and where this water will become available. Projections under both scenarios suggest increased precipitation during the monsoon season, most likely in the form of isolated heavy rainfall events, which, in combination with other circumstances, may lead to flooding. Conversely,

projections under both scenarios also suggest decreased precipitation in the post monsoon season. In combination with increased temperature extremes, this can lead to additional evaporation and evapotranspiration, putting pressure on surface and groundwater requirements for a variety of uses, including irrigation and drinking water. Furthermore, the VRA finds that future drought conditions are likely to increase in hilly regions of the State although they are likely to improve in mid and lower (plain) districts of Uttarakhand.¹

Figure 1: Composite water vulnerability for Uttarakhand

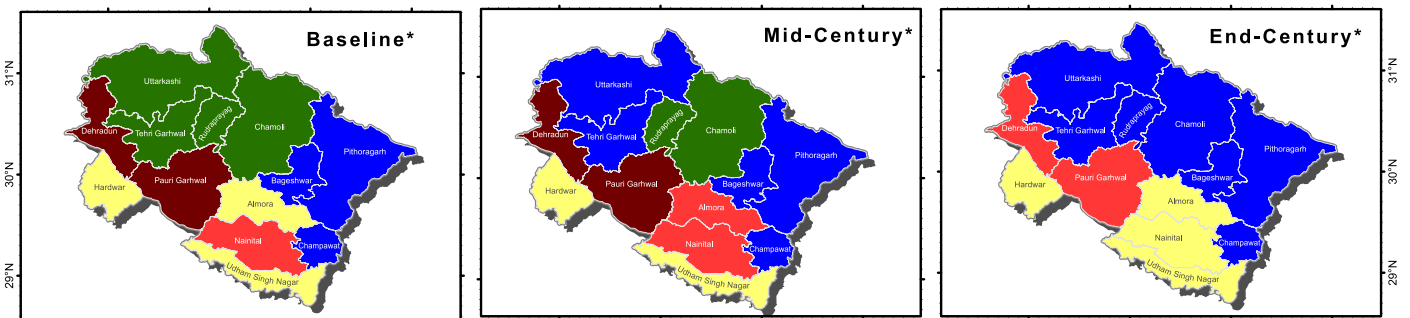
RCP 4.5

Water



RCP 8.5

Water



Vulnerability Scale



Analysis & Layouts prepared by INRM Consultants, New Delhi

The figure shows the current and projected vulnerability of the State's districts based on a number of water-related factors including water availability and extreme events of flood and drought. As seen, Pauri Garhwal and Dehradun are currently the most vulnerable due to less surface water and ground water availability per capita in monsoon and non-monsoon months and high crop water stress in the non-monsoon (rabi) season. Champawat, Bageshwar and Pithoragarh are relatively the least vulnerable due to factors such as maximum availability of surface and ground water per capita and less crop water stress in monsoon as compared to other districts.

¹ Under both scenarios, high water stress is likely in parts of Chamoli and Pithoragarh towards mid and end century. Almora, Champawat, Nainital and Udham Singh Nagar are projected to improve in drought conditions towards mid and end century. In the extreme scenario Rudraprayag and Uttarkashi experience worsened drought conditions toward the mid-century, with improvement toward the end of the century.

“Water sources that have been perennial for 20-25 years are continuously drying due to lack of recharge during summers. More water is required to recharge these sources”

- Climate Action Group, SCCC²

These changes in water availability have implications for all sectors, particularly for agriculture and energy. For agriculture, the State’s biggest user of water, reduced availability of water means greater stress on crops, increased vulnerability to pests and diseases, and reduced yields. For energy, this implies a greater need for inter and intra-state river flow management for energy generation during drought periods. Communities which are completely dependent on rainfall or springs, particularly in the hilly districts, are at risk of reduced supply due to lack of groundwater recharge.

2.2. Increased risk of flooding

On the likelihood of flooding, the magnitude of peak discharge is projected to increase towards end-century compared to the mid-century. Under the moderate scenario (RCP 4.5), peak discharges in parts of Dehradun, Haridwar, Tehri Gharwal and Uttarkashi are likely to increase by 30 to 40%.³ Peak discharges in parts of the rest of 13 districts are projected to decrease by 10 to 15% towards end-century. Under the extreme scenario (RCP 8.5), peak discharges are likely to increase in all districts ranging from 10 to 15% towards 2021-2050, and 18 to 20% towards 2071-2098. Overall, the implication is that flooding is likely to increase, with widespread consequences for all parts of the society and economy. It is important to note that the VRA results do not take into account flooding due to events such as cloudbursts, which could further increase the risk of disasters.

2.3. Increased stress on dam infrastructure

The VRA results specifically show an increased risk of

flooding at the Tehri and Kalagargh dam locations based on the analysis of return periods or the likelihood of a high magnitude flood event to occur within a specific duration.⁴ Dams are designed to withstand a once in a 100-year discharge based on historic data. At the Tehri dam, this maximum flow is now expected to occur once in 50 years under both scenarios and timelines. At the Kalargh dam, the 100-year maximum flow is expected to be comparable to a once in a 55 to 70-year event by the mid and end centuries respectively, taking into account the future flow series simulated with the projected climate. Hundred-year return period events in the future will likely be of a higher magnitude, and combined with an increase in the frequency of events, may have implications for the structural and operating performance of both dams, including for example more frequent operation of spillways, changes in flood management, and river regulation. Existing design standards, construction methods and materials, and operating procedures – designed based on historic climate data – will need to be reviewed to ensure that they are able to cope with the changing conditions.

“Some dam structures already have seismic activity factored into their construction, some consider a 1,000 or even 10,000-year return period.”

- Climate Action Group, SCCC

2.4. Potential improved stream flow

Analysis of flow duration curves (which show the ability of a basin to provide flows of various magnitudes for various periods of exceedance) shows that dependable stream flows will increase under both scenarios (marginally under the moderate scenario [RCP 4.5] and significantly under the extreme scenario [RCP 8.5]),⁵ which is a positive outcome on several fronts. It has important implications for the design of structures on rivers and streams, particularly run-of-the-river hydropower projects, which must have

² The SCCC or the State Climate Change Centre is a semi-autonomous body led by the Uttarakhand Forest Department. The Climate Action Group is a cross-sectoral group of department officials meant to contribute to the climate agenda in the state through coordination and interaction with the SCCC.

³ Representative concentration pathways (RCP) scenarios are greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) to describe four possible climate futures, depending on how much greenhouse gases are emitted in the years to come. In RCP 4.5 emissions peak around 2040, then decline. In RCP 8.5, emissions continue to rise throughout the 21st century.

⁴ A return period is an estimate of the likelihood of an event, such as flood or a river discharge flow to occur. It is a statistical measurement based on historic data denoting the average recurrence interval over an extended period of time. This information is used for risk analysis (e.g. to decide whether a project should be allowed to go forward in a zone of a certain risk, or to design structures to withstand an event with a certain return period).

⁵ Stream flow at 95% and 90% dependability is expected to increase. In terms of monthly flow, this means that for 11.4 (95%) or 10.8 (90%) months out of 12 months in a year, a particular flow will be available.

a minimum flow in order to generate power. The VRA results show that the minimum required flows will occur throughout most of the year. This may also have positive implications for energy generation, availability of water for human consumption, industrial use, irrigation projects, and for wider ecosystem benefits, since a minimum level of water is likely to be available in streams almost all year round.

3. VRA LIMITATIONS

Limitations to hydrological modelling in the VRA include inadequate glacier and snow information for snow hydrology simulation. Glacier and snowmelt have important implications on the availability of water resources but have been accounted for in the VRA's projections without validation. Therefore potential increase or decrease in water availability owing to glacial melt has been subject to the validity of the initial conditions used in the models for the snow and glacial cover.

It is also difficult to model the availability of spring water because of the unique physics of flow and the lack of observed data. This has resulted in water from spring sources not being accounted for in the VRA. As a result, the VRA is unable to provide information on the availability of drinking water supply in hill communities.

There is inadequate information on the source and volume of irrigation water currently used. Surrogate data from current crop management practices (irrigation from surface and ground water) based on land-use maps, irrigation source maps, and district-wise average irrigation was used. Temperature data is of a coarse resolution, making it difficult to project changes at a micro (e.g. district or block) level.

4. ON-GROUND VULNERABILITY AND COPING STRATEGIES

The PRA results indicate a number of current on-ground vulnerabilities linked to the water sector (see Box 1). These primarily relate to water supply for irrigation and drinking, and have clear links to the VRA projections. Deterioration of water quality in sources and springs due

to heavy rainfall has been reported by many villages in the PRA sample including Chameli (Tehri Garhwal) and Karni Guth (Champawat), which is expected to worsen under extreme precipitation events as projected by the VRA. All villages have also observed that changing patterns of snowmelt and rainfall are impacting the quantity of water available in these local sources. Sources are drying up due to lack of groundwater recharge in summers. Decreased precipitation in the post-monsoon season has already been observed on the ground, and the trend is projected to continue in future, posing a particular risk to villages which have no irrigation such as Kharni Guth, Chameli and Kantari (Uttarkashi) or limited facilities such as Majuli (Nainital). Implementing water storage and conservation options is thus an important consideration to increase climate resilience now and in future. In terms of protecting water supply from the impacts of extreme precipitation events, establishing and strengthening early warning systems (EWS) will be important, ensuring last mile connectivity to villages so that preventative measures may be taken to protect water sources.

5. CLIMATE POLICY LANDSCAPE

The key document linked to climate change and the water sector in Uttarakhand is the Uttarakhand Action Plan on Climate Change (UAPCC).

At the national level, the water sector is guided by the National Water Mission, one of the eight missions under the National Action Plan on Climate Change (NAPCC), with the overall objective of conserving water, minimizing wastage and ensuring its more equitable distribution both across and within states through integrated water resources development and management.

In light of the VRA findings, water policies and plans in Uttarakhand would benefit from a review in order to manage areas of current and emerging risk due to climate change, as well as potential opportunities. At present, an overarching water policy document as well as a groundwater policy document are in the final stages of preparation and currently under review by the Irrigation Department. There is an opportunity an opportunity to integrate the VRA findings across all categories of water use, in order to support climate resilient decision making. Some of the relevant water policies and schemes that need to be examined in light of the VRA are:

- The Uttarakhand policy (2016, in final stages of preparation)
- Draft policy for groundwater management, Uttarakhand Jal Sansthan (2016, awaiting approval)
- Uttarakhand Flood Plain Zoning Act (2012)
- Uttarakhand Water Management and Regulatory Act (2013)
- Uttarakhand State Perspective and Strategic Plan 2009-2027, Watershed Management Directorate
- District irrigation plans⁶

Adaptation to climate change is featured in India’s National Water Policy (NWP) of 2012, which calls for water management strategies, plans, and interventions that take into account the impacts of a changing climate on water availability, quantity, and quality.

The water sector is an important target area of India’s Nationally Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change

(UNFCCC), which aims to better adapt to climate change by enhancing investments in development programmes in a number of areas including water resources and the Himalayan region. Interventions that implement and deliver NDC objectives may be eligible for international finance from multilateral and bilateral development partners.

6. AGENDA FOR CLIMATE ACTION IN WATER

The following table provides suggested areas of action to be undertaken in the water sector over the next five years based on findings of the top-down VRA, a bottom-up review of community trends, and a review of existing state and national priorities.

CLIMATE IMPACT AREA	ACTION	TYPE OF INTERVENTION
Seasonal changes in water availability	<ul style="list-style-type: none"> • Map the availability, supply and demand of water resources at the basin level, guided by the VRA findings incorporating technical assessments and review at regular intervals. 	Information and research
	<ul style="list-style-type: none"> • Focus on Participatory Irrigation Management (PIM) at the Gram Panchayat level. Decentralised governance has proven effective in the protection and management of water sources in catchment areas which will become more important in light of future climate impacts.^v 	Strengthening existing programmes
	<ul style="list-style-type: none"> • Develop and implement a multi-hazard early warning system (EWS) to better predict and prepare for incidences of drought and flooding, ensuring last-mile connectivity. Build capacity of local governments and communities for EWS governance and management. 	Strengthening existing programmes
	<ul style="list-style-type: none"> • Conduct comprehensive feasibility studies on proposed hydropower projects in light of the VRA. For e.g. decrease in rainfall causing reduction in water resources, potentially leading to underperformance of hydropower projects and compromised security of energy supply. 	Information and research
	<ul style="list-style-type: none"> • Conduct scientific analysis of spring water dynamics in order to better plan groundwater recharge schemes in hilly districts.^{vi} 	Information and research
	<ul style="list-style-type: none"> • Promote water saving and re-use schemes such as rainwater harvesting, creating impounding reservoirs to collect surface water, and re-use of sewage water. 	Strengthening existing programmes

⁶ Further programme areas are listed in the UAPCC.

CLIMATE IMPACT AREA	ACTION	TYPE OF INTERVENTION
Increased risk of flooding	<ul style="list-style-type: none"> Improve flood forecasting through flood plain mapping and preparation of inundation maps for flood-prone areas guided by VRA projections. Adopt an optimum combination of structural (e.g. storage reservoirs, embankments) and non-structural measures (e.g. flood forecasting, flood plain zoning and catchment area treatment) for flood management, taking into account VRA findings. 	<p>Information and research</p> <p>Strengthening existing programmes</p>
Changes stream flow	<ul style="list-style-type: none"> Use VRA findings on stream flow dependability when assessing and planning projects such as run-of-the-river hydropower, drinking water and irrigation projects, to take advantage of when and where river flows are likely to be sustained year-round. 	<p>Information and research</p>
Implications for dam infrastructure	<ul style="list-style-type: none"> To account for increasing probability of large magnitude flood events occurring in the future, a) re-assess the design of current major water infrastructure (such as the Tehri and Kalagarh dams) and b) re-evaluate Central Water Commission (CWC) criteria for new dams in view future climate change. Develop guidance for decision-makers in water resource management to be able to use relevant VRA outputs (eg. return periods and risk of extreme hydrological events) and conduct their own assessments/stress tests during the design, construction and maintenance of major water infrastructure and assets. Regular monitoring, evaluation and maintenance of dams/reservoirs, linked to EWS for a better understanding of when and where flooding may occur. 	<p>Information and research</p> <p>Strengthening existing programmes</p> <p>Information and research</p>
Climate change can undermine development objectives	<ul style="list-style-type: none"> Integrate VRA results into the surface and groundwater water policies currently being finalised, in order to minimise future climate risks and seize potential opportunities. In line with the National Water Mission (2012) and National Water Policy (2012), adopt an Integrated Water Resources Management (IWRM) approach, taking the river basin or sub-basin as the unit for planning, development and management of water resources, and factoring in the impact of climate change on resource availability. Develop groundwater and surface water use schemes with an incentive or tariff system to discourage users from over-extracting water. 	<p>Policy review and mainstreaming</p> <p>Policy review and mainstreaming</p> <p>Strengthening existing programmes</p>

7. DEVELOPMENT CO-BENEFITS

The suggested areas of climate action in would lead to the following development co-benefits:

- Achieve National Water Mission's goal of increasing water use efficiency by 20% by 2017.
- Fulfil the objectives of India's National Water Mission of conserving water and ensuring its more equitable distribution.
- Reduce mortality, injury, and disease linked to flooding events.
- Improve safety and more efficient operation of major water infrastructure.
- Increase agricultural production and productivity due to better water management.

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- ^{iv} Ibid
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- ^{vi} Consultation with Uttarakhand Climate Action Group, 4 October 2016, Dehradun.



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