AGENDA FOR CLIMATE ACTION

ENERGY

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

Prepared under the project, “strengthening State strategies for Climate Actions” being implemented by United Nations Development Programme (UNDP) and State Climate Change Centre, Uttarakhand. The project is funded by Swiss Agency for Development Cooperation (SDC)

NOTE: This sectoral brief focuses on building climate resilience in the energy sector. Whilst recognising the importance of reducing greenhouse gas emissions in various sectors and monitoring this reduction, this brief focuses on approaches to reduce vulnerability and build resilience in the energy sector.
1. OVERVIEW OF ENERGY SECTOR IN UTTARAKHAND

India is the world’s fourth largest consumer of energy and has met its development needs by using available domestic resources of coal, uranium, oil, hydropower and other renewable resources, supplementing domestic production by imports. Uttar Pradesh is uniquely positioned in the energy sector as it has high hydroelectric power potential (the third highest in India). Uttar Pradesh is home to the Tehri dam, the largest in India with 2.4 gigawatts (GW) of electricity generating capacity.

Demand for energy, an important indicator of economic development, has been growing steadily in Uttar Pradesh; energy consumption has grown at a rate of 4.46% since 2012. As of December 2016, the total installed energy capacity of Uttar Pradesh was 3719 megawatts (MW), with 1315 MW (35%) generated by State agencies, 1542 (41%) by the private sector, and 861 MW (23%) by the Centre. 60% of the State’s installed capacity is from hydropower, and 25% from thermal sources. 9% of total capacity is generated by renewable energy sources, representing more than a twofold increase since 2011 when the Uttar Pradesh Action Plan on Climate Change (UAPCC) was being drafted.

As per the reassessment studies of the hydroelectric power potential in various river basins of India carried out between 1978-1987, Uttar Pradesh has a total capacity of 18175 MW, with 1281 MW or 71% yet to be developed; this represents a sizable potential for hydropower in the State, including the potential to export to other states. Cumulative Environment Impact Assessments (CEIA) and Carrying Capacity Studies (CCS) of the rivers Alaknanda and Bhagirathi have been completed and similar studies for other river basins are underway, which will help understand their hydropower potential and help ensure sustainable usage of rivers for electricity generation. These basin-level studies represent a step beyond traditional EIAs, as they adopt an integrated approach to assess impacts due to various developmental projects. They are aimed at assessing the cumulative ecological impact of all the hydroelectric projects planned or under execution.

Despite its great potential, the power sector in Uttar Pradesh faces several challenges. As in many states, there are persistent power shortages. While the energy deficit in Uttar Pradesh was 214 million units (MU) (1.7%) during 2015-16, lower than the national average (2.1%) during the same period, households still face frequent disruptions in power supply, especially in rural areas but also in cities. The reasons for this lie primarily in transmission and distribution problems. Uttar Pradesh utilities experienced aggregate technical and commercial (AT&C) losses of 20.18% in 2014-15. These losses, due to several reasons, including overloading of lines, poor repair and maintenance as well as electricity theft, contribute to an increase in the cost of power for consumers.

Rural electrification has greatly improved over the years but remains an issue in the State. According to figures from both the 2011 census and the Uttar Pradesh Power Corporation Limited (UPCL), as of 2014, 5% of households remained un-electrified, all of these in rural areas. The latest figures from Grameen Vidyutikaran show that 69 villages remain un-electrified. However, many reports cite the fact that despite official figures, many of Uttar Pradesh’s village households remain in the dark.

Difficult terrain in Uttar Pradesh’s hilly regions means that energy access for many rural villages can be a problem; the same conventional energy systems used in the plains cannot reach remote communities in the hills. Therefore, non-conventional, renewable energy sources are also important and have been promoted by the State government, particularly small-scale hydro and solar. Uttar Pradesh has several perennial streams where water is available throughout the year; the State’s renewable energy policy estimates the untapped potential that could be harnessed through small scale hydropower projects using such streams is 600 MW by 2020. The state also has a dedicated Solar Power Policy. Overall, the State plans to add 345 MW of renewable energy plants and save 358.64 MU by 2019.

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1Aggregate Technical and Commercial (AT&C) losses refer to transmission and distribution losses along with losses in revenue collection.

2Data from UPCL and the 2011 Census differs; using these numbers and in consultation with the State government, the 24X7 Power for All Uttar Pradesh report calculates that 1,09,047 households out of 20,94,536 (58%) have been electrified.

3Uttar Pradesh’s Policy for Harnessing Renewable Energy Sources sets out guidelines for 5 different types of renewable energy projects: small scale hydro, co-generation (using thermal energy from industrial waste), biomass/Agro residue and waste, urban, municipal and industrial liquid/solid waste; wind; solar and geothermal.
Uttarakhand's energy sector is vulnerable to natural disasters such as landslides triggered by events such as flash floods and cloudbursts. This was illustrated in June 2013, when torrential rains rapidly raised the water level of the moraine-dammed Chorabari Lake. The dam breached and released 400,000 m³ of water into the already flooded Mandakini River, inundating the city of Kedarnath and severely damaging at least two hydropower sites downstream.

2. CLIMATE VULNERABILITY OF THE ENERGY SECTOR IN UTTARAKHAND

Uttarakhand's energy systems are vulnerable to change in both the average and extreme levels of climate impacts, with the potential to affect electricity demand, supply, and infrastructure. Particularly, Uttarakhand's dependence on hydropower means that energy generation is sensitive to changes in weather and climate affecting the amount of water available in rivers. In winter, the discharge in rivers falls due to freezing, which results in generation dropping to one-third in comparison with summer months. At the same time, energy demands increase due to demand for heating, resulting in an overall supply-demand deficit.

In addition to posing risks, climate change may in some scenarios present new opportunities particularly for hydropower which, if managed appropriately, may benefit the sector. It is worth noting though that there is a degree of uncertainty linked to all model-based projections, particularly on precipitation, making it necessary to focus on policy options that are robust against multiple scenarios.

The Vulnerability and Risk Assessment (VRA) points to five areas of future impact on energy:

1. Rising temperatures and humidity resulting in increased energy demand
2. Seasonal changes in water availability
3. Potential improved stream flow
4. Increased stress on dam infrastructure
5. Increased risk of flooding

2.1. Rising temperatures and humidity resulting in increased energy demand

Under both scenarios and timelines, seasonal maximum temperatures in Uttarakhand are projected to increase (see Figure 1).

![Projected Future Changes in Seasonal Maximum Temperature for mid-century and end-century with respect to Baseline (1981 - 2010) for Uttarakhand (RCP 4.5 and RCP 8.5)](attachment:image)

*It is important to note that the VRA did not specifically investigate/model the impact of climate change on the energy sector; implications are drawn wherever relevant. Because one of the focus sectors of the VRA is water, there are naturally more implications to be drawn for hydropower.*
Under the moderate and extreme scenarios and across both timelines, the highest maximum temperature increases are projected in the winter season (January and February), as well as the pre-monsoon season (March, April, and May) under the extreme scenario.

In addition to increased temperatures, the VRA also projects increased humidity levels across time-lines and scenarios. The combined effect of temperature and humidity on the human body is measured by humidex which is an index number to describe how hot the weather feels to the average person. A humidex of over 90 warrants extreme caution, above 103 indicates danger, and above 125, extreme danger. Increases in temperature and humidex values are likely to alter the level, timing, and geographic distribution of electricity demand for cooling. This has already been occurring in the State.‡‡

Additionally, areas that previously did not require cooling are projected to experience increased temperatures and thus require cooling.

Projected district-level vulnerability: The districts in the southern plains which are already susceptible to higher temperatures such as Haridwar, Nainital, and Udham Singh Nagar are at particular risk for further increase in temperature and humidity levels (humidex > 100-125) between June and August in the mid-century suggesting the need for additional cooling to avoid discomfort and heat-related illnesses. In the end-century almost half of the State is projected to witness humidex values above 90 with values in the currently susceptible southern districts touching potentially dangerous levels of 103 and 125.

2.2. Seasonal changes in water availability

Electricity generation through hydropower is highly dependent on water availability. Generally in winter, the discharge in rivers falls due to freezing, which results in generation dropping to one-third in comparison with summer months. At the same time, energy demands increase due to demand for heating, resulting in an overall supply-demand deficit.‡‡

Climate change is expected to the situation. 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. 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.§

These changes in water availability have implications for all sectors, particularly energy. For energy, this implies a greater need for inter and intra-state river flow management for energy generation during drought periods. Communities which depend on micro hydro for electricity are at risk of reduced generation capacity due to lack of groundwater recharge.

‡‡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.
2.3. 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]). This is a positive outcome on several fronts. It has important implications for the design of hydropower projects, which are planned at a 90% dependable flow. The 90% dependable flow rate is also used as a measure of ground water contribution to stream flow and thus a measure of run-of-the-river hydropower potential. The VRA results show that the minimum required flows will occur throughout most of the year. This may have positive implications for energy generation, including small scale generation, as a minimum level of water is likely to be available in streams almost all year round.

2.4. Increased stress on dam infrastructure

The VRA results specifically show an increased risk of flooding at Tehri and Kalagarh dam locations based on the analysis of return periods or the likelihood of a high magnitude flood event to occur within a specific duration. 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 Kalagarh 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.

These findings are particularly interesting given a recent study conducted at the regional level in the Himalayas which found that many existing and potential hydropower projects in India, Nepal, Pakistan and China are at risk from Glacial Lake Outburst Flood (GLOF) discharges, which means they could be inundated with water from melting glaciers. Evidence from this study as well as Uttarakhand’s VRA suggest that hydropower projects must be able to account for higher water flows in future. 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.

2.5. Increased risk of flooding

Uttarakhand, like all Himalayan states, is prone to heavy monsoon rainfall, landslides and floods, which can lead to disasters such as the June 2013 floods. The VRA indicates that flooding may increase in future; 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, Hardwar, Tehri Garhwal and Uttarkashi are likely to increase by 30 to 40%. 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 including for energy infrastructure, particularly hydropower plants. 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 devastating impacts.

3. LIMITATIONS OF THE VRA

Hydrological modelling in the VRA contains inadequate glacier and snow information. Glacier and snowmelt have important implications on the availability of water resources; they have been accounted for in the VRA projections but without validation. Therefore potential increase or decrease in water availability owing to glacier melt has been subject to the validity of the initial conditions used in the models for the snow and glacier cover.

3.1.1. On-ground vulnerability and coping strategies

The PRA gives a limited indication of vulnerabilities and coping strategies directly related to energy issues, since this sector was not focussed on during village visits. Current on-ground vulnerabilities linked to the energy sector have been outlined in Box 1. All villages sampled are connected to the power grid and feel they have enough electricity throughout the year in their homes. Firewood is the primary option for cooking fuel in many villages, and most of the firewood is collected from the Van Panchayats. Across villages, women typically spend anywhere between two to six hours a day collecting firewood across seasons. Cow dung is used as the primary fuel in one village.

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1Representative 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.

2Stream 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.

3A 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).
Energy policies and plans in Uttarakhand would benefit from a review – in line with the VRA findings – in order to manage areas of current and emerging risk due to climate change, as well as potential opportunities. Some of the relevant energy policies and schemes that need to be examined in light of the VRA are:

- 24X7 Power for All, a joint initiative between the Government of Uttarakhand and Government of India to provide quality and reliable power supply 24X7 to consumers
- Uttarakhand Green Energy Cess Act (2014)
- Energy Conservation Handbook, developed by the Uttarakhand Renewable Energy Development Agency (UREDA) and the University of Petroleum and Energy Studies Dehradun with support from the Bureau of Energy Efficiency within the Ministry of Power

Furthermore, the energy sector is an important component of India’s Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC), which aims to better mitigate and adapt to climate change by enhancing investments in development programmes in a number of areas including energy, water resources, and the Himalayan region. The NDC specifically highlights hydropower as one of the sources of clean energy being promoted in the country to reduce emissions and increase energy access. Interventions that implement and deliver NDC objectives are likely to be eligible for international finance from multilateral and bilateral development partners.

### 5. AGENDA FOR CLIMATE ACTION

The following table suggests areas of action to be undertaken in the energy 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.

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<tr>
<th>Climate Impact Area</th>
<th>Action</th>
<th>Type of Intervention</th>
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</table>
| Rising temperatures and humidity levels resulting in increased energy demand | • Promote energy conservation and efficiency initiatives such as those outlined in Uttarakhand's Energy Conservation Handbook and consider developing and implementing training programmes for different target groups such as agriculture and industry  
• Consider making energy conservation and efficiency initiatives such as use of roof top solar panels, solar water heaters and efficient light bulbs, mandatory in government buildings.  
• Investigate options to decrease losses in transmission and distribution, which is already a State priority, and will increase efficiency to help meet rising demand | Strengthening existing programmes  
Information and research |
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<tr>
<th>Climate Impact Area</th>
<th>Action</th>
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| Seasonal changes in water availability  | • Conduct comprehensive feasibility studies on proposed hydropower projects in light of changes in water availability due to climate change. For e.g. decrease in rainfall causing reduction in water resources, potentially leading to underperformance of hydropower projects and compromised security of energy supply  
  • Due to the potential challenges associated with hydropower, conduct research on feasibility of alternative energy sources, such as wind, solar and biomass as well as electricity generation methods, for example generation from waste  
  • Evaluate the feasibility of multipurpose dam projects, where hydropower generation (contributing to energy security) is combined with water storage for improved irrigation, drinking water, and flood regulation during extreme events (noting that information exchange and coordination between different institutions and sectors is essential for such projects) | Information and research                        |
| Potential improved stream flow          | • Use VRA findings on stream flow dependability when assessing and planning run-of-the-river hydropower projects, to take advantage of when and where river flows are likely to be sustained year-round  
  • Promote and develop community managed micro and mini hydropower projects where stream flows are expected to be sustained | Strengthening existing initiatives             |
| Increased risk of flooding              | • 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 of likely future climate change  
  • Develop guidance for decision-makers in water resource management to be able to use relevant VRA outputs (e.g. 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  
  • Incorporate a comprehensive disaster mitigation plan that considers climate change in all hydropower projects, in accordance with the new act on dam safety, to help manage impacts from extreme events  
  • Conduct regular monitoring, evaluation and maintenance of dams/reservoirs, linked to early warning systems for a better understanding of when and where flooding may occur | Strengthening existing initiatives  
  Information and research  
  Capacity building  
  Strengthening existing initiatives |
| Increased stress on dam infrastructure  |                                                                                                                                             |                                               |
| Climate change can undermine development objectives | • Ensure that State's sectoral vision and objectives are drawn up in a single energy policy document, which will serve as a guide to climate-resilient decision making in line with State priorities  
  • Establish a state-level energy committee to monitor and review actions taken in line with the UAPCC and provide future directions for the power sector  
  • Set up river discharge stations to systematically collect hydrological data on Uttarakhand's rivers, to be kept in a data bank library to improve the scientific evidence base  
  • | Strengthening existing initiatives  
  Strengthening existing initiatives  
  Information and research |

*As per UAPCC recommendation*
### Climate Impact Area

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<tr>
<th>Action</th>
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<tr>
<td>Conduct climate VRA of energy sector, including analysis of past climate impacts on energy sector (operational, performance, maintenance, financial impacts) and potential future impacts</td>
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<td>Develop an awareness raising programme within relevant ministries on the impacts of climate change on energy systems and how to manage these impacts</td>
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<tr>
<td>Revisit studies of hydroelectric power potential in various river basins of India (the last study was carried out between 1978-1987) to factor in future climate change impacts on water availability and help ensure sustainable usage of the river for electricity generation. For example, conduct new Carrying Capacity Studies (CCS) and Cumulative Environmental Impact Assessment (CEIA) studies, such as those conducted for rivers Alaknanda and Bhagirathi, to inform planning of new projects. These basin-level studies represent a step beyond traditional EIAs, as they adopt an integrated approach to assess impacts from various developmental projects and assess the cumulative ecological impact of all the hydropower projects planned or under execution.</td>
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### Type of intervention

- Information and research
- Capacity building
- Information and research

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### 6. DEVELOPMENT CO-BENEFITS

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

- Help meet rural energy needs through sustainable energy, as per Uttarakhand's renewable energy policy, helping to contribute to socioeconomic development in rural areas
- Promote low-carbon and climate resilient growth to not only reduce emissions and decrease vulnerability to a changing climate, but also to improve the State's energy security
- Help meet India's future energy needs of 2499 terawatt-hours by 2030 (from 776 in 2012) as per India's NDC
- Contribute to achieving India’s voluntary goal of reducing the emissions intensity of its GDP by 20–25%, over 2005 levels, by 2020 as per India's NDC
- Contribute to India's NDC mitigation strategy of further developing India's hydropower potential, for example through small and mini hydel projects
- Contribute to reaching UPCL’s target to reduce AT&C losses to 14% by March 2020
- Contribute to goals laid out in 24X7 Power For All joint initiative between the State and central government with the aim to provide 24x7 power available to all households, industry, commercial businesses, public needs, any other electricity consuming entity and adequate power to agriculture farm holdings by 2019.
- Through development of regulated multipurpose dam projects, build resilience to changes in water resources by providing storage capacity when water availability is less, decreasing vulnerability to water shortages.

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