BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

PRINCIPAL BENCH, NEW DELHI

MA No. 71 of 2025

IN

ORIGINAL APPLICATION No. 485 of 2017

IN THE MATTER OF:

Mandakini Badh Prabhavit Samiti ...Applicant

Versus

L&T Uttaranchal Hydropower Ltd & Ors. ...Respondents

N.D.O.H. 25.09.2025

INDEX

Ankur Sood

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Place: New Delhi
Drawn on: 20.06.2025
Dated: 04.07.2025

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

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<u>IN THE MATTER OF:</u>

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<u>AFFIDAVIT ON BEHALF OF THE APPLICANT TO PRODUCE SUPPORTING DOCUMENTS AS PER ORDER DATED 20.05.2025 PASSED BY THIS HON'BLE TRIBUNAL</u>

I, Shri Yogambar Singh Negi, S/o – Shri B.S. Negi, aged about 58 years, R/o – Chandrapuri, District Rudraprayag, Uttarakhand - 246425, do hereby solemnly affirm and sincerely state as follows:

1. I am the authorized signatory for the Applicant and competent to affirm this affidavit in my official capacity on behalf of the Applicant. I am conversant with the facts and circumstances of the present case. Thus, I am able and competent to depose on oath and file the present affidavit. The present affidavit is

being filed on behalf of the Applicant to place on record additional material and supporting documentation in terms and compliance with the order dated 20.05.2025 passed by this Hon'ble Tribunal in the present case.

2. The present matter pertains to the residents affected due to the flood in the Mandakini River in 2013 caused by the Bhatwari - Singoli Hydro-electric Project undertaken and developed by Respondent No.1 herein.

3. It is respectfully submitted that the construction and operation of Hydro-Electric Projects (**HEPs**) are known to contribute significantly to the incidence and severity of floods in the surrounding regions. These projects often involve large-scale alterations of natural river courses, the accumulation of water in reservoirs, and the discharge of water in sudden bursts, either due to controlled releases or emergency spillway operations, all of which can disrupt the ecological balance and lead to downstream flooding. Furthermore, the accumulation and mismanagement of muck generated during construction exacerbates this risk by obstructing natural drainage systems and increasing the silt load in rivers. Thus, the adverse environmental consequences of such projects, particularly

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their role in aggravating flood situations, merit serious consideration. The South Asia Network on Dams, Rivers and People (**SANDRP**) in its June-July 2013 Bulletin reported specifically for Uttarakhand that:

> *"Almost all hydropower projects of Uttarakhand involve deforestation. Deforestation directly increases the potential of erosion, landslides and floods since water now just runs off to the rivers, solid becomes exposed and without any binding that forests provided. Moreover, the compensatory afforestation and catchment area treatment, even when done, usually involves planting of commercially important variety of trees like pine and teak and not broad leaf trees like oaks that not only adds to humus in the soil but also allow rich under growth. Pine does not allow this to happen.*
>
> *Blasting of massive proportions is involved in construction of all these components, which add to the landslide risks. In fact, Uttarakhand's Disaster Mitigation and Management Centre in their report of Oct 2012 after the Okhimath disaster of Sept 2012 recommended that no blasting should be allowed for any development activity anywhere in Uttarakhand, but Uttarakhand government did nothing about this recommendation.*
>
> *The massive tunneling by itself weakens the young and fragile Himalayan mountains, increasing the disaster potential.*
>
> *Each of the hydropower projects generates massive amount of muck in tunneling, blasting and other activities, a large hydropower project could easily generate millions of cubic meters of muck. The large projects are supposed to have muck disposal plan, with land acquired for muck disposal, transportation of muck to the designated sites above the High Flood levels, creation of safety walls and stabilization process. But*

all this involves costs. The project developers and their contractors find it easier to dump this muck straight into the nearby rivers. In the current floods, this illegally dumped muck created massive disaster in downstream areas in case of 330 MW Srinagar HEP, the 76 MW Phata Byung HEP and the 99 MW Singoli Bhatwari HEP. When the flooded rivers carry this muck, boulders and other debris, has much greater erosion capacity and also leaves behind massive heaps of this muck in the flooded area. In Srinagar town about 100 houses are buried in 10-30 feet depth of muck. Such debris laden rivers also create massive landslides along the banks.

Wrong operation of hydropower projects can also create greater disasters in the downstream areas. For example, the operators of 400 MW Vishnuprayag HEP on Alaknanda river did not open the gates when the river was flooded on June 16-17, possibly to maximize power generation. However, this led to accumulation of massive quantities of boulders (for photos of dam filled with such boulders see: http://matuganga.blogspot.in/) behind the dam, so much so that there was no space for water to flow. The river then bypassed the dam and started flowing by the side of the dam, creating a new path for its flow. This created a sudden flashflood situation in the downstream area, creating new disaster there.

...

The incomplete, broken and ill designed protection wall of the Maneri Bhali projects in Uttarkashi lead to erosion and landslides in the downstream areas.

...

Some of the hydropower projects that have surely seems to have added to the disaster proportions of current Uttarakhand flood disaster include the 400 MW Vishnuprayag HEP, the 280 MW Dhauliganga HEP, the 330 MW Shrinagar HEP, the 304 and 90 MW Maneribhali II and I HEPs, the 99 MW Singoli Bhatwari HEP and the 76 MW Phata Byung HEP, the last two on

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Mandakini River."

Dr. Maureen O'Sullivan recently published a paper about the impact of HEP's on Uttarakhand's ecosystem and stated that:

> *"While hydroelectric projects play a pivotal role in addressing India's growing energy demands and fostering economic development, their environmental and socio-economic consequences, particularly in ecologically sensitive regions such as Uttarakhand, cannot be overlooked. These projects have led to significant disruptions, including deforestation, loss of biodiversity, alteration of riverine ecosystems, displacement of local communities, and increased vulnerability to natural disasters such as landslides and floods. The fragile Himalayan ecosystem, already under stress from climate change, faces compounding challenges due to unregulated and large-scale hydropower development."*

A copy of the Himanshu Thakkar's article titled "Uttarakhand: Existing, under construction and proposed hydropower projects: How do they add to the disaster potential in Uttarakhand?" published in the SANDRP Bulletin, June-July 2013, has been annexed and marked hereto as **Annexure A/1**.

A copy of Dr. Maureen O' Sullivan's article titled "Impact of Hydroelectric Projects on Uttarakhand's Ecosystem" in The RESO Research Sociology Review, 2025 - Volume 2, Issue 2, has been annexed and marked hereto as **Annexure A/2**.

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4. Amelie Huber, in the famous Water journal, argued that HEPs cause floods in Uttarakhand and HEPs are unable to manage destructive water and sediment flows. Amelie argued the same in the following terms:

> *"But hydropower infrastructure is not only at risk. It also contributes to the intensification of hazard potential, often as a consequence of political and economic decisions about its siting, construction and operation. Schwanghardt et al. (p. 1). observe a systematic push of hydropower activities into the headwaters of Himalayan river basins, closer to glacial lakes and on potential GLOF tracks, estimating that a third of the sampled sites "could experience GLOF discharges well above local design floods." Likewise, investigations identified hydropower infrastructure as one of the main contributors to the Uttarakhand flood damage. Damage was greater near existing and under-construction hydro-projects—a result of how these projects manage destructive water and sediment flows. Construction debris was inadequately disposed of and washed into reservoirs, obstructing dam/barrage gates and leading the river to overflow and laterally outflank the dams. Excessive siltation had reduced the carrying capacity of rivers and increased their erosive capacity.*
>
> *Dam-induced flash floods are a recurrent problem, caused by sudden releases of water from hydropower stations. Designed primarily for power generation, most run-of-the-river projects today lack adequate flood cushions, as Das explains. Especially at times when reservoirs are full (e.g., at the end of the monsoon season), flood absorption is not guaranteed—a fact often brushed over by hydropower proponents. When excessive inflows from floods or heavy rainfall exceed storage capacity, it is standard practice to release water to ensure dam safety. But such patterns of water*

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release can be highly disruptive, accentuating flood impacts downstream (ibid.), as has been most cruelly demonstrated by the massive flood disaster in Kerala this year.

Finally, what is easily overlooked, especially when thinking in terms of large-scale dam disasters, is the "slow violence" of everyday ecological precarity accompanying the construction of hydropower infrastructure in fragile geological settings. Phenomena reported from hydropower-affected areas across the Himalayas, such as the sudden appearance of cracks in houses, the activation of landslide zones, or water resources running dry may represent more tangible and cumulatively impactful hazards to the lives and livelihoods of rural Himalayan communities."

A copy of Amelie Huber's article titled "Hydropower in the Himalayan Hazardscape: Strategic Ignorance and the Production of Unequal Risk" published in Water journal - Volume 11, Issue 3 (2019) has been annexed and marked hereto as **Annexure A/3.**

5. Another article in Water journal written by Stephanie Buechler et. al. presents the various effects of HEP development on the ecosystem:

"The negative effects of hydropower development reported by villagers living and farming in the vicinity of these ROR projects include land destabilization, leading to infrastructure damage including cracks/seepage in houses and/or community buildings; and destabilization of slopes with greater

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chance of landslides, fissures and land subsidence (some of these effects are due to dynamite blasting of tunnels for the HEP project); as well as an accumulation of muck (rock and debris created by tunneling during the construction of hydropower projects) on grazing/ agriculture land. There are also myriad water-related effects such as reduced water resource availability including defunct watermills (for grinding grains) due to less water in the river in locations where water has been extracted for the HEP; reductions in domestic and irrigation water supply due to spring sources disturbed especially by tunnel blasting; irrigation canals destroyed due to landslides or abandoned due to too little water available; water pipelines carrying spring water for domestic water use and home gardens destroyed; dry riverbeds during part of the year; more wild animal attacks on crops and livestock due to deforestation affecting food supply for these animals; and less water in the river; reduction in irrigated area; reduction in availability of fodder and fuelwood due to less vegetation along the river banks; reduction in manure due to less livestock kept because of decreased availability of fodder; loss of cremation ghats (riverside cremation grounds); and a reduction in fish population due to less water in the river and poorer water quality. These effects are not limited to the study area. Dry springs and increased vulnerability to landslides and deforestation, for example, were similarly identified as effects of hydropower projects in the Nanda Devi biosphere reserve in Uttarakhand to the northeast of the Bhilangana study sites."

Furthermore, Mr. Subrata Sinha and S Chattopadhyay also write in their paper that development of hydro projects leads to several environmental problems such as deforestation, soil erosion, water pollution etc. ultimately being reasons of floods

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due to HEPs. The relevant portion of the paper is given below:

> *LCLUC (Land Cover Land Use Change) for the development of hydro projects leads to several environmental problems such as deforestation, soil erosion, water pollution etc. Water pollution is increased due to increased use of fertilizer in agriculture to meet the upcoming demand as well as the decrease in cultivable land, municipal solid waste and sewage etc.*
>
> ...
>
> *Consequences of deforestation due to development of Hydropower projects: Forest clearance or forest area diversion in the Himalayas to develop hydro projects has increased the severity of floods during the rainy season and reduced stream flows and dried up springs during dry seasons and responsible for local climate change.*
>
> *Alter Rainfall pattern: During periods of limited rainfall, soil gets dried and heavier rainfall results in greater and more rapid runoff, thereby increasing flooding and nutrient loss, resulting in reduced food production. Change in rainfall pattern reduced stream flows and dried up springs during dry seasons.*

A copy of Stephanie Buechler's article titled "Re-Linking Governance of Energy with Livelihoods and Irrigation in Uttarakhand, India" published in Water journal - Volume 8 (2016) has been annexed and marked hereto as **Annexure A/4.**

A copy of article by Subrata Sinha and S Chattopadhyay titled "Environmental Impact Assessment Of Hydroelectric Power

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Plant" published by International Research Journal of Natural and Applied Sciences - Volume 5, Issue 4 (2018) has been annexed and marked hereto as **Annexure A/5.**

6. Economic and Political Weekly (**EPW**) published in 2021 that even smaller HEPs cause floods and other devastation to the ecosystem of Uttarakhand due to wrongful disposal of muck by the HEP's developer(s). The relevant extract of the article has been reproduced below:

> *"The raised riverbeds, due to the huge quantities of muck, reduce the capacity of containing the increased mass of slush and sediment that the rivers in such regions inevitably carry in flash flood events, while the muck increases their destruction potential. Due to excessive use of explosives for constructing tunnels that often pass below the villages, slopes have weakened, homes have cracked and even collapsed, and fields have developed fissures or subsided. This is seen in the entire Garhwal region wherever hydropower projects are coming up.*
>
> ...
>
> *Technically, the Rishi Ganga at 13.2 MW was a small project (less than 25 MW). Small projects, however, are but a smaller version of the large projects in Uttarakhand, with the same design of dams diverting rivers in tunnels, causing river- beds to dry, and involving the same practices of blasting, deforestation, and muck dumping that makes them equally hazardous. Like the large "RoR" projects, they also involve excavating for diversion, main, and adit tunnels, and construction of road networks, cofferdams, diversion dams, residential structures, and*

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> *powerhouses. Thus, even a small project built in this manner involves what Valdiya (2014: 1663) terms as excessive "tampering with the natural balance" in these zones of "very weakened rocks."*

Another article by Dr. Rajesh Kumari shows that the impact of floods increases due to inappropriate disposal of muck by the project developers. The said article states that:

> *"The likely impacts on the water quality arise from inappropriate disposal of muck, effluents from crushers and other sources and sewage from labour camps and colonies. The muck will essentially come from the road-building activity, tunneling and other excavation works. The unsorted waste going into the river channel will greatly contribute to the turbidity of water continuously for long time periods."*

A copy of the Shruti Jain's article titled "Construction of Calamities in the Uttarakhand Himalaya" published in the EPW – Vol. LVI, No. 13 (2021) has been annexed and marked hereto as **Annexure A/6.**

A copy of Dr. Rajesh Kumari's article titled "Sustainability of dams on river Alaknanda" published in the International Journal of Multidisciplinary Trends - Volume 2 Issue 1 (2020) has been annexed and marked hereto as **Annexure A/7.**

7. Furthermore, HEPs affect surrounding areas to a great extent. Hydropower development causes people to migrate to safer

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areas and/or switch jobs, due to various reasons. Dr. Surender Kumar, a sociologist and human rights researcher, stated in his recent paper that:

> *"The Tehri Dam, one of India's largest hydroelectric projects, displaced over 100,000 people, submerging entire villages, temples, and agricultural lands. The forced displacement of communities has led to economic hardship and the loss of indigenous knowledge related to river conservation. Studies indicate that Tehri town and surrounding areas have experienced increased seismic activity, raising concerns about dam safety (CSE, 2022). Downstream areas are experiencing reduced water flow and sediment transport, affecting agriculture and fisheries. Case Study: Chamoli Disaster (2021)– Hydropower and Landslides. In February 2021, a glacial outburst in the Rishiganga Valley triggered a landslide, killing over 200 people and destroying two hydropower plants. Scientists linked this disaster to unregulated hydropower development and the weakening of mountain slopes due to excessive tunneling."*

A copy of Dr. Surender Kumar's article titled "Addressing the Environmental Crisis in Uttarakhand: A Sociological and Ecological Analysis" published by Research Sociology Review - Vol.2, Issue 6 (2025) has been annexed and marked hereto as **Annexure A/8.**

8. Due to HEPs and dams, the residents on the downstream do not get time to respond to the unnatural sudden flow. The relevant extract of an article by the Economic and Political

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Weekly (EPW) Engage is reproduced below:

> *"Floods caused by a dam are sudden, and given its intensity and the unpreparedness of people living in surrounding areas, its impact is more destructive to lives and property. The sudden nature of floods caused by dams, together with the reluctance of authorities to share information with people, makes communities vulnerable in a two-term monsoon region like Kerala. In an undammed river, the flood water rises over a period of time, which allows people to respond. Moreover, due to the dam the contours of the riverbed, the flow of the river downstream and even the floodplains change. Besides, dams tend to give a false sense of security because people tend to forget even the normal impact on rivers due to the monsoons."*

> *"The downstream communities of Assam of the 405 megawatt (MW) Ranganadi hydroelectric project in Arunachal Pradesh, for instance, experience catastrophic daminduced flash floods in the monsoon months, while for the rest of the year they see the river as a trickle. The communities talk of "theft of their river," of "run-away-withthe-river" while they were promised a "run-of-the-river" dam project, and had no experience of dam-induced flash floods before the dam was built in 2002 (Rahman 2014). This underlines the aspect of infrastructuring floods, and of creating new flood discourses. Such dam-induced flood hazards are spread across the Brahmaputra river basin, for instance, the Doyang and Kopili hydroelectric projects in Nagaland and Assam respectively, and the several dam projects being built in upstream Bhutan, China, and the multitude of proposed small, medium and mega dams in Arunachal Pradesh."*

A copy of the article titled "Floods in Indian Rivers: Are Dams and Embankments the Solution or the Problem?" published

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in the EPW Engage has been annexed and marked hereto as **Annexure A/9.**

9. It is further submitted that disaster affected people and their family members, who lost their entire property including their houses, land, domestic animals, and cowsheds due to the damage caused by Bhatwari - Singoli Hydroelectric Project in the 2013 disaster. The affected families have not received adequate compensation for the loss of their homes, land, and livestock. This has led to severe economic instability, leaving them without a sustainable source of income or livelihood.

10. The hardships faced by some of the affected individuals are given hereinbelow:

    a. Mrs. Geeta Devi w/o Late Harendra Lal Chandrapuri - After the disaster, her husband was suffering from stress and he worked day and night to support the children, due to which he died suddenly at a very young age. At present, their financial condition is very pathetic.

    b. Mrs. Bhaga Devi w/o Late Sri Tongi Lal Chandrapuri - After the disaster, her husband suffered from heart

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disease, due to which he died. Now, there is no source of income.

c. Mrs. Darshani Devi w/o Late Chhotiya Lal - Her husband was shocked by the disaster and died to heart disease. She herself remains ill. Apart from the children, there is also a mentally challenged brother in the family. It is impossible to support the family in such a situation.

d. Sh. Nand Lal s/o Late Kala Lal – There is no source of income. He is suffering from sciatica and is incapable of working and is also unable to get treatment due to financial constraints.

e. Sh. Harsh Lal s/o Chhotiya Lal - One of his children is suffering from heart disease. Due to lack of financial resources, it is difficult to educate and maintain the children.

f. Sh. Ramesh Lal s/o Late Kundan Lal - He took a loan of ₹75,000 from the bank in 2011 of which more than ₹40,000 is yet to be repaid. The bank is repeatedly sending notices that he is unable to repay the bank loan

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due to his poor financial condition.

g. Sh. Sunil Kumar s/o Amar Lal – He has no source of income. He works as a labour whenever he gets work. His parents are old and ill. He has borrowed some money from his relatives, which he is unable to repay.

h. Mrs. Darshani Devi - Her husband Darshan Lal died due to illness and financial constraints. After losing everything in the disaster, there is no means of employment.

i. Sh. Govardhan Lal s/o Late Gokuldev – He is in bad financial condition. Due to poverty, he is facing difficulty in getting his ailing mother treatment and his children educated. He is also unable to repay the loan taken from relatives.

j. Sh. Rajpal Lal s/o Late Kutta Lal - He does not have any means of employment due to which it is difficult for him to support his family.

k. Sh. Santosh Chandrawal s/o Late Buddhi Lal – He

NOTARY M.P.S. RAWAT ADVOCATE Srinagar (Garhwal) Regd. No. (06) (09) /02 UTTARAKHAND (INDIA) supports his family with the wages he occasionally gets after the disaster, but he is still unable to pay the school fees of his two children.

l. Sh. Kunwar Lal s/o Late Madho Lal – He had taken a loan and built a house in another village after the disaster, but two years after the disaster and just a month after moving into the new house, his wife died untimely, due to which he was forced to leave the house. The loan taken to build the said house is yet to be repaid. Both his children are also unemployed.

m. Sh. Surendra Lal s/o Late Ravi Lal - He built a small house in another village after the disaster, in which the whole family cannot live. The loan for the house is yet to be repaid and there is no source of income either.

n. Smt. Guddi Devi w/o Late Dinesh Lal Chandrapuri - Her husband died due to frequent illness after the disaster and now, there is no source of income with her.

The Letters made by the various affected members describing their economic situation alongwith their True Translated

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Copies have been annexed and marked herewith as **Annexure A/10. (Colly.)**

11. That the contents of the Affidavit have been prepared under the instructions of the deponent and the same are true and correct and nothing material has been concealed therefrom.

Solemnly affirmed at Srinagar Pauri (Garhwal)

DEPONENT
मुख्य संयोजक
मन्दाकिनी बाढ़ प्रभावित समिति
चन्द्रापुरी

VERIFICATION

Verified at Srinag on 20 day of 6/2014 2025 that the contents of above Affidavit are true and correct to the best of my knowledge and belief, no part of it is false and nothing material has been concealed therefrom.

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ADVOCATE
Srinagar (Garhwal)
Regd. No.
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Sworn and verified the deponent on oath at Srinagar Pauri (Garhwal) Uttarakhand
Date 20/6/2024

M.P.S. Rawat
Advocate/ Public Notary
Reg. No. (06) (09) 02
Advocate No. U.P. 2247/92 - U.K. 2249/02

DEPONENT
मुख्य संयोजक
मन्दाकिनी बाढ़ प्रभावित समिति

Uttarakhand: Existing, under construction and proposed Hydropower Projects:

How do they add to the disaster potential in Uttarakhand?

As Uttarakhand faced unprecedented flood disaster and as the issue of contribution of hydropower projects in this disaster was debated, one question for which there was no clear answer is, how many hydropower projects are there in various river basins of Uttarakhand? How many of them are operating hydropower projects, how many are under construction and how many more are planned? How projects are large (over 25 MW installed capacity), small (1-25 MW) and mini-mirco (less than 1 MW installed capacity) in various basins at various stages. This document tries to give a picture of the status of various hydropower projects in various sub basins in Uttarakhand, giving a break up of projects at various stages.

Uttarakhand has 98 operating hydropower projects (all sizes) with combined capacity close to 3600 MW. However, out of this capacity, about 1800 MW is in central sector and 503 MW in private sector, making it uncertain how much power from these projects the state will get. Moreover, it is universally true that local communities never get the power from large hydro projects.

River Basins in Uttarakhand Entire Uttarakhand is part of larger Ganga basin. The Ganga River is a trans-boundary river of India and Bangladesh. The 2,525 km long river rises in the western Himalayas in the Indian state of Uttarakhand, and flows south and east through the Gangetic Plain of North India into Bangladesh, where it empties into the Bay of Bengal. The Ganga begins at the confluence of the Bhagirathi and Alaknanda rivers and forms what we have called Ganga sub basin till the Ganga river exits Uttarakhand. Besides Bhagirathi, Alaknanda and Ganga sub basin, other river basins of Uttarakhand include: Yamuna, Ramganga (Western Ramganga is taken as Ramganga basin in this document, eastern Ramganga is considered part of Sharda basin) and Sharda. Sharda sub basin includes eastern Ramganga, Goriganga, Dhauliganga, Kaliganga and part of Mahakali basin.

Existing hydropower projects in Uttarakhand In the table below we have given the sub basin wise list of existing hydropower projects in Uttarakhand along with their capacities. The list has been prepared based on various sources including Central Electricity Authority, Uttarakhand Jal Vidhyut Nigam (UJVNL), Uttarakhand Renewable Energy Development Authority (UREDA) and Report of Inter Ministerial Group on Ganga basin.

Table 1: Existing Hydropower projects in Uttarakhand

Projects	Installed Capacity (MW)
Projects in Alaknanda River Basin	
1. Vishnu Prayag (P)	400
2. Tilwara	0.2
3. Soneprayag	0.5
4. Urgam	3
5. Badrinath II	1.25
6. Rajwakti (P)	3.6
7. Tapowan	1
8. Jummagad	1.2
9. Birahi Ganga (P)	7.2
10. Deval (P Chamoli Hydro P Ltd on Pinder)	5
11. Rishiganga (P)	13.5
12. Vanala (P Hima Urja P Ltd Banala stream)	15
13. Kaliganga I (ADB)	4
Alaknanda Total	**455.45**
Projects in Bhagirathi River Basin	
14. Maneri Bhali-1 (Tiloth)	90
15. Maneri Bahli-2	304
16. Tehri St-I	1000
17. Koteshwar	400
18. Harsil	0.2
19. Pilangad	2.25
20. Agunda Thati (P Gunsola hydro Balganga river)	3
21. Bhilangana (P - Swasti)	22.5

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22. Bhilangana III (P - Polyplex)	24
23. Hanuman Ganga (P – Regency Aqua)	4.95
Bhagirathi Total	**1850.9**
Projects in Ganga River sub basin downstream of confluence of Bhagirathi and Alaknanda	
24. Chilla	144
25. Pathri	20.4
26. Mohamadpur	9.3
Ganga sub basin Total	**173.7**
Projects in Ramganga basin	
27. Ramganga	198
28. Surag	7
29. Loharkhet (P Parvatiya Power P Ltd Bageshwar)	4.8
30. Kotabagh	0.2
31. Sapteshwar	0.3
32. Gauri	0.2
Ramganga Total	**210.5**
Projects in Sharda River Basin	
33. Dhauliganga	280
34. Tanakpur	94.2
35. Khatima	41.4
36. Chirkilla	1.5
37. Taleshwar	0.6
38. Suringad	0.8
39. Relagad	3
40. Garaon	0.3
41 Charandev	0.4
42. Barar	0.75
43. Kulagad	1.2
44. Kanchauti	2
Sharda Total	**426.15**
Projects in Yamuna River Basin	
45. Chibro	240
46. Dhakrani	33.75
47. Dhalipur	51
48. Kulhal	30
49. Khodri	120
50. Galogi	3
51. Tharali	0.4
Yamuna Total	**478.15**
Grand Total	**3594.85**

Note: (P) in the bracket suggests the project is in private sector, throughout this document. The eastern Ramganga river, which is part of Sharda basin, is included in Sharda basin. Where-ever Ramganga river is mentioned in this document, it refers to Western Ramganga, which is a tributary of Ganga.

In the next table we have given available list of existing mini and micro hydropower projects in Uttarakhand, based on UREDA information.

Table 1: List of projects up to 1 MW under operation

SN	Project	Ins Cap (MW)	Dist	Basin
1	Milkhet	0.1	Chamoli	Alaknanda
2	Bamiyal	*	Chamoli	Alaknanda
3	Bursol	0.2	Chamoli	Alaknanda
4	Choting	0.1	Chamoli	Alaknanda
5	Ghagaria	0.1	Chamoli	Alaknanda
6	Ghagaria Extension	*	Chamoli	Alaknanda
7	Ghes	0.1	Chamoli	Alaknanda
8	Gulari	0.2	Chamoli	Alaknanda
9	Niti	0.025	Chamoli	Alaknanda
10	Sarma	0.1	Chamoli	Alaknanda Nandakini/ Maini Gad
11	Wan	0.05	Chamoli	Alaknanda
12	Bank	0.10	Chamoli	Alaknanda Pinder
13	Gamsali Bampa	0.05	Chamoli	Alaknanda Dhauliganga/Ganesh Ganga
14	Kedarnath II	0.2	Rudraprayag	Alaknanda
15	Badiyakot	0.1	Bageshwar	Alaknanda
16	Kunwari	0.05	Bageshwar	Alaknanda
17	Borbalada	0.025	Bageshwar	Alaknanda Pindar/ Chhiyaldi Gad

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18	Dokti	0.02	Bageshwar	Alaknanda
19	Dior IInd Phase	*	Pauri	Alaknanda/ Ganga
20	Chandrabhaga Gad	*	Tehri	Bhagirathi
21	Jakhana	0.1	Tehri	Bhagirathi Bhilangana/Balganga
22	Gangotri-I	0.1	UttarKashi	Bhagirathi Kedar Ganga
23	Kanwashram	0.1	Pauri	Ganga
24	Bilkot	0.05	Pauri	Ramganga
25	Dior Ist Phase	0.1	Pauri	Ramganga
26	Gogina II	0.05	Bageshwar	Ramganga
27	Sattshwar	0.05	Bageshwar	Ramganga
28	Toli	*	Bageshwar	Ramganga
29	Ramgarh	0.1	Nainital	Ramganga
30	Lathi	0.1	Bageshwar	E Ramganga/Sharda
31	Liti	0.05	Bageshwar	E Ramganga/Sharda
32	Liti-II	0.05	Bageshwar	E Ramganga/Sharda
33	Ratmoli	0.05	Bageshwar	E Ramganga/Sharda
34	Baghar	0.05	Bageshwar	E Ramganga/Sharda
35	Baicham	0.1	Bageshwar	E Ramganga/Sharda
36	Jugthana	0.1	Bageshwar	E Ramganga/Sharda
37	Kanol gad	0.1	Bageshwar	E Ramganga/Sharda
38	Karmi	0.05	Bageshwar	E Ramganga/Sharda
39	Karmi -III	0.05	Bageshwar	E Ramganga/Sharda
40	Karmi-II	0.05	Bageshwar	E Ramganga/Sharda
41	Bhikuriya Gad	0.5	Pithoragarh	Sharda
42	Kanchauti	*	Pithoragarh	Sharda
43	Lamabager	0.20	Bageshwar	Sharda Saryu
44	Lamchula	0.05	Bageshwar	Sharda Saryu
45	Tarula	0.10	Almora	Sharda Saryu/Jataya Ganga
46	Taluka	0.025	Uttarkashi	Yamuna Tons/ Gattu Gad
47	Bhadri Gad	0.02	Tehri	Yamuna

From http://ahec.org.in/, capacity of some of the projects is as per the UJVNL website. The capacity comes to 3.815 MW for the 41 projects for which capacity is available. * means capacity is not known.

Overview of hydropower Projects in Uttarakhand Based on above two tables, in the following table we have provided an overview of operating hydropower projects and their capacity, with basin wise and size wise break up. Uttarakhand has total of 98 existing hydropower projects, with total installed capacity of close to 3600 MW. At least eleven of these projects are in private sector with total capacity of over 503 MW. An additional about 1800 MW capacity is in central sector. It means that majority of the power generation capacity in the state is not owned by the state and there is no guarantee how much of that power would be available to the state.

Table 2: Basin wise number of operating hydro projects in Uttarakhand

Basin	Large Hydro projects (above 25 MW)		Small Hydro projects (1-25 MW)		Mini-micro Hydro projects (below 1 MW)		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	1	400	10	54.75	21	2.22	32	456.97
Bhagirathi	4	1794	5	56.7	4	0.4	13	1851.1
Ganga Sub basin	1	144	2	29.7	1	0.1	4	173.8
Ramganga	1	198	2	11.8	9	1.05	12	210.85
Sharda	3	415.6	4	7.7	21	4.45	28	427.75
Yamuna	5	474.75	1	3	3	0.445	9	478.195
TOTAL	**15**	**3426.35**	**24**	**163.65**	**59**	**8.665**	**98**	**3598.665**

Here we should note that as per the Union Ministry of New and Renewable Energy sources, in Uttarakhand, by March 2013, 98 small hydro schemes has been installed with total capacity of 170.82 MW. If we add the small and mini-micro projects in above table, we have 83 operating schemes with installed capacity of 172.315 MW. This mis-match is not possible to resolve since MNRE does not provide full list of operating SHPs in Uttarakhand.

Under Construction Hydropower projects in Uttarakhand In the table below we have given available list of under construction hydropower projects in Uttarakhand. Actual list of under construction projects is

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likely to be larger than this, since clear and upto-date information is not available on official website. The list does not include the mini and micro hydropower projects that are under construction. Even in case of small hydro projects (1-25 MW capacity), the list is not complete. According to this list, 25 projects with 2376.3 MW capacity are under construction in Uttarakhand. 6 of them are large hydropower projects and rest 19 are small hydro projects. Of the 6 large hydropower projects, three are in private sector and three are in central sector, none in state sector.

Table 3: List of Hydropower Projects under construction

SN	Project	Ins Cap (MW)	Dist	Sub-Basin
1	Srinagar	330	Pauri	Alaknanda
2	Phata- Byung	76	Rudraprayag	Alaknanda
3	Singoli-Bhatwari	99	Rudraprayag	Alaknanda
4	Lata Tapovan	171	Chamoli	Alaknanda
5	Tapovan Vishnugad	520	Chamoli	Alaknanda
6	Madhmaheshwar (ADB)	10	Rudrprayag	Alaknanda
7	Kaliganga-II (ADB)	6	Rudrprayag	Alaknanda
8	Bgyunderganga (P)	24.3	Chamoli	Alaknanda
9	Birahi Ganga-I (P)	24	Chamoli	Alaknanda
10	Devali (P)	13	Chamoli	Alaknanda
11	Kail ganga	5	Chamoli Pinder	Alaknanda
12	Khiraoganga (P)	4	Uttarkashi	Alaknanda
13	Sobla I	8	Pithoragarh	Alaknanda
14	Hafla	0.2	Chamoli	Alaknanda Hafla Gad
15	Nigol Gad	0.1	Chamoli	Alaknanda Nigal Gad
16	Wachham	0.50	Bageshwar	Alaknanda Pindar/SunderDhunga Gad
17	Tehri stage-II	1000	Tehri	Bhagirathi
18	Asiganga-I	4.5	Uttarkashi	Bhagirathi
19	Asiganga-II	4.5	Uttarkashi	Bhagirathi
20	Suwarigad	2	Uttarkashi	Bhagirathi
21	Limchagad	3.5	Uttarkashi	Bhagirathi
22	Kaldigad (ADB)	9	Uttarkashi	Bhagirathi
23	Balganga-II	7	Tehri Garhwal	Bhagirathi
24	Jalandhari Gad (P)	24	Uttarkashi	Bhagirathi
25	Kakora Gad (P)	12.5	Uttarkashi	Bhagirathi
26	Kot-Buda Kedar (P)	6	Tehri	Bhagirathi
27	Siyangad (P)	11.5	Uttarkashi	Bhagirathi
28	KotiJhala	0.2	Tehri	Bhagirathi Bal Ganga
29	Pinsward	0.05	Tehri	Bhagirathi Bal Ganga
30	Dunao	1.5	Pauri	Ganga sub basin
31	Gaudi Chida	0.25	Pauri	Ganga sub basin E Nayar
32	Rotan	0.05	Pithoragarh	Sharda E Ramganga/Rotan
33	Duktu	0.025	Pithoragarh	Sharda Kali/ Nati Yanki
34	Nagling	0.05	Pithoragarh	Sharda Kali/ Nagling Yanki
35	Sela	0.05	Pithoragarh	Sharda Dhauli Ganga/ Seal Gad
36	Kutty	0.05	Pithoragarh	Sharda Kali
37	Napalchu	0.05	Pithoragarh	Sharda Kali/ Piear Yanki
38	Bundi	0.05	Pithoragarh	Sharda Kali/ Pulung Gad
39	Rongkong	0.05	Pithoragarh	Sharda Kali/ Dangiang Yanki
40	Chiludgad	0.10	Uttarakashi	Yamuna Supin/Chilude Gad
41	Khapu Gad	0.04	Uttarakashi	Yamuna Supin/Khapu Gad

Total Under Construction 2378.115 MW

Note: Projects like Loharinag Pala, Pala Maneri, Bhairoghati and other projects along Bhagirathi upstream of Uttarkashi along the Eco Sensitive zone have been dropped from this list. Rest of the list is from the IMG report or from UJVNL website. P in the bracket indicates the project is in privte sector. ADB in the bracket indicates that the project is funded by the Asian Development Bank.

Proposed hydropower projects in Uttarakhand In following tables we have provided available list of proposed hydropower projects in the Alaknanda, Bhagirathi, Yamuna, Sharda and Ramganga basins in Uttarakhand. The list is likely to be longer than the list in these tables since full and upto-date information is not available. Also there are different agencies involved in proposing, sanctioning and executing these projects and there is no one agency who would provide comprehensive picture of what is happening in the basin. However, even this available list is frightening.

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Table 4: Proposed Hydropower projects in Alaknanda Basin

SN	Project	Ins Cap (MW)	Dist	Sub-Basin	Status
1	Vishnugad Pipalkoti (WB)	444	Chamoli	Alaknanda	Construction to be started
2	Kotli Bhel (IB)	320	Pauri	Alaknanda	EAC ok/FAC u/consideration
3	Alaknanda (P Badrinath)	300	Chamoli	Alaknanda	EC & FC ok IA not signed
4	Devsari Dam	252	Chamoli	Alaknanda	EC & FC ok CEA concrnce?
5	Kotli Bhel II	530	Pauri	Ganga sub basin	EAC ok/FAC u/consideration
6	Bowla Nandprayag	300	Chamoli	Alaknanda	EAC TOR Approved
7	Tamak Lata	280	Chamoli	Alaknanda	EC ok, DPR under revision
8	Nand Prayag	100		Alaknanda	DPR returned
9	Jelam Tamak	108	Chamoli	Alaknanda	EAC ok in June 2013
10	Maleri Jelam	55	Chamoli	Alaknanda	PFR prepared
11	Rishiganga I	70	Chamoli	Alaknanda	PFR prepared
12	Rishiganga II	35	Chamoli	Alaknanda	PFR prepared
13	Gohana Tal	60	Chamoli	Alaknanda	PFR prepared
14	Rambara	24	Rudraprayag	Alaknanda	IMG report
15	Birahi Ganga-II (P)	24	Chamoli	Alaknanda	DPR under revision
16	Melkhet (P)	56	Chamoli	Alaknanda Pinder	Proposed
17	Urgam-II	3.8	Chamoli	Alaknanda	Under S&I
18	Bhyunder Ganga	243	Chamoli	Alaknanda	FC under consideration
19	Nand Pyayag Langasu	141	Chamoli	Alaknanda	EAC TOR Approved
20	Rambara	76	Rudraprayag	Alaknanda	EAC TOR u/consideration
21	Bagoli	90	Chamoli	Alaknanda	Proposed
22	Bangri	44	Chamoli	Alaknanda	Pinder
23	Madhya Maheshwar	350	Chamoli	Alaknanda	Proposed
24	Ming Nalgaon	114	Chamoli	Alaknanda	Pinder
25	Padli	66	Chamoli	Alaknanda	Proposed
26	Thapli	44	Chamoli	Alaknanda	Proposed
27	Utyasu-I	70	Chamoli	Alaknanda	Proposed
28	Utyasu-II	205	Chamoli	Alaknanda	Proposed
29	Utyasu-III	195	Chamoli	Alaknanda	Proposed
30	Utyasu-IV	125	Chamoli	Alaknanda	Proposed
31	Utyasu-V	80	Chamoli	Alaknanda	Proposed
32	Utyasu-VI	70	Chamoli	Alaknanda	Proposed
33	Rampur Tilwari	25	Rudraprayag	Alaknanda	Proposed
34	Chunni semi	24	Rudraprayag	Alaknanda	Proposed Mandakini
35	Kosa	24	Chamoli	Alaknanda	Dhauliganga
36	Vijay nagar- Rampur	20	Rudraprayag	Alaknanda	Proposed
37	Nandakini-III	19.5	Chamoli	Alaknanda	Proposed
38	Nayar	17	Pauri	Ganga sub basin	Nayar
39	Alaknanda I	15	Chamoli	Alaknanda	Proposed
40	Buara	14	Bageshwar	Alaknanda	Pindar
41	Duna Giri	10	Chamoli	Alaknanda	Dhauliganga
42	Alaknanda II	10	Chamoli	Alaknanda	Proposed
43	Balkhila-II	10	Chamoli	Alaknanda	Proposed
44	Mandani Ganga	10	Rudraprayag	Alaknanda	Mandakini Mandani ganga
45	Rishiganga	8.25	Chamoli	Alaknanda	Proposed
46	Subhain	8	Chamoli	Alaknanda	Dhauliganga
47	Son	7	Rudraprayag	Alaknanda	Mandakini son gad
48	Kalp ganga	6.25	Chamoli	Alaknanda	Proposed kalpganga
49	Lustar	6	Rudraprayag	Alaknanda	Mandakini Lustar
50	Madhya maheshwar -II	6	Rudraprayag	Alaknanda	Mandakini madmaheshwar
51	Hom 6	6	Chamoli	Alaknanda	Dhauliganga
52	Amrit ganga	6	Chamoli	Alaknanda	Amrit ganga balsuti gadera
53	Gaddi	5.25	Chamoli	Alaknanda	dhauliganga Gaddi Gadera
54	Deval	5	Chamoli	Alaknanda	Proposed
55	Ghrit Ganga	5	Chamoli	Alaknanda	Proposed
56	Jumma	5	Chamoli	Alaknanda	Proposed
57	Ringi	5.5	Chamoli	Alaknanda	Dhauliganga
58	Tamak	5	Chamoli	Alaknanda	Proposed
59	Balkhila-I	5.5	Chamoli	Alaknanda	Proposed Balkhila
60	Basti –I	4	Rudraprayag	Alaknanda	Proposed
61	Basti –II	4	Rudraprayag	Alaknanda	Proposed
62	Laxmanganga	4	Chamoli	Alaknanda	Proposed
63	Nil ganga	3	Chamoli	Alaknanda	Proposed
64	Santodhar – I	2	Pauri	Ganga sub basin	W Nayar

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65	Santodhar – II	2	Pauri	Ganga sub basin	W Nayar
66	Birahiganga	4.8	Chamoli	Alaknanda	Proposed
67	Byaligaon	2.25	Pauri	Ganga sub basin	E Nayar
68	Ghirit Ganga	1.3	Chamoli	Alaknanda	Proposed
69	Jummagad	1.2	Chamoli	Alaknanda	Proposed
70	Kailganga	3	Chamoli	Alaknanda	Proposed
71	Kakra	1	Rudraprayag	Alaknanda	Proposed
72	Kali Ganga	3	Chamoli	Alaknanda	Proposed
73	Garud Ganga	0.6	Chamoli	Alaknanda	Proposed
74	Gansali Bampa	0.05	Chamoli	Alaknanda	Dhauliganga/Ganesh Ganga
Alaknanda Total		**5199.25**			

Table 5: Proposed Hydropower projects in Bhagirathi Basin

SN	Project	Ins Cap (MW)	Dist	Sub-Basin	Status
1	Kotli Bhel (IA)	195	Pauri	Bhagirathi	EC/FAC stage 1
2	Jhalakoti (P)	12.5	Uttarkashi	Bhagirathi	Proposed dharamganga
3	Bhilangana II A	24	Uttarkashi	Bhagirathi	Proposed
4	Karmali	140	Uttarkashi	Bhagirathi	IMG, on Eco-sensitive zone?
5	Jadhganga	50	Uttarkashi	Bhagirathi	IMG: PFR prepared
6	Bhilangana IIB	24	Tehri	Bhagirathi	Under S&I
7	Bhilangana IIC	24	Tehri	Bhagirathi	Under S&I
8	Pilangad-II	4	Uttarkashi	Bhagirathi	Proposed
9	Bhela Tipri	100	Uttarakashi	Bhagirathi	Proposed
10	Nelong	190	Uttarakashi	Bhagirathi	Proposed
11	Asiganga-III	9	Uttarkashi	Bhagirathi	Proposed
12	Gangani (P)	8	Uttarkashi	Bhagirathi	Proposed
13	Balganga-I	5	Tehri Garhwal	Bhagirathi	Proposed
14	Khirao ganga	4	Uttarkashi	Bhagirathi	Proposed
15	Lagrasu (P)	3	Tehri Garhwal	Bhagirathi	Proposed
16	Songad	3	Uttarkashi	Bhagirathi	Proposed
17	Jalandhari Gad	3	Uttarakashi	Bhagirathi	Proposed
18	Jalkurgad I	2	Tehri Garhwal	Bhagirathi	Proposed jalkur gad
19	Rataldhara	0.4	Tehri Garhwal	Bhagirathi	Proposed Jalkur Gad
20	Lamb Gaon	0.4	Tehri Garhwal	Bhagirathi	Proposed Jalkur gad
21	Dhatirmouli	0.4	Tehri Garhwal	Bhagirathi	Proposed Jalkurgad
22	Gangi-Richa	0.2	Tehri	Bhagirathi	Bhilangana/ Re Gad
Bhagirathi Total		**801.9**			

Table 6: Proposed Hydropower projects in West Ramganga Basin

SN	Project	Ins Cap (MW)	Dist	Sub-Basin	Status
1	Babas Dam	88	Almora	Ramganga	Proposed
2	Khati	63	Bageshwar	Ramganga	Proposed
3	Lumi	54	Bageshwar	Ramganga	Proposed
4	Kuwargarh	45	Bageshwar	Ramganga	Proposed
5	Bawas Gaon	34	Nainital	Ramganga	Proposed
6	Jamrani Dam	30		Ramganga	Proposed
7	Khutani	18	Bageshwar	Ramganga	Proposed
8	Sarju Stage-II (P)	15	Bageshwar	Ramganga	Proposed
9	Sarju Stage-III (P)	10.5	Bageshwar	Ramganga	Proposed
10	Sheraghat	10	Almora	Ramganga	Kho
11	Baura	14	Bageshwar	Ramganga	Proposed
12	Sarju Stage-I (P)	7.5	Bageshwar	Ramganga	Proposed
13	Balighat	5.5	Bageshwar	Ramganga	Proposed
14	MehalChaura-I	4	Pithoragarh	Ramganga	Proposed
15	MehalChaura-II	3	Pithoragarh	Ramganga	Proposed
16	Agarchatti	2	Pithoragarh	Ramganga	Proposed
17	Kho I	2	Pauri	Ramganga	Kho
18	Kho II	2	Pauri	Ramganga	Proposed
19	Harsila	0.7	Bageshwar	Ramganga	Proposed harsila gad
20	Kalsa	0.3	Nainital	Ramganga	Proposed
Ramganga Total		**408.5**			

Table 7: Proposed Hydropower projects in Sharda Basin

SN	Project	Ins Cap (MW)	Dist	Sub-Basin	Status
1	Mapang Bogudhiyar (P)	200	Pithoragarh	Sharda	EAC TOR Approved
2	Bogudhiyar Sarkaribhyol (P)	170	Pithoragarh	Sharda	EAC TOR Approved

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3	Sarkaribhyol Rupsiabagar	210	Pithoragarh	Sharda	EAC TOR Approved
4	Rupsiabagar Khasiabara	260	Pithoragarh	Sharda	EAC Ok / FAC Rejected
5	Bokang Baling	330	Pithoragarh	Sharda	Proposed THDC
6	Chungar Chal	240	Pithoragarh	Sharda	Proposed NHPC
7	East Ram Ganga Dam	30	Pithoragarh	Sharda	Proposed
8	Khartoli Lumti Talli	55	Pithoragarh	Sharda	Proposed
9	Budhi	192	Pithoragarh	Sharda	Mahakali
10	Garba Tawaghat	610	Pithoragarh	Sharda-Mahakali	Proposed NHPC
11	Garbyang	131	Pithoragarh	Sharda	Mahakali
12	Lakhanpur	160	Pithoragarh	Sharda	Proposed
13	Malipa	138	Pithoragarh	Sharda	Mahakali
14	Pancheshwar	6000	Pithoragarh	Sharda	Indo Nepal Project
15	Purnagiri Dam	1000	Champawat	Sharda	Indo Nepal Project
16	Tawaghat - Tapovan	105	Pithoragarh	Sharda	Mahakali
17	Taopvan Kalika	160	Pithoragarh	Sharda	Mahakali
18	Tapovan Chunar	485	Pithoragarh	Sharda	Proposed
19	Sela Urthing	230	Pithoragarh	Sharda	Proposed
20	Urthing Sobla (P)	340	Pithoragarh	Sharda	Proposed
21	Sobla Jhimjingao	145	Pithoragarh	Sharda	Proposed
22	Kalika - Baluwakot	120	Pithoragarh	Sharda	Mahakali
23	Kalika Dantu	230	Pithoragarh	Sharda	Proposed
24	Dhauliganga Intermediate	200	Pithoragarh	Sharda	Proposed NHPC
25	Gauriganga III A & B	140	Pithoragarh	Sharda	Proposed NHPC
26	Madkini (P)	39	Pithoragarh	Sharda	Proposed
27	Burthing - Purdam	5	Pithoragarh	Sharda	Proposed Jakula
28	Jimbagad	7.7	Pithoragarh	Sharda	Proposed
29	Suringad-II	5	Pithoragarh	Sharda	Proposed
30	Tanga (P)	5	Pithoragarh	Sharda	Proposed
31	Tankul	12	Pithoragarh	Sharda	Proposed
32	Motighat (P)	5	Pithoragarh	Sharda	Proposed
33	Painagad	9	Pithoragarh	Sharda	Proposed
34	PhuliBagar- Kwiti	4	Pithoragarh	Sharda	Proposed Jakula
35	Kumeria- Garjia (Bawas)	12.5	Nainital	Sharda	Kosi
36	Balgad	8	Pithoragarh	Sharda	E Ramganga
37	Kuti SHP	6	Pithoragarh	Sharda	Maha Kali/ Kuti yangti
38	Palang SHP	6.5	Pithoragarh	Sharda	Maha Kali/ Plang gad
39	Najyang SHP	5.5	Pithoragarh	Sharda	Maha Kali/ Najyang gad
40	Simkhola SHP	8.75	Pithoragarh	Sharda	Maha Kali/ Simkhola gad
41	Birthi	1	Pithoragarh	Sharda	Balchinn
42	Baram	1	Pithoragarh	Sharda	Dhauli Ganga/ Baram Gad
43	Unchiya	0.05	Pithoragarh	Sharda	Dhauli Ganga/ Khari Gad
44	Murtoli	0.02	Pithoragarh	Sharda	Gorigang/ Martoligad
45	Burphu	0.03	Pithoragarh	Sharda	Goriganga/ Martoligad
46	Ralam	0.03	Pithoragarh	Sharda	Goriganga/ Ralangad
47	Ram Gad-II	0.1	Nainital	Sharda	Kosi/ Ramgad
48	Watcm	0.1	Pithoragarh	Sharda	Ramgad E/ Watchraila
	Total Sharda Basin	**12022.28**			

Table 8: Proposed Hydropower projects in Yamuna Basin

SN	Project	Ins Cap (MW)	Dist	Sub-Basin	Status
1	Lakhwar	300	Dehradun	Yamuna	EAC TOR Approved
2	Vyasi	120	Dehradun	Yamuna	EAC Recommended
3	Arakot Tuni	81	Uttarkashi	Yamuna	EAC TOR Approved
4	Tuni Plasu	66	Dehradun	Yamuna	EAC TOR Approved
5	Mori-Hanol (P)	63	Uttarkashi	Yamuna	EAC TOR Approved
6	Naitwar Mori (Dewari Mori)	60	Uttarkashi	Yamuna	EAC Recommended
7	Hanol Tuni (P)	60	Uttarkashi	Yamuna	EAC Recommended
8	Jakhol Sankri	45	Uttarkashi	Yamuna	EAC TOR Approved
9	Kishau	600	Dehradun	Yamuna	Proposed
10	Chammi Naingaon	540	Uttarakashi	Yamuna	Proposed
11	Chatra Dam	300	Uttarakashi	Yamuna	Proposed
12	Taluka Sankri	140	Uttarkashi	Yamuna	Proposed
13	Taluka Dam	112	Uttarakashi	Yamuna	Proposed
14	Sankri Mori	78	Uttarakashi	Yamuna	Proposed
15	Barkot Kuwa	42	Uttarakashi	Yamuna	Proposed
16	Hanuman Chatti Sianachatti	33	Uttarakashi	Yamuna	Proposed

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17	Barnigad Naingaon	30	Uttarakashi	Yamuna	Proposed
18	Rupin Stage V (P)	24	Uttarkashi	Yamuna	Proposed
19	Damta - Naingaon	20	Uttarkashi	Yamuna	Proposed
20	Tons	14.4	Uttarkashi	Yamuna	Proposed
21	Supin	11.2	Uttarkashi	Yamuna	Proposed
22	Rupin Stage IV (P)	10	Uttarkashi	Yamuna	Proposed
23	Rupin Stage III (P)	8	Uttarkashi	Yamuna	Proposed
24	Barnigad	6.5	Uttarakashi	Bhagirathi	Proposed
25	Pabar	5.2	Dehradun	Yamuna	Proposed
26	Badyar (P)	3	Uttarkashi	Yamuna	Proposed
27	Lagrasu	3	Tehri	Yamuna	Proposed
28	Rayat (P)	3	Tehri	Yamuna	Proposed
29	Ringali	1	Tehri Garhwal	Yamuna	Proposed Aglar Ringaligad
30	Purkul	1	Dehradun	Yamuna	Tons
31	Paligad	0.3	Uttarkashi	Yamuna	Proposed Paligad
32	Rikhani Gad	0.05	Uttarkashi	Yamuna	Rikhanigad
33	Bijapur	0.2	Dehradun	Yamuna	Tons
Yamuna Total		**2780.85 MW**			
Grand Total		**21212.78 MW**			

Note: EAC: Expert Appraisal Committee of MoEF; FAC: Forest Advisory Committee of MoEF; EC: Environment Clearance: FC: Forest Clearance; TOR: Terms of Reference (of EIA); for Alaknanda, the first 17 projects are listed as given in IMG report and for Bhagirathi first 8 projects are as listed in IMG report. However, many of these projects have been recommended to be dropped by the WII (Wildlife Institute of India) report. Also, IMG and others have said that no other projects should be taken up in Bhagirathi and Alaknanda basins. The projects listed above in the Bhagirathi basin beyond serial number 8 and those in Alaknanda basin beyond 17 would in any case not be taken up.

Overview of Hydropower Projects In the table 10 we have provided and overview of proposed hydropower projects in Uttarakhand based on the information from above five tables.

Table 9 Overview of Proposed Hydropower Projects in Uttarakhand

Basin	Large Hydro projects (above 25 MW)		Small Hydro projects (1-25 MW)		Mini-micro Hydro projects (below 1 MW)		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	29	4823	43	375.6	2	0.65	74	**5199.25**
Bhagirathi	5	675	13	125.5	4	1.4	22	**801.9**
Ramganga	6	314	12	93.5	2	1	20	**408.5**
Sharda	26	11920	16	101.95	6	0.33	48	**12022.28**
Yamuna	17	2670	13	110.3	3	0.55	33	**2780.85**
TOTAL	**83**	**20402**	**97**	**806.85**	**17**	**3.93**	**197**	**21212.78**

Overview of hydropower projects in Uttarakhand In the table 11 we have given basin-wise figures of total large, small and mini-micro hydropower proejcts (including existing, under construction and proposed) projects in Uttarakhand. According to Union Ministry of New and Renewable energy, total potential of small hydro in Uttarakhand is 1707.87 MW from 448 small hydro projects. If we take that into account the figures in the following tabes would change (go up) accordingly.

Table 10: Basin wise total capacities for large, small and mini HEPs in Uttarakhand

Basin	Large Hydro projects (above 25 MW)		Small Hydro projects (1-25 MW)		Mini-micro hydro projects (<1 MW)		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	35	6419	61	524.65	26	3.67	122	**6947.32**
Bhagirathi	10	3469	28	266.7	10	2.05	48	**3737.75**
Ganga Sub basin	1	144	3	31.2	2	0.35	6	**175.55**
Ramganga	7	512	14	105.3	11	2.05	32	**619.35**
Sharda	29	12335.6	20	109.65	35	5.155	84	**12450.405**
Yamuna	22	3144.75	14	113.3	8	1.135	44	**3259.185**
TOTAL	**104**	**26024.35**	**140**	**1150.8**	**92**	**14.41**	**336**	**27189.56**

In the table 12 we have put together the number and capacities of existing, under construction and proposed hydropower projects in various basins of Uttarakhand. Uttarakhand government has plans to have total of 336 hydropower projects with total capacity of 27189.56 MW. Largest number (122) of such projects are in Alaknanda basin, the largest capacity is proposed to be in Sharda basin at 12450.405 MW.

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Table 11: Overview of all Hydropower projects in Uttarakhand

Basin	Existing Hydro projects		Under construction		Proposed HEPs		Total Hydro projects	
	No of projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW	No of Projects	Capacity, MW
Alaknanda	32	456.97	16	1291.1	74	5199.25	122	**6947.32**
Bhagirathi	13	1851.5	13	1084.75	22	801.9	48	**3737.75**
Ganga Sub basin	4	173.8	2	1.75	-	-	6	**175.55**
Ramganga	12	210.8	-	-	20	408.5	32	**619.35**
Sharda	28	427.75	8	0.375	48	12022.28	84	**12450.405**
Yamuna	9	478.195	2	0.14	33	2780.85	44	**3259.185**
TOTAL	**98**	**3598.665**	**41**	**2378.115**	**197**	**21212.78**	**336**	**27189.56**

Basin Maps Maps of Hydroelectric Projects in various sub basins of Uttarakhand are available at the following links. Please note that the maps are based on information available when the maps were created in 2011:
http://sandrp.in/basin_maps/Hydropower_Projects_in_Ganga_Basin.pdf, http://sandrp.in/basin_maps/Bhagirathi%20150411.jpg
http://sandrp.in/basin_maps/Alaknanda%20150411.jpg, http://sandrp.in/basin_maps/Mandakini150411.jpg
http://sandrp.in/basin_maps/Goriganga150411.jpg, http://sandrp.in/basin_maps/Major_Hydro_Projects_in_Yamuna_Basin.pdf

How do the hydropower projects increase the disaster proportions? This is a question that a lot of journalists, TV anchors and other have been asking since the Uttarakhand disaster. Here is a quick response to that question:

Almost all hydropower projects of Uttarakhand involve deforestation. Deforestation directly increases the potential of erosion, landslides and floods since water now just runs off to the rivers, soild becomes exposed and without any binding that forests provided.

⇒ Almost all hydropower projects of Uttarakhand involve deforestation. Deforestation directly increases the potential of erosion, landslides and floods since water now just runs off to the rivers, soild becomes exposed annd without any binding that forests provided. Moreover the compensatory afforestation and catchment area treatment, even when done, usually involves planting of commercially important variety of trees like pine and teak and not broad leaf tress like oaks that not only adds to humus in the soil, but also allow rich under growth. Pine does not allow this to happen. This change in character of forests is something Gandhiji's disciple Mira Behen has been warning since independence, but there is little impact of this on the forest department.

⇒ The largest amount of deforestation in Uttarakhand has happened basically for HEPs.

⇒ All the run of the river projects involve building of a dam, diversion structure, desilting mechanism, tunnels that could have length of 5 to 30 km and width sufficient to carry three trains side by side, as also roads, townships, mining, among other components. All of these components increase the disaster potential of the area in one or the other way. Cumulative impacts of all the components of any projects and all the projects in a given basin is likely to be larger than the addition of the impacts of individual projects in many cases.

⇒ Blasting of massive proportions is involved in construction of all these components, which add to the landslide risks. In fact Uttarakhand's Disaster Mitigation and Management Centre in their report of Oct 2012 after the Okhimath disaster of Sept 2012 recommended that no blasting should be allowed for any development activity anywhere in Uttarakhand, but Uttarakhand government did nothing about this recommendation.

⇒ The massive tunneling by itself weakens the young and fragile Himalayan mountains, increasing the disaster potential.

⇒ Each of the hydropower projects generate massive amount of muck in tunneling, blasting and other activities, a large hydropower project could easily generate millions of cubic meters of muck. The large projects are supposed to have muck disposal plan, with land acquired for muck disposal, transportation of muck to the designated sites above the High Flood levels, creation of safety walls and stabilization process. But all this involves costs. The project developers and their contractors find it easier to dump this muck straight into the nearby rivers. In the current floods, this illegally dumped muck created massive disaster in downstream areas in case of 330 MW Srinagar HEP, the 76 MW Phata Byung HEP and the 99 MW Singoli Bhatwari HEP. When the flooded rivers carry this muck, boulders and other debris, has much greater erosion capacity and also leaves behind massive heaps of this muck in the flooded area. In

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Srinagar town about 100 houses are buried in 10-30 feet depth of muck. Such debris laden rivers also create massive landslides along the banks.

⇒ Wrong operation of hydropower projects can also create greater disasters in the downstream areas. For example the operators of 400 MW Vishnuprayag HEP on Alaknanda river did not open the gates when the river was flooded on June 16-17, possibly to maximize power generation. However, this lead to accumulation of massive quantities of boulders (for photos of dam filled with such boulders see: http://matuganga.blogspot.in/) behind the dam, so much so that that there was no space for water to flow. The river than bypassed the dam and started flowing by the side of the dam, creating a new path for its flow. This created a sudden flashflood situation in the downstream area, creating new disaster there.

Blasting of massive proportions is involved in construction of all these components, which add to the landslide risks. In fact Uttarakhand's Disaster Mitigation and Management Centre in their report of Oct 2012 after the Okhimath disaster of Sept 2012 recommended that no blasting should be allowed for any development activity anywhere in Uttarakhand, but Uttarakhand government did nothing about this recommendation.

⇒ The incomplete, broken and ill designed protection wall of the Maneri Bhali projects in Uttarkashi lead to erosion and landslides in the downstream areas.

Damaged Hydro Projects A large number of hydropower projects are likely to have suffered damage due to the flood disaster in Uttarakhand. Some of the projects that have suffered damage include:

- According to the update from http://www.energylineindia.com/on June 27, 2013, the **520 MW under construction Tapovan Vishnugad** HEP has suffered damaged by rains on June 16, 2013: "While construction of diversion tunnel was completed in April this year, the same was washed away due to heavy rains on June 16. Diversion dyke has washed away and damages have been observed in chormi adit approach road. In August last year, the flash floods had caused serious damages in the coffer dam of the project."
- **400 MW Vishnuprayag HEP of JP Associates has suffered serious, but as yet unassessed damage**(http://www.indianexpress.com/news/jaiprakash-power-tanks-15–as-plant-shuts-down-in-uttarakhand/1133083/). As per MATU PR (http://matuganga.blogspot.in/), the project has also been cause of damage in Lambagad village, which was also flahsed on front page of TOI on June 25, 2013, though without mentioning the project. The blog also provides the before and after pictures of the upstream and downstream of the project.
- **76 MW Phata Byung HEP of Lanco in Mandakini Valley in Uttarakhand**
- **99 MW Singoli Bhatwari HEP of L&T in Mandakini Valley in Uttarakhand** NDTV India reported that the water level of the river has gone up due to the silt dumped by dams. This is likely to be due to the Phata Byung and Singholi Bhatwari HEPs.
- **Kali Ganga I, Kali Ganga II and Madhyamaheshwar HEP, all in Mandakini Valley, all of UJVNL, all hit by mudslides** (http://www.indianexpress.com/news/uttarakhands-r500-crore-request-to-prevent-landslides-pending-since-2009/1132351/)
- **Assiganga projects on Assiganga river in Bhagirathi basin in Uttarakhand**
- **5 MW Motighat I HEP in Goriganga basin in Pithoragarh** (Himalprakriti report)
- **280 Dhauliganga Project of NHPC in Pithoragarh district of Uttarakhand** (reports said the power house was submerged, but is now working, part of the township was submerged.)
- The Himalaya Hydro (HH) Tanga Phase I for 5 MW, located along the Paina gad in Goriganga basin, is badly damaged. The dam has got smashed by a deluge of huge boulders. One sluice gate is torn through. The metal filter-gates are all choked with boulder debris, and the remnant concrete and gate pulleys of the dam are now stranded mid-river, with both banks eroded and the river now running along the true-left bank. (Himalprakriti report)

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- The UREDA 500 KW Motigad microhydel on Moti gadh (a tributary of Paina gadh) at Bindi (Dani Bagad) is also badly damaged. The water has broken through the wall, cut under the foundation, inundated the turbines with water and debris, and smashed the housing for the electrical distribution system. (Himalprakriti report)

Each of the hydropower projects generates massive amount of muck. A large hydropower project could generate millions of cubic meters of muck. The projects are supposed to have muck disposal plan, with land acquired for muck disposal, transportation of muck to the designated sites above the High Flood levels, creation of safety walls and stabilization process. But the project developers find it easier to dump this muck into the rivers. In the current floods, this illegally dumped muck created massive disaster in downstream areas.

- The 5.5' diameter head race waterpipes taking water to the HH Phase II, located on the Gori opposite Seraghat, has also been damaged. The generator and housing for the HH Ph II has collapsed into the river. All this damage is said to have happened on the evening of 17th June. People working as non-skilled labour have been sent home for a few months, but welding work on the new pipes feeding the powerhouse is still underway! (Himalprakriti report)

It has been now reported (http://www.business-standard.com/article/companies/gvk-l-t-hydel-projects-hit-by-floods-113062300394_1.html) that the 330 MW Srinagar project, a cause for downstream destruction, has itself suffered massive damages on June 17, 2013, with breach of its protective embankment. The report also mentions the damage to the L&T's Singoli Bhatwari HEP on Mandakini river.

Down to Earth (http://www.downtoearth.org.in/content/hydropower-projects-suffer-severe-damage) has given some details of damage to some of the HEPs, quoting UJVNL sources. It says: 19 small hydropower projects have been completely destroyed, while others have been damaged (see table below).

Table 12: Estimated losses to hydel Projects in Uttarakhand

Project	Location	Capacity, MW	Esimated loss
Dhauli Ganga	Pithoragarh	280	30 Cr (power house submerged)
Kaliganga I	Rudraprayag	4	1819 (Power house and 4 houses washed away)
Kaliganga II	Rudraprayag	6	Rs 16 Cr (Power house and 4 houses washed away)
Sobla	Pithoragarh	8	Rs 14 Cr (completely washeda away)
Kanchauti	Pithoragarh	1.5	Rs 20 Cr (part of the project washed away)
Chirkila	Pithoragarh	1.5	Rs 20 Cr (part of the project washed away)
Manneri Bhali I & II	Uttarkashi	304 + 90	Rs 2 + 5 cr (walls collapsed, silt in barrages)

In addition, a large number of projects had to stop generation temporarily due to high silt content, including Maneri Bhali I and II, Tanakpur, Dhauli Ganga, Kali Ganga I, some of the Yamuna basin projects among others.

Wrong operation of projects can also create greater disasters in the downstream areas. The operators of 400 MW Vishnuprayag HEP on Alaknanda river did not open the gates when the river was flooded on June 16-17, possibly to maximize power generation. However, this led to accumulation of massive quantities of boulders behind the dam. The river than bypassed the dam and created a new path. This created a sudden flashflood situation in the downstream area, creating new disaster there.

Conclusion This article was intended to give an overview of hydropower projects in Uttarakhand. However, we should add that there are many glaring issues related to these hydropower projects, some of the key issues on environment governace include the following.

Most of these projects are out of the environmental governance. Projects below 25 MW do not require EIA, Social Impact Assessment, public consultation, environmental clearance, environmental management plan or monitoring. This is clearly wrong as all projects have environmental impacts, and they are particularly serious in Himalayan region with multiple vulnerabilities. We have for years demanding that all projects above 1 MW should need environment clearance, EIA and so on.

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- Even for projects above 25 MW we do not have any credible environmental or social impact assessment. Former Environment Minister Jairam Ramesh is on record having accepted that most EIAs are dishonest cut and paste jobs. We do not have any credible process in place to ensure that EIAs are proper and those that are not are rejected and consultants are black listed. Jairam Ramesh did put in place a process of registration of EIA consultants under the Quality Council of India, but that is completely non transparent, unaccountable and ineffective process. It is amazing that reputed NGOs like the Centre for Science and Environment are on board of this process, but they have completely failed to achieve any change and have chosen to remain quite.
- The Environment clearances of the River Valley Projects (which includes hydro projects and dams) is considered by the Expert Appraisal Committee on River Valley Projects appointed by Union Ministry of Environment and Forests. However, the ministry chooses members of the EAC such that they rarely object to any project. As per SANDRP analysis in six years ending in Dec 2012, the EAC had not said NO to any project for environment clearance. Its appraisal of projects, EIAs, public consultation process and its own minutes were found to be inconsistent, unscientific and loaded in favour of the project developers.
- Our environment compliance system is non-existing. The projects are supposed to implement the environment management plan *pari passu* with the project work, they are supposed to follow the conditions of environment clearance, follow the environmental norms, but who is there to ensure this actually happens? The Union Ministry of Environment and Forests which is supposed to ensure this compliance has no capacity the officials tell us. The officials do not have time to even check if six monthly compliance reports are being submitted or make any surprise visits. However they do not even seem to have will, since we have seen no change in this situation for decades. Nor do they seem to have willingness, since even when NGOs present photographic and video and other evidence of violations they refuse to take action.
- One way to achieve compliance is to have a project monitoring committee for each project where over 50% of the members are from local communities and other independent persons and such committees ok must be required each stage for the project to go ahead. We have been suggesting this for long, but the MoEF has shown no willingness to follow this.
- More pertinently, none of the assessment reports look at the impact of the projects from their impacts on the disaster potential of the area. Each of these projects have significant impact on the disaster potential of the area, particularly in the context of vulnerable state like Uttarakhand. This should be a must for all such projects.
- Similarly the projects must also be seen through the climate change lenses, again in vulnerable area like the Himalayas. How the project will impact the local climate, how it will have impact on adoption capacity of the local communities and also how the project itself will be impacted in changing climate. This again we have been writing to the MoEF numerous times, but without any success so far.
- Most significantly, the only impact assessments that we have is for specific projects of over 25 MW capacity. However, we have no credible cumulative impact assessment for any of the river basins of Uttarakhand, which also takes into account carrying capacity of the river basins and all the interventions that are happening in the basins. As our critique of so called cumulative impact assessment of Bhagirathi-Alaknanda basins done by AHEC of IIT Roorkee shows (http://www.sandrp.in/hydropower/Pathetic_Cumulative_Impact_Assessment_of_Ganga_Hydro_projects.pdf), it was not much of a cumulative impact assessment. WII (Wildlife Institute of India, Dehradun) report was somewhat better within the mandate given to it (assessment of hydro projects on aquatic and terrestrial biodiversity), but the most important recommendation of the WII report that at least 24 projects should be dropped has not been accepted by the MoEF, so what is the use of the cumulative impact assessment in such a situation?

In response to my question on a programme on *Headlinestoday* channel anchored by Rahul Kanwal on July 8, 2013 (in presence of panel that also included Dr Vandana Shiva and Vimlendu Jha), the Uttarakhand Chief Minister Shri Vijay Bahuguna agreed that he will institute an enquiry into the damage due to the hydropower projects and hold them accountable for such damage. Let us see how soon and how independent and credible enquiry he institutes.

Unless we address all of the above issues in a credible way, there is little wisdom in going ahead with more hydropower projects in Uttarakhand. They will invite greater disaster. Uttarakhand has many other options for development. Firstly Uttarakhand

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people should get first right over all the power that is getting generated within Uttarakhand. Secondly, this is not a plea for no projects, but to address the crucial issues without addressing which we are in no situation to even know the impacts or address the issues. Thirdly, Uttarakhand needs to take up power generation options that do not accentuate the disaster potential of the area. Such options include micro hydro, hydro kinetics, and solar and biomass based power in addition to better utilization of existing infrastructure.

Unfortunately, going ahead with more hydropower projects in current situation would be invitation to greater disasters. In fact, the Uttarakhand government should not allow even the damaged and under construction hydropower projects until al the conditions mentioned above are satisfied.

Some of the hydropower projects that have surely seems to have added to the disaster proportions of current Uttarakhand flood disaster include the 400 MW Vishnuprayag HEP, the 280 MW Dhauliganga HEP, the 330 MW Shrinagar HEP, the 304 and 90 MW Maneribhali II and I HEPs, the 99 MW Singoli Bhatwari HEP and the 76 MW Phata Byung HEP, the last two on Mandakini river. In response to my question on a programme on *Headlinestoday* channel anchored by Rahul Kanwal on July 8, 2013 (in presence of panel that also included Dr Vandana Shiva and Vimlendu Jha), the Uttarakhand Chief Minister Shri Vijay Bahuguna agreed that he will institute an enquiry into the damage due to these hydropower projects and hold them accountable for such damage. Let us see how soon and how independent and credible enquiry he institutes.

Himanshu Thakkar

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Impact of Hydroelectric Projects on Uttarakhand's Ecosystem

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Abstract

This research paper explores the environmental and socio-economic impact of hydroelectric projects in Uttarakhand, a state situated in the Himalayan region of India. While hydroelectric power contributes to sustainable energy goals, the ecological and societal costs associated with these projects are significant. The study examines deforestation, biodiversity loss, river ecosystem disruption, climate change implications, and socio-economic issues and offers suggestions for sustainable development.

Keywords

Hydroelectric projects, Uttarakhand, deforestation, biodiversity loss, river ecosystem, climate change, socio-economic impact, sustainable development.

1. Introduction

Uttarakhand, often referred to as the "Land of Gods," is endowed with vast water resources due to its glacial rivers, making it a prime location for hydroelectric projects. However, the rapid development of these projects has raised concerns regarding their long-term impact on the environment and local communities (Negi, 2021). Uttarakhand, located in the northern part of India, is home to the majestic Himalayas, vast water resources, and numerous glaciers. Known as the "Land of Gods," it is not only a spiritual center but also a key region for renewable energy production, especially hydroelectric power. The state's strategic importance in the Indian context is further enhanced by its hydrological potential. With numerous rivers, streams, and glaciers, Uttarakhand is an ideal location for hydropower generation, which plays a crucial role in meeting India's

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growing energy demands.

However, the rapid expansion of hydroelectric projects in Uttarakhand has raised numerous concerns related to environmental degradation, displacement of local communities, and long-term socio-economic impacts. The region's fragile ecosystem, characterized by steep slopes, unique biodiversity, and vulnerability to natural disasters, makes it especially sensitive to large-scale infrastructure projects like dams and hydropower plants. While the government views these projects as a sustainable solution to meet energy needs, their implications on local ecosystems, biodiversity, and human settlements are profound. In this paper, we analyze the impact of hydroelectric projects on Uttarakhand's ecosystem. The study explores deforestation, the loss of biodiversity, disruption of river systems, and socio-economic issues arising from the displacement of local communities. Furthermore, we examine policy initiatives, technological innovations, and sustainable solutions aimed at reducing the negative impacts of these projects. This research ultimately seeks to provide a balanced perspective, offering insights into how hydroelectric power generation can coexist with environmental protection and sustainable development.

2. Literature Review

The development of hydroelectric power projects has been a central aspect of India's renewable energy strategy, with the potential to significantly reduce dependence on fossil fuels. India's government has heavily promoted hydroelectric energy as part of its 175 GW renewable energy target by 2022, and Uttarakhand has been pivotal in this effort, owing to its geographic and hydrological features. However, the implementation of these projects has also attracted significant scrutiny from environmentalists, local communities, and researchers. Several studies have examined the environmental impacts of hydroelectric power plants in the Himalayan region. Researchers like Rawat (2010) and Tiwari et al. (2016) have focused on the loss of biodiversity, deforestation, and the disruption of natural ecosystems as direct consequences of large-scale hydropower development in Uttarakhand. Their findings suggest that the construction of dams and reservoirs, while providing energy benefits, often results in the inundation of large areas of forested land, which leads to the displacement of wildlife and loss of critical habitats. The adverse effects on local flora and fauna, especially on species endemic to the region, have been a major concern. According to Sharma (2018), the decline in species diversity is one of the most alarming impacts of hydropower development in Uttarakhand.

In addition to environmental concerns, the socio-economic consequences of hydropower projects have been widely discussed. Many of these projects have led to

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[1]the displacement of local populations, resulting in loss of livelihoods and cultural identity for affected communities. A study by Joshi et al. (2020) highlights that the displacement of rural communities, coupled with inadequate resettlement strategies, has created long-lasting socio-economic issues, including poverty, unemployment, and social unrest. Furthermore, these projects often disrupt local economies, which are traditionally dependent on agriculture, tourism, and small-scale industries. Another significant issue is the impact on the river ecosystems. Hydroelectric plants, especially large-scale ones, interfere with the natural flow of rivers, affecting water quality, sediment transport, and fish migration. According to the National River Conservation Directorate (2017), such disruptions to river ecosystems can lead to the loss of fish species that are crucial to the local diet and economy. Similarly, the alteration of river flow can exacerbate the risks of floods and landslides, especially in a region like Uttarakhand, which is prone to such natural disasters. The disruption of sediment transport, as outlined by Mehta (2019), causes downstream erosion, which impacts both the agricultural sector and local communities.

Furthermore, studies have highlighted the implications of climate change in the context of hydropower projects. Research by Thakur and Singh (2021) suggests that the retreat of glaciers due to global warming may result in a reduction of hydropower generation in the coming decades. This is particularly concerning for projects relying on glacial meltwater, as the long-term sustainability of these sources becomes uncertain. Additionally, changes in precipitation patterns due to climate change may lead to alterations in river flows, affecting the capacity of hydropower plants and potentially increasing vulnerability to extreme weather events such as floods and droughts. While hydroelectric power remains a viable alternative to fossil fuel-based energy, it is evident that the development of these projects requires a holistic approach that accounts for the ecological, social, and economic costs. Several scholars, including Kaur (2017), have called for integrated environmental impact assessments and stakeholder consultations to ensure that hydropower projects contribute to sustainable development while minimizing adverse impacts.

3. Research Methodology

3.1 Research Design

This study adopts a mixed-method approach to understand the multifaceted impacts of hydroelectric projects on Uttarakhand's ecosystem. A combination of qualitative and

[1] Mixed-methods research combines qualitative and quantitative approaches to address complex questions. See Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.). Sage Publications.

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quantitative data collection techniques was employed.

3.2 Data Sources

Primary Data: Interviews with local residents, environmental activists, and project officials; field surveys and observational visits to impacted areas.

Secondary Data: Government reports, peer-reviewed journals, environmental studies, and disaster reports, including the 2021 Chamoli Avalanche Report.

3.3 Sampling Techniques

Purposive sampling was used to select respondents from communities affected by displacement and environmental experts. A total of 50 respondents were interviewed across Chamoli, Tehri Garhwal, Rudraprayag, and Uttarkashi districts.

3.4 Analytical Tools

Qualitative Analysis: Thematic analysis was applied to identify patterns in interviews and observations. *Quantitative Analysis:* Statistical tools such as SPSS were used to analyze data on land-use changes, biodiversity loss, and river flow disruptions. GIS and remote sensing were employed to map deforestation and river basin changes.

3.5 Ethical Considerations

Participants were informed about the study's purpose, and consent was obtained before interviews. Confidentiality was maintained throughout the research.

4. Importance of Hydroelectric Projects

Hydroelectric power is a renewable energy source contributing to India's energy security. Key advantages include reduced fossil fuel dependence (World Bank, 2021), mitigation of greenhouse gas emissions (Ghosh & Singh, 2020), and rural electrification and economic development (Ministry of Power, 2022).

4. Findings

4.1 Environmental Impact

Deforestation and Biodiversity Loss: Construction activities have resulted in significant forest loss. An estimated 10,000 hectares of forest cover were affected by hydroelectric projects between 2000 and 2022. Wildlife displacement was reported, with species such as snow leopards and Himalayan musk deer facing habitat loss.

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River Ecosystem Disruption: Altered river flow patterns due to damming have caused a 30% reduction in fish populations, particularly migratory species like mahseer. Sediment retention in reservoirs has affected downstream fertility and aquatic biodiversity.

Climate Change Implications: Glacial melting has accelerated in areas with high dam density. The Chamoli disaster highlighted the risks of glacier-related events exacerbated by construction activities.

4.2 Socio-economic Impact

Community Displacement: Over 100,000 individuals have been displaced by major projects, including Tehri Dam, facing loss of livelihoods and cultural heritage. Economic Viability: While projects generate revenue, the high costs of repairs due to frequent landslides and floods reduce profitability.

4.3 Disaster Risks

The Chamoli avalanche of 2021, exacerbated by hydroelectric construction, caused extensive damage. Hydroelectric infrastructure in landslide-prone areas remains vulnerable to natural disasters.

4.4 Policy and Implementation Gaps

Despite regulatory frameworks such as the Environmental Impact Assessment (EIA), implementation gaps were evident. Projects often bypassed ecological safeguards due to weak enforcement.

5. Case Studies

5.1 Tehri Dam

Benefits: Provides 1,000 MW of electricity and supports irrigation.

Challenges: Submerged over 100 villages, leading to widespread displacement and ecological degradation.

The Tehri Dam, one of the tallest dams in the world, stands as a symbol of India's hydropower development but also exemplifies the significant environmental and social challenges associated with such projects. Constructed on the Bhagirathi River in Uttarakhand, the Tehri Dam generates over 1,000 MW of electricity and provides water for irrigation and drinking purposes to several northern states. Despite these benefits,

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the project has been mired in controversies.[2]

Environmental Impact: The construction of the Tehri Dam resulted in the submergence of over 42 square kilometers of forested and agricultural land, leading to the loss of biodiversity and critical wildlife habitats. The altered river flow disrupted aquatic ecosystems, impacting fis[3]h populations and downstream communities reliant on the river for sustenance.

Socio-Economic Issues: The project displaced over 100,000 people, primarily from the town of Tehri and surrounding villages. Many residents faced inadequate compensation and struggled to adapt to new environments. Cultural heritage, including temples and historical sites, was also lost under the reservoir waters. Risk Factors: Located in a seismically active region, the Tehri Dam has raised concerns about its safety in the event of an earthquake. The potential for catastrophic flooding in case of dam failure underscores the need for robust disaster preparedness measures.

5.2 Vishnugad-Pipalkoti Project

Concerns: Increased landslide frequency and reduced downstream water flow. Resistance: Local protests highlight the lack of adequate resettlement measures. The Vishnugad-Pipalkoti project, currently under construction on the Alaknanda River, is another example of a large-scale hydropower initiative in Uttarakhand. Designed to generate 444 MW of electricity, the project is touted as a step toward reducing dependence on fossil fuels.

Environmental Concerns: The tunneling and blasting required for the project have caused landslides and deforestation, destabilizing the fragile Himalayan terrain. Water diversion has affected the natural flow of the river, impacting downstream ecosystems.

Community Impacts: Local communities have reported issues such as reduced water availability for irrigation and the drying up of natural springs. The project has also sparked protests over inadequate resettlement packages for those displaced by construction activities.

Sustainability Challenges: Critics argue that the long-term viability of the project is

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[2] Joshi, P., & Negi, G. C. S. (2020). Impact of Hydroelectric Projects on Local Communities: A Study of Displacement in Uttarakhand. Environmental Management, 45(2), 235-243.

[3] For detailed biodiversity loss assessments, refer to Rawat, V. (2010). Deforestation and Biodiversity Loss in Uttarakhand. Indian Journal of Forestry, 33(4), 451-465.

Sediment disruption is a critical consequence of dam construction. See Mehta, A. (2019). Sediment Disruption and River Morphology in Uttarakhand. Journal of Himalayan Studies, 12(3), 145-162.

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uncertain due to climate change, which may reduce water flow in the Alaknanda River over time.

5.3 Policy and Legal Framework

India has implemented laws to regulate environmental impacts, such as:

Environmental Impact Assessment (EIA) (MoEFCC, 2020).

Wildlife Protection Act, 1972 (WWF India, 2020).

Forest Conservation Act, 1980 (Negi, 2021).

6. Sustainable Solutions

6.1 Integrated River Basin Management (IRBM)

IRBM ensures holistic management of river ecosystems, balancing ecological needs and energy generation (Joshi et al., 2020).

6.2 Small-scale Hydroelectric Projects

Focusing on small-scale projects can reduce environmental disruption while meeting local energy demands (Rautela, 2022).

6.3 Disaster Management and Risk Reduction

Strengthening early warning systems and conducting regular risk assessments are crucial in disaster-prone regions (Chamoli Disaster Report, 2021).

6.4 Increased Vulnerability

Hydroelectric projects in Uttarakhand significantly alter natural landscapes, increasing the region's vulnerability to disasters such as landslides, floods, and earthquakes. The 2013 Kedarnath floods, triggered by a glacial lake outburst flood (GLOF), demonstrated the devastating consequences of unchecked development in a fragile ecosystem. Studies indicate that deforestation, tunneling, and reservoir-induced seismicity contribute to the increased frequency and intensity of disasters in the region.

6.5 Role of Climate Change

Climate change exacerbates disaster risks in Uttarakhand. Glacial retreat, changing precipitation patterns, and the increased likelihood of extreme weather events compound the challenges posed by hydroelectric projects. For instance, the February 2021 Chamoli disaster, caused by a rock and ice avalanche, destroyed two hydropower

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plants and highlighted the risks associated with infrastructure development in a warming climate.

6.6 Mitigation Strategies

Effective disaster risk management requires a combination of policy reforms, technological advancements, and community engagement. Policy Measures: Strict enforcement of environmental regulations and adherence to guidelines for construction in eco-sensitive zones are critical. The government must also prioritize river basin management plans that account for the cumulative impacts of multiple hydropower projects. Technological Innovations: The use of advanced monitoring systems, such as satellite-based remote sensing and early warning systems, can help detect and mitigate potential risks.

Community Involvement: Empowering local communities through awareness programs, capacity building, and participatory decision-making ensures that disaster management plans are inclusive and effective.

Recent Developments and Policy Initiatives

6.7 Government Initiatives

Uttarakhand Chief Minister Pushkar Singh Dhami has been actively seeking approval for new hydroelectric projects to boost the state's energy capacity. In October 2024, he requested the central government's clearance for 21 new hydel power projects with a combined capacity of 2,123 MW (The Times of India, 2024). These projects aim to harness the state's hydroelectric potential, which is estimated at about 25,000 MW, though currently, only 4,200 MW is being utilized (The New Indian Express, 2024).

6.8 Infrastructure Development

The state government has also initiated work on projects like the 22.80 MW Bernigad and 6 MW Rayat Hydroelectric Projects, expected to commence within the next two years (Energy Central, 2024). Additionally, there are plans to develop pump storage projects to enhance energy security and meet increasing power demands.

6.9 Challenges and Considerations

Despite these initiatives, several proposed projects, totaling approximately 4,800 MW, are pending due to environmental concerns and legal challenges (Garhwal Post, 2024). The state faces a significant gap between energy demand and availability, particularly during winter months when hydroelectric generation decreases. This situation

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underscores the need for a balanced approach that considers both energy development and environmental sustainability.

7. Technological Innovations

7.1 Sediment Management

Sediment bypass tunnels and desilting chambers can mitigate ecological disruptions caused by sediment retention (World Bank, 2021).

7.2 Fish-friendly Turbines

Innovative turbine designs allow safer passage for aquatic life, minimizing harm (Joshi et al., 2020).

8. Conclusion

While hydroelectric projects play a pivotal role in addressing India's growing energy demands and fostering economic development, their environmental and socio-economic consequences, particularly in ecologically sensitive regions such as Uttarakhand, cannot be overlooked. These projects have led to significant disruptions, including deforestation, loss of biodiversity, alteration of riverine ecosystems, displacement of local communities, and increased vulnerability to natural disasters such as landslides and floods. The fragile Himalayan ecosystem, already under stress from climate change, faces compounding challenges due to unregulated and large-scale hydropower development. To ensure the long-term sustainability of these initiatives and protect the region's ecological balance, it is imperative to adopt comprehensive sustainable practices. This includes conducting detailed environmental impact assessments (EIAs) prior to project approval, restoring degraded ecosystems, and implementing robust afforestation programs to compensate for lost green cover. Policymakers must enforce stringent environmental regulations and adhere to international best practices to minimize harm. Furthermore, technological innovations, such as sediment management systems, fish-friendly turbines, and run-of-the-river projects, should be prioritized over traditional dam-based methods to reduce ecological disruption.

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Article

Hydropower in the Himalayan Hazardscape: Strategic Ignorance and the Production of Unequal Risk

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Abstract: Rapidly expanding hydropower development in areas prone to geological and hydro-climatic hazards poses multiple environmental and technological risks. Yet, so far these have received scant attention in hydropower planning processes, and even in the campaigns of most citizen initiatives contesting these dams. Based on qualitative empirical research in Northeast India, this paper explores the reasons why dam safety and hazard potential are often marginal topics in hydropower governance and its contestation. Using a political ecology framework analyzing the production of unequal risks, I argue that a blind-eye to environmental risks facilitates the appropriation of economic benefits by powerful interest groups, while increasing the hazardousness of hydropower infrastructure, accelerating processes of social marginalization. More specifically, this paper brings into analytical focus the role of strategic ignorance and manufactured uncertainty in the production of risk, and explores the challenges and opportunities such knowledge politics create for public resistance against hazardous technologies. I posit that influencing the production of knowledge about risk can create a fertile terrain for contesting hazardous hydropower projects, and for promoting alternative popular conceptions of risk. These findings contribute to an emerging body of research about the implications of hydropower expansionism in the Himalayan hazardscape.

Keywords: large dams; dam safety; hazard risk; environmental governance; uncertainty; knowledge politics; marginalization; political ecology; Himalayas; India

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1. Introduction

> "[Dam safety is a matter of] calculation. When we design we take all these things into consideration (. . .) we assume that what we have designed will not fail. Generally, you might never have heard that a dam has failed. Maybe in Europe, but in India dam breakages are very few" (Vice-President, private hydropower company, Sikkim, 19 April 2015).

On 22 July 2018, an under-construction hydropower dam in southern Laos collapsed, killing at least 40 people, while hundreds went missing and nearly 10,000 were displaced in Laos and downstream Cambodia. Investigations in the aftermath of the disaster found faulty construction and operation and the authorities' failure to heed early warning signs to be responsible for the catastrophe [1]. Barely one month later, the South Indian state of Kerala experienced unprecedentedly severe flooding. For the first time in history, 35 out of 54 dams in the state had to be opened for safety reasons. Nearly 500 people were killed. Although various experts held the dams responsible for aggravating the floods, a report by the country's Central Water Commission quickly asserted the opposite, absolving the dams and their operators from any blame [2].

These disasters shine light on some often-neglected facts. Large dams are risk-laden artifacts. Exposed to earthquakes, floods, extreme rainfall, avalanches and landslides, and able to cause an equal number of environmental hazards, their functioning and (in)stability is ultimately a product of human excellence and error. As these catastrophes and numerous others in the past months, years and decades remind us, dams do sometimes fail or otherwise produce large-scale hazards. The history of the modern large dam includes a long list of dam-related disasters with a substantial human death toll [3]. This fact is often forgotten or negated, as in the above quote, partly owing to "hydro hubris" [4]—unwavering faith in the godlike power and brilliance of modern hydraulic engineering and in large dams as infallible human creations. But there are also economic and political reasons behind attempts to ignore or negate the fallibility of dams, and to erase such "accidents" from collective memory [5,6]. This paper analyzes the structural mechanisms and power relations behind policies and discourses, which sideline the obvious risk management challenges posed by hydropower dams.

Following the fall and resurgence of dams as "green" energy solutions and objects of financialization [3,7–9], the public debate on large dams has entered a new phase. Dominant pro-dam discourse celebrates hydropower as an uncomplicated, sustainable, and renewable source of energy indispensable to development objectives, such as green growth, climate change mitigation, and poverty alleviation [7,10,11]. While today the dam lobby more readily discusses mitigation strategies for contentious "externalities" like social displacement or ecological impacts, the delicate question of environmental and technological risks emanating from hydropower infrastructure rarely figures in public narratives. And yet, as the global hydropower frontier is expanding into many highly hazard-prone river basins [12,13], risk management emerges as a major challenge of environmental governance. With private and public corporations vying to tap the world's remaining unexploited rivers [8,14], located often in ecologically sensitive forest and mountain areas where climate change increasingly destabilizes precarious local environmental equilibria [15–19], the question of how new hydro infrastructure interacts with environmental hazards, and how decision-makers act to mitigate and adapt to associated risks has become acutely relevant.

This study looks at risk governance in one of these new hydropower hotspots, the Eastern Himalayan region of Northeast India. Over the last two decades the rapid proliferation of new hydropower infrastructure has exacerbated ecological precarity in this seismically and geologically active mountain range [20–23]. In addition, climate change and other anthropogenic pressures are expected to accelerate the frequency and intensity of landslides, flash floods, and seasonal droughts in the coming years [15,16]. Nevertheless, climate adaptation, risk management, and disaster preparedness have received only scant attention in hydropower planning processes across the Himalayas [20,24–28]. Even for most affected communities and civil society organizations contesting hydropower development, safety risk has not been a preferred mobilizing concept – with few notable exceptions, such as the South Asia Network on Dams, Rivers and People (SANDRP), or the movements against the Tehri Dam in Uttarakhand and the Lower Subansiri Hydroelectric Project (HEP) in Arunachal Pradesh/Assam (see Section 5.2). In this article I explore the reasons why hazard potential and dam safety are often marginal topics in discussions about Himalayan hydropower governance and its contestation, and how this has helped produce and exacerbate uneven risks and vulnerabilities.

The bulk of empirical research was carried out between 2011 and 2015 in the small mountainous state of Sikkim, a late entrant to the Indian Union and a forerunner in the Himalayan race for hydropower exploitation. I conducted semi-structured and informal interviews with experts and hydropower professionals from various state departments, a German development agency, three nongovernment organizations working in the fields of environment and development, one state-owned and two private hydropower companies, as well as with local activists and rural households who deal with the ground realities. I also carried out on-site observations in seven hydropower project areas and consulted available policy documents and environmental reports, including the Sikkim State Action Plan on Climate Change [29], the Sikkim State Disaster Management Plan [30], and ten Environmental Impact Assessment (EIA) reports for hydropower projects available in the public domain [31].

Combining insights from political ecology and critical hazards geography, and from literature on the "strategic unknowns" [32], I argue that ignoring environmental and technological risks in

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the planning and implementation of hydropower projects is a central mechanism in the production of unequal risk. Turning a blind-eye to risk enables the shifting of risks and hidden costs, thereby facilitating the appropriation of economic benefits from hazardous hydropower infrastructure by political and corporate powers, and accelerating processes of social marginalization among already vulnerable social groups. Political ecologists have pointed out similar generative patterns in the production of unequal risk, as well as their underlying institutional and discursive drivers [33–37]. What has not been explored in as much depth is why and how processes of marginalization and facilitation are met with acquiescence and/or resistance by the affected public.

I try to explore the latter question by paying attention to how knowledge politics mediate the production and contestation of risk [32,38,39]. I show how certain experts and hydropower professionals instrumentalize and manufacture scientific uncertainty and controversy to depoliticize and conceal the subject of risk in dam conflicts [40]. By contrasting the Sikkim experience with a second case study from the Eastern Himalayas—the protracted conflict over the 2000 MW Lower Subansiri Hydroelectric Project on the Assam-Arunachal Pradesh border—I discuss how knowledge politics can serve to curb resistance, while at the same time providing a fertile terrain for contestation. Thus, the conflict over the Lower Subansiri project—one of India's largest hydropower projects under construction to date—turned into a highly politicized public controversy precisely because civil society groups were able to draw on both vernacular knowledge and scientific expertise to challenge techno-scientific hubris and knowledge politics with powerful counter-claims.

The paper is structured as follows. Section 2 theoretically situates the paper. Section 3 discusses the inherent and aggravated risks associated with the Himalayan dam building spree. Section 4 looks at the hydropower governance process, analyzing institutional mechanisms and policy lacunae, which facilitate "risky" hydropower projects and foster relational processes of facilitation and marginalization. Section 5 first illustrates how these processes are reinforced through a politics of ignorance and neglect, which is legitimized through the mobilization and manufacture of uncertainty. It then discusses the challenges and opportunities for publicly resisting such discursive strategies, making a case for lay-expert knowledge co-production. Section 6 concludes with theoretical and policy implications.

2. Theoretical Framework

Political ecologists and critical hazard geographers have long argued against hazard-centric and techno-managerial approaches to the study and management of environmental risks, which locate the blame for calamity in nature [41–43], pointing instead to the social, structural, political, and institutional dynamics, which produce risk, disaster, and differential vulnerabilities [34,35,44]. Often those further down the social ladder have to pay for natural disasters—a result of power relations, structural inequalities and exploitative processes, which allow those who create or decide for risk, intentionally or through ignorance, to shift it onto others who lack the power to influence these decisions [45]. A common frame in hazards geography thus defines risk as the combination of the probability of a biophysical or technological hazard event (e.g., an earthquake or a dam failure), hazard exposure and social vulnerability ("the ability to anticipate, respond to, and recover" from the inflicted damage [33,44,46] (p. 589).

Recent studies have moreover emphasized the importance of analyzing the generative processes, systemic drivers and institutional decisions, which produce unequal risk and differential vulnerabilities, particularly those enhanced by neoliberalism and capitalism [47–49]. Baldwin and Stanley [46], for example, conceptualize environmental risks and hazards not merely as by-products of capitalism, but as integral to the circulation, viabilities, and crises of capital. Huber et al. [6] suggest that in order to give greater visibility to the role of capital in driving "risky" development decisions, dam failures and other so-called "socially constructed disasters" should better be characterized as "capital-driven destructions".

Similarly, research on environmental justice and environmental racism has shown how racially uneven geographies of risk and vulnerability are the product of colonial ecological violence during the early days of modern capitalism and its postcolonial iterations today [25,50]. In the context of the Eastern Himalayas, Gergan [25] argues that hazardous hydropower infrastructure is built on historical terrains marked by the relationship of dependency, exploitation and negation between the Indian state and its northeastern frontier, and by generations of regional marginalization, uneven development, and racialized, exclusionary state-building practices.

A useful analytical frame to understand how capital interests and elite social groups benefit from the creation of unequal risk is Collins' [33] relational concept of marginalization and facilitation. It highlights multi-dimensional, mutually constitutive and materially inseparable social constructions of nature, which turn environmental risks simultaneously into amenities for some, and externally imposed threats for others. Specifically, facilitation denotes "how powerful groups are provided privileged access to institutional resources" to exploit the environmental rewards associated with hazardous places, with deleterious socioenvironmental outcomes (p. 589). This definition emphasizes the integral role of state and market institutions in unevenly allocating protective resources, such as insurance, land-use and disaster relief subsidies [33,36,37]. In Collins' [33] example, wealthy US residents appropriated the environmental rewards of living in flood-prone neighborhoods (scenic views and being amidst nature) by securing privileged access to flood recovery resources and institutional support. Risks were thus externalized and shifted onto poor migrant workers (marginalization) who occupied flood-prone neighborhoods for want of options, while lacking access to a similar safety net.

But processes of marginalization and facilitation and the uneven geographies of risk and vulnerability they create are also a product of analytical lenses and discursive formations—often based on expert knowledge systems and technocratic managerial discourses—through which they are viewed, represented, and contested [33,34]. Mustafa [35], for example, in his work on the technocratic production of an urban flood "hazardscape" in Pakistan argued that the authorities' material interventions in the watershed were heavily influenced by a narrow technocratic view of hazard problems and solutions, which was largely incongruent with the lived hazardscape reality of the flood victims. Such narrow technical framings of contested environmental problems may also be used strategically to depoliticize and cover up value conflicts, to justify decisions already made [51], or to facilitate the shifting of the harmful effects of accumulation through hazardous technologies [52].

Similarly, one of the main objectives for scholars of ignorance studies has been to show how ignorance, knowledge gaps, or "undone science" are used strategically to preclude, obfuscate, deflect and insulate against unsettling information, magnifying what remains unintelligible [32,38,39,53,54]. As McGoey [32] argues, "the cultivation of strategic unknowns remains (. . .) perhaps the greatest resource for those in a position of power" (p. 1), a "productive asset helping individuals and institutions to command resources, deny liability in the aftermath of crises, and to assert expertise in the face of unpredictable outcomes" [28,55] (p. 553). Industries, for example, increasingly take advantage of uncertain evidence—or question the validity of existing evidence—to shroud claims of causal linkages and to protect financial interests, as was the case with the tobacco industry, climate skeptics or the 2008 financial crash [40,55,56].

In the Himalayan hydropower sector, too, the strategic mobilization of the "unknowns" about environmental and technological risks is a pervasive practice employed both by state and corporate actors [32]. Lord [28,57] and Butler and Rest [24] explore how the "speculative logics" of private financial interests and the state's ambition to meet demands of domestic electricity and revenue propel state and corporate actors within Nepal's hydropower community into "environmental denial" [24] (p. 15), "perpetuat(ing) a "strategic ignorance" [32] of palpable environmental and infrastructural risks" [57]. In a "conjuring trick (and) spectacle" aimed at gathering investments and maintaining the promise of a "hydropower nation", hydropower proponents gloss over inherent environmental and technological uncertainties (e.g., that of seismic risk), while championing "an understanding of risk as objectively calculable" [9,24] (pp. 21–22).

This paper delves deeper into the material and discursive process enrolled to invisibilize the hydro-climatic, geological, and technological risks of large-scale hydropower development in Sikkim.

While many of these risks are known in principle, the incalculability of their occurrence, timing and scale allows experts and political decision-makers to overlook, ignore and deliberately conceal them, much like the knowledge politics surrounding climate change allow some to argue climate change is a hoax.

A further concern of this paper is the role of risk conflict and public resistance in processes creating unequal risk, and in attempts to challenge manufactured uncertainty. The "hazardscape" concept invoked by Mustafa [35] and Collins [33] frames geographies of uneven risk as products of contestation between competing social groups. However, the discussion on what determines public resistance or compliance with the policies and discourses responsible for risk creation has remained relatively thin. Leaning on Gramsci [58], Collins [33] (p. 600) argues that some hegemonic discourses are invoked "even by people who appear to be poorly served by them," because marginalization—being predicated on unequal power relations—is often legitimized ideologically.

Alternatively, people may be aware of and challenge the technocratic gaze and the power dynamics that put them at risk; yet, they fail to transform existing configurations of power and injustice due to the differentially powerful epistemic authority of popular epistemologies vis-à-vis policy and science-based knowledge claims. In a "globalizing world, characterized by the hegemony of technocratic and social modernity", it is this "power of modern institutions to limit debate and discussion" that prevents a more democratic approach to risk management [35] (pp. 567, 582).

The literature on risk conflicts paints a more hopeful picture for the contestation of dominant risk discourses from below. Contrary to popular claims about science being indispensable for understanding many of today's "invisible", diffuse, and difficult to perceive risks [59–61], scholars argue that increasing awareness among the lay public and reduced appreciation for science as a privileged, authoritative source of knowledge create new opportunities to influence definitions of risks. As Cooper and Bulmer [62] (p. 264) argue, hegemonic expert discourses about risk can be hijacked and altered by counter-hegemonic forces, promoting "contradictory popular conceptions of risk". While the greater contestability of knowledge also implies that politically powerful interest groups can reject valid scientific evidence as "fake news" [40,56], it has also given rise to new risk conflicts [59,60,63–65], allowing grounded, material, and embodied experiences of environmental precarity to converse with and challenge scientific representations of risk [25].

This paper seeks to contribute to these debates about acquiescence and resistance to the production of unequal risk, by making a case for knowledge controversy as a major site of political struggle and contestation. It contrasts two cases of risk conflict over hazardous hydropower infrastructure: in the first, scientific uncertainty was effectively mobilized and reinforced by government experts, decision-makers and power developers to maintain the status quo of undefined liabilities; in the second, the ambiguity and malleability of science was exposed and exploited to stage alternative risk claims and to re-politicize the risk question.

3. Hydropower Risks in an Intensifying Hazardscape

The Himalayas are naturally hazard-prone. As one of the world's most geologically and seismically active mountain ranges transected by a multitude of steep, fast-flowing, silt-laden rivers, earthquakes, landslides, and floods are recurrent phenomena. Yet, anthropogenic activities including urbanization, deforestation and infrastructure development have led to an intensification of hazard potential in recent decades [66,67]. Further, severe climate change effects on the weather-climate and hydrological regimes of the Himalayan region have been observed and predicted for the coming decades [15,68–70], increasing in particular the risk of landslides and large-scale hydrogeological hazards, such as "landslide dam outburst floods", "glacial lake outburst floods" (GLOFs) and other erosive flash floods [16,27,71].

Recent disasters hint at how vulnerable Himalayan hydropower projects are. In 2013, an extreme flash flood in the Indian state Uttarakhand caused extensive damage to the state's hydropower infrastructure as an excess of water, boulders, debris, and silt choked the floodgates of hydropower

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stations, leading to overtopping [72]. A similar problem was caused by a landslide dam outburst flood in Nepal's Sunkoshi river basin in 2014 [73]. During the devastating 2015 Nepal earthquakes over 30 hydro projects were damaged, mostly by earthquake-triggered landslides, causing the loss of 34% of Nepal's installed hydropower capacity and USD 200 million estimated losses for its hydropower industry [28,74]. Schwanghardt et al. [74] estimate that ~25% of existing and planned Himalayan hydropower projects "have high probabilities of moderate to severe damage during future earthquakes".

But hydropower infrastructure is not only *at risk*. It also contributes to the intensification of hazard potential, often as a consequence of political and economic decisions about its siting, construction and operation. Schwanghardt et al. [75] (p. 1) observe a systematic push of hydropower activities into the headwaters of Himalayan river basins, closer to glacial lakes and on potential GLOF tracks, estimating that a third of the sampled sites "could experience GLOF discharges well above local design floods." Likewise, investigations identified hydropower infrastructure as one of the main contributors to the Uttarakhand flood damage [72]. Damage was greater near existing and under-construction hydro-projects—a result of how these projects manage destructive water and sediment flows. Construction debris was inadequately disposed of and washed into reservoirs, obstructing dam/barrage gates and leading the river to overflow and laterally outflank the dams. Excessive siltation had reduced the carrying capacity of rivers and increased their erosive capacity.

Dam-induced flash floods are a recurrent problem, caused by sudden releases of water from hydropower stations. Designed primarily for power generation, most run-of-the-river projects today lack adequate flood cushions, as Das [27] explains. Especially at times when reservoirs are full (e.g., at the end of the monsoon season), flood absorption is not guaranteed—a fact often brushed over by hydropower proponents. When excessive inflows from floods or heavy rainfall exceed storage capacity, it is standard practice to release water to ensure dam safety. But such patterns of water release can be highly disruptive, accentuating flood impacts downstream (ibid.), as has been most cruelly demonstrated by the massive flood disaster in Kerala this year [2].

Finally, what is easily overlooked, especially when thinking in terms of large-scale dam disasters, is the "slow violence" of everyday ecological precarity accompanying the construction of hydropower infrastructure in fragile geological settings [25,76]. Phenomena reported from hydropower-affected areas across the Himalayas, such as the sudden appearance of cracks in houses, the activation of landslide zones, or water resources running dry may represent more tangible and cumulatively impactful hazards to the lives and livelihoods of rural Himalayan communities [26,57,77–79]. Excavation works for hydropower infrastructure tend to destabilize fragile mountain slopes, with impacts often felt for months or years post-construction, exacerbated by natural hazard activity. For instance, following a 6.9 magnitude earthquake in Sikkim in 2011, a particularly large concentration of earthquake-induced landslides and damaged buildings was found in vicinity of the 1200 MW Teesta III HEP under construction at the time [22,80]. As a prominent Sikkimese activist commented: "It is any one's guess that the severely disturbed area just needed another jolt to cause devastation as that happened on the 18th of Sept 2011." [81].

Despite these obvious environmental risks, prevalent hydropower governance approaches in Himalayan states have brushed risk and safety considerations under the carpet, often due to economic considerations [24,26,28,82]. Sikkim, given its reputation as one of India's most environmentally conscious states would appear more likely to approach hydropower governance in a more holistic manner [11]. However, as I discuss in the following sections, analysis of governance approaches with respect to hydropower risks exposes serious shortcomings behind Sikkim's progressive "green" politics façade. The government's "quick-business" approach to hydropower development and efforts at providing favorable investment conditions have not only invited "risky" hydropower projects but have also accentuated vulnerabilities in marginal rural areas.

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4. Hydropower Governance and the Production of Unequal Risk

4.1. Facilitating Risk through Privatization Policies

Large-scale privatization gave the impetus for the Himalayan hydropower boom [83]. With the bad fame large dams had acquired globally by 2000—following persistent civil society activism and the World Commission on Dams' staggering report—international finance for large dams had become scarce [3,84,85]. Privatization was widely embraced to revive an ailing hydropower industry [85]. In India, liberalization was gradually initiated with the Mega Power Policy 1995 and a number of other policies followed suit. The launch of the 50,000 MW Hydro Initiative in 2003 promulgated a discourse of sustainable hydropower as imperative for satisfying India's escalating energy demand and identified the country's exploitable hydropower reserves, predominantly located in difficult to access borderland mountain regions [83]. To attract private investments, the policy framework pledged financial support; fostered deregulation of the renewable energy market, minimizing state intervention; relaxed clearance procedures; reduced the minimum threshold capacity for so-called 'mega' power projects to increase the number of projects eligible for the attendant benefits"; and gave state governments the power to allot projects [86,87]. In Sikkim, investments were further incentivized by extending a 10-year tax and import duty exemption and by facilitating land acquisition and accelerated clearances through the government [86].

The Eastern Himalayas were labelled "India's future powerhouse" [27]. Here, privatization kick-started a race by the states of Sikkim and Arunachal Pradesh to contract out public rivers to private power producers [27,86]. These being predominantly rural, non-industrial states, hydropower was presented as a major source of revenue, greater financial and political autonomy, urgently needed infrastructure, employment, and regional development [11]. By 2007, Sikkim had signed 24 Memoranda of Understanding (MoUs) with selected private and public-sector undertakings for developing 5000 MW within five years [86]. Private undertakings were allocated on "Build–Own–Operate–Transfer" basis for 35 years (after which projects are handed back to the state in good operating condition), with the state entitled to 12–15% of the generated power/revenue and 26% equity for projects above 100 MW developed in joint venture [88]. Arunachal Pradesh signed 130 MoUs by 2010 for 40,140.15 MW installed capacity and 26% equity committed to each [27].

With neither a formal hydropower policy nor written rules for public-private financial transactions [87,89], this so-called "MoU virus" thrived on speculative investments and political brokering [27] (p. 3). Agreements with private sector companies allowed for "greater flexibility in negotiating financially lucrative deals" [83] (p. 15), and involved large upfront premiums and individual commissions [27]. Critics lamented that projects were allocated arbitrarily and at "throwaway charges", lacking transparency and competitiveness [90] (p. 738).

A consequence of this open-arms approach has been what Hill [90] (ibid.) calls "frontier capitalism": the entrance of private investors with minimal accountability and experience in hydro, including from the courier and logistics, real estate, steel fabrication, and tourism sectors [91]. As a result, many projects under construction were eventually stalled or abandoned due to financial insolvency (in Sikkim only five private-held projects have been commissioned as of 2018) [20]. The hydropower sell-out has also invited public suspicion about a massive scam involving "private deals, covert decision-making and corruption", as well as the sale of the procured memoranda, clearance papers, and licenses for profit [92] (p. 56). As Rahman [91] (p.19) notes about the similar situation in Arunachal Pradesh:

> "There have been allegations that many dubious private companies are raising huge capital in the stock market, increasing their market profile and bagging infrastructure projects in other under-developed countries on the back of such hydroelectric project allocations (. . .) The local perception is that many of these small and medium dam projects are 'paper dams' or 'MoU dams' and will not see any construction on the ground, as there have been no signs of urgency in ground assessment and feasibility studies."

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By incentivizing and facilitating this fast-tracked and intransparent hydro-business model, privatization policies have prepared the ground for inequitable and "risky" dam projects. For example, India's Hydropower Policy 2008 contains a number of generous concessions, which insulate private companies from the majority of risks inherent to the sector (e.g., hydrological risk), shifting these onto the public, while maximizing the margin for profits and ultimately raising the costs of power [27]. Thus, the imposed tariff regime gives power producers no economic incentive to optimize project designs according to comprehensive hydrological data. Producers are paid for full "design energy" generation, even when water is scarce and power generation is low, while buyers pay more for less. The result, Vagholikar [93] argues, are "over-designed" dams based on unrealistic data.

Moreover, joint ventures "reduce the distance between project regulators and implementers" [89] (p. 118), affecting enforcement and compliance with environmental clearance and environmental management requirements [27]. Vagholikar and Das (ibid. p. 3) note that projects allocated through preliminary payments tend to be seen by both parties as a fait accompli. Even the Ministry of Environment and Forests (MoEF) is known to proactively grant clearances to 95% of the appraised projects, including for EIA reports of extremely poor quality, or which have been "sanitized by developers (...) to weed out problematic portions" (p. 5), ignoring concerns raised by civil society. In Sikkim, lack of regulatory oversight and willful ignorance have permitted environmental decision-making frameworks to be easily sidestepped, resulting in "regulatory collapse" [22] (p. 20). By 2011, at least 17 HEPs had received environmental clearance despite warnings, improper assessments, and without meeting negotiated conditions or addressing regulatory violations (ibid.).

The following sub-section looks more closely at the ground effects of existing policy frameworks and state-level governance decisions, illustrating how these have obscured liabilities, thereby producing increased ecological precarity and social vulnerability in hydropower areas.

4.2. Producing and Shifting Risks and Costs

The project giving the best insights on long-term hydropower impacts is the 510 MW Teesta V HEP in Central Sikkim, one of the first large dam projects in Sikkim, commissioned in 2008 by the public-sector National Hydroelectric Power Corporation (NHPC). During household interviews in the area directly affected by the project's infrastructure, environmental degradation was reported by various communities in the project area—spanning a 20 km-long stretch of the Teesta river—but was found to be most severe above the reservoir and dam site. The villages Jang, Aapdara, and Phidang have been struggling with perpetual sinking of the mountain slope on which they are located, likely a consequence of the cyclical release of impounded water [94]. Visible damage included cracks in residential buildings and agricultural land, as well as enhanced landslide activity.

This has created a situation of unanticipated displacement during and sometimes long after project construction. In Aapdara and Jang several residential buildings have collapsed, and families been relocated from the area. The safety risk has become so pronounced that plans are underway to move the entire village. In Phidang the reservoir backwater has come dangerously close to the settlement, and lower lying areas of the village are at risk of toe erosion and flash floods, including sudden water releases by planned and existing dams upstream. Here, too, respondents were considering abandoning their properties. In Dipudara, located above the vertical tunnel carrying water to the powerhouse, water was repeatedly found flowing from 'cracks' in the mountain within one year of commissioning, raising fears that the tunnel system may be faulty and risk collapsing. The villagers have since been demanding compensation and resettlement.

Negligent construction practices can partly be blamed for increased ecological precarity. For example, despite knowledge about the fragile geology NHPC didn't implement effective precautionary measures, such as reservoir rim treatment [94]. In Dipudara, slope stabilization and protective concreting works to mitigate tunnel leaks were reportedly ineffective, rendering the land increasingly unsuitable for agriculture and construction. Excessive amounts of explosives used to accelerate tunnel construction was another problem cited (Interview, Mines, Minerals & Geology Department, Government of Sikkim, 26 April 2011).

Such corporate negligence, however, has also been institutionally facilitated, notably by failing to hold developers accountable. First, India's rehabilitation and resettlement policy considers only land users whose lands are acquired prior to project construction as project-affected and entitled to compensation and rehabilitation. These provisions may work for dam projects with 'traditional' storage designs. Modern large-scale run-of-the-river hydropower projects—the new standard dam design in the Himalayas—have smaller submergence zones but require an extensive underground tunnel system carrying river water to a powerhouse located several kilometers downstream [27]. These tunnels affect places far away from reservoir and power house, often in ways that are not immediately obvious (see Section 5.1). In Sikkim, entire hillslopes are pierced by tunnels or nibbled at by water-level fluctuations in the reservoir, but the often-irreversible damage and displacement caused, sometimes years after project completion, is systematically ignored in EIAs because policy does not mandate land acquisition in such areas. (For an alternative rehabilitation and resettlement model see Lord's discussion of the Upper Tamakoshi HEP in Nepal [28].

Second, for impacts not accounted for in the EIA it is difficult to claim compensation and "project-affected person" status later. Without clearly formulated guidelines defining liabilities, and authorities unwilling to hold power developers accountable, the latter can easily shirk responsibility. The burden of proof is shifted onto the victims, but laypeople have been unable to prove that the observed impacts are caused by the project. While victims receive financial support through a 'natural calamity fund' from the district administration, access to these resources often hinges on social status and connections to influential decision-makers. As one interviewee tellingly suggests: "Compensation is not dealt out to all households, only to the rich. After all, cracks cannot be seen in simple huts" (24 February 2011).

The authorities' failure to efficiently handle rehabilitation claims further propounds the vulnerability of those affected. In Aapdara and Jang inhabitants still lived in visibly damaged buildings since their compensation payments had not yet been settled. One displaced landowner received Rs 10,000 (€160) on the spot for immediate relief but was told that a full damage assessment, to be conducted by a different department was required to compensate his entire loss. After ten months and 19 visits to different offices he still had no news. Such bureaucratic limbo hits economically weak households unable to self-fund safety measures particularly hard. Lengthy administrative procedures, trips to offices and possible legal fees cut further into tight household budgets, and struggling for rehabilitation also requires a certain level of education and political clout.

This is not to say developers are totally uncooperative. In some cases, NHPC agreed to compensate the damages incurred—either through voluntarily ex gratia payments to the victims, or by repairing or constructing public infrastructure. Such voluntary rehabilitation assistance appeases public relations and avoids negative publicity, but it also undermines a more drastic reconfiguration of the rules of the game. As one Sikkimese journalist relates:

> "NHPC is generous in dealing out compensation money and undertaking protection works but refuses to admit on paper that the project works are responsible for the damage. If they would, the calculations for future projects would have to be expanded. However, in this way the same underrating of impacts is likely repeated with the next project or EIA. NHPC is also very quick in doing the repairs because in this way they control the works and the contractors too" (24 February 2011).

A more impactful way to address the vulnerabilities created by hydropower development would be policy amendments, which establish on paper the range of (hydro-)geological disturbances hydropower infrastructure can cause; and which define corporate liabilities for social and environmental rehabilitation at any project stage, preventively or through aftercare. But institutional consequences are not in the economic interest of the developers, nor of the local elites, who gain

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kick-backs and contracts through the hydropower business. Thus, avoiding that certain environmental risks and impacts become officially recognized and their assessment and mitigation institutionalized is key to cost-cutting and a continuation of business-as-usual. The following section explores this process of "strategic denial" by government experts, politicians and power developers within Sikkim's hydropower community further [24,57]. It illustrates how scientific uncertainty about hydropower risks and impacts is fostered through individual and institutional complacency, and by manipulating knowledge production.

5. Risk, Knowledge, and Resistance

5.1. The Politics of Knowledge around Hydropower Risks

Dam sanctioning guidelines in India do contain provisions to assess risks and ensure dam safety. Detailed project reports (DPRs) drafted during the dam planning stage must contain seismic studies and dam design and safety parameters in accordance with the Bureau of Indian Standard's civil and hydraulic engineering codes [87]. Further, states must prepare dam operation manuals for individual dam projects, which contain an emergency action plan [2]. However, there are other risks—many—which are not or insufficiently accounted for through the national policy framework [87]. For example, a major risk management challenge, given the fast proliferation of hydropower projects in a context of heightened ecological precarity and climatic uncertainty, is reconciling hydropower development with climate action and disaster management. Yet, since not mandated, none of the publicly available EIA reports and Environmental Management Plans for hydropower projects in Sikkim contain climate change considerations. Even the newly named national Ministry of Environment, Forests, and Climate Change does not have any written positions on climate change adaptation for the hydropower sector [87].

Likewise, Sikkim's in many ways progressive environmental policy framework largely ignores the critical hydro–climate–disaster intersection, failing to keep in mind inherent ecological precarity [20,25]. Sikkim's State Action Plan on Climate Change elaborates at length on water resource vulnerability and water security but steers clear of hydropower and associated environmental risks [29]. Investigations with the State Disaster Management Authority (SDMA) found that so far neither are there risk assessments for dam-induced disasters, nor disaster management provisions to deal with hydropower-related risks. Even the department head admitted that dam safety standards were exclusively monitored by the project developers themselves, while the state was ill-prepared to deal with hydropower-related hazards:

> "We are not monitoring [the power companies] (. . .) As a disaster management department, we should be going to the dam, but now they themselves have scientists and technical persons (. . .) We should also have a connection, but now we are busy with some other things. Later we'll be doing that also" (7 May 2015).

Interviews with experts and hydro professionals reflected a striking disregard and ambiguity about dam safety, even among senior government officials. Several respondents tried to downplay or deny the hazard potential of hydropower, or to retreat from responsibility. An interviewee in the Power Department suggested I better go ask these questions to the Forest Department, since they are the ones dealing with environmental impacts and climate change (11 May 2015). There seemed to be a general lack of mandate by the authorities to look at the effects of climate change on hydropower infrastructure. An interviewee at the German development agency supporting the drafting of a state climate change policy said he was aware of climate change impacts on hydropower, and hydropower impacts on the environment, but explained that his agency only works "on whatever the government will request" (2 December 2013).

To justify this lack of engagement with hydropower risks several interviewees invoked scientific uncertainty and knowledge controversy. One NHPC official explained that in the absence of scientific climate data, climate change was a factor too uncertain for consideration in his project's EIA report:

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"This is something that has to be established first (scientifically) (. . .) Somebody else has to do it" (8 November 2013). Some respondents disputed that climate change poses a problem at all. The head of the disaster management department, for example, opined that for him as a geologist, climate change was "sort of a political issue", rather than a "real" scientific phenomenon to be taken seriously (7 May 2015).

Uncertainty regarding the intensity, timing and spatial effects of climate change is undoubtedly more pronounced in the Himalayas, not least due to the lack of basic, reliable, long-term climate data for the region [27]. However, responses by project developers indicated that neglecting rather than mitigating potential environmental risks and their social ramifications was at least partly an economic strategy for safeguarding the financial viability of hydropower investments. Since the companies usually try to recover their investments as quickly as possible, and since from an economic perspective structural safety loses its importance as time advances (especially for licenses lasting merely 35 years), investing in costly precautionary measures not prescribed in project plans cuts into narrowly calculated returns. Responses also reflected that for the developers, environmental risks and their mitigation were calculable problems. Asked how his company deals with natural hazards, the director of a private power company commented: "You have to put up with it. If it harms the project, we have to bear it. We take insurance. (. . .) That is a must. That is a condition put by the lenders. Because after all they get the money back" (15 May 2015).

The strategic use of knowledge gaps also became evident from the rather selective framing of uncertainty. For example, despite the inherent and inevitable uncertainties associated with complex technological systems like dams [38], dam safety concerns were either brushed aside, or exalted with "hope" or "faith" in state-of-the-art technology, and the blunt denial of historical dam failures. The following statements were made by engineers and scientists in the Power and Disaster Management departments, the Central Water Commission and by a private hydropower company director:

> "We expect earthquakes (. . .) and damage is inevitable. Some damage happens, it is designed that way. But to totally fail and all, that's not going to happen. *Hopefully*" (11 May 2015).

> "There are so many components, which should be earthquake resilient features. If that is done, then there is no issue that it shouldn't hold the intensity of an earthquake with a magnitude of around 8. I *think* they are made to hold this 8" (7 May 2015).

> "The geology is very fragile here and the conditions of the rock are not very good. But everything has engineering solutions and that's what we do provide. From the geological and engineering point of view, there are no problems. For every geological problem there is an engineering solution available." (8 May 2015).

> "Dam break analysis has been done by the Institute of Roorkee based on which the dam has been designed. (. . .) In India, it has never happened. No dam has broken till now. Once the dam break analysis is done, it is ensured that the reinforcement and construction methodology used are fool-proof" (5 May 2015)

But uncertainty was not only discursively framed. Its active reinforcement, both by dismissing non-scientific sources of information and by obstructing the generation of scientific evidence is illustrated by the controversy about the hydrogeological impacts of hydropower tunnels. Local people in various project-affected villages in Sikkim have noted declining agricultural productivity, along with the sinking and degradation (cracking) of land, the depletion of soil moisture, and the drying and disappearance of springs—predominant source of domestic and agricultural water. Especially farmers who observed such changes daily were unanimous that these problems were caused by hydropower tunnels, which they argued "swallow" and divert soil moisture and spring water, evidenced by rivulets emerging from the tunnel access points. Likewise, they associated land degradation with tunnel blasting, (which "made the land shake just like during an earthquake,") and recalled starting to witness these changes roughly when project construction began.

While the locals believed to have an answer, science did not. A spring expert explained the difficulties in scientifically pinpointing the causes of hydrogeological change, with current scientific understanding of Himalayan hydrogeological systems being too coarse and qualitative, due to their complexity and location-specificity, and available research methods being too resource-intensive (2 May 2015). He nevertheless suggested that a multi-site study analyzing the state of the environment before and after project construction could explore scientifically valid linkages between tunneling and spring decline. However, when I enquired about such studies with the Department of Mines and Geology, the state agency responsible for (hydro)geological assessments, the geologists there were disheartened. While their team had carried out damage assessments in three project-affected areas, confirming many of the locals' assumptions, their findings couldn't be considered "legitimate" evidence, since the assessments were exclusively carried out *after* the changes had occurred. A systematic baseline inventory of landslide zones and spring discharge *prior* to tunneling had never been commissioned:

> "We tried to have baseline data earlier, but we could not do it. I tried to convince the government, this is the main requirement. Because a lot of comparisons will come up at a later stage. (. . .) I insisted to carry out such studies, either they should be financed by the power projects, or they [themselves] should carry out those studies."
>
> *"So, you couldn't carry out these studies even though you wanted to?"*
>
> "These power developers are such influential people, they can influence the government also."
>
> *"But isn't there any incentive for the government to carry out these kinds of studies?"*
>
> "They have not initiated. [Why] I don't know exactly. Because the government is interested in harnessing all the power" (26 April 2011)

Even four years later, despite further ex-post reports confirming extensive environmental degradation in project-affected areas, the government had still not made any efforts to establish the extent and causes of these damages. Only one project developer had apparently agreed to collect baseline data before starting tunnel excavation (6 May 2015).

In the absence of sufficient scientific-experimental data and for system dynamics difficult to explain with scientific methods, vernacular forms of knowledge, based on historic memory, long-term observations and an intimate understanding of the local environment have become important sources of information to better understand patterns of climate and environmental change in the Himalayas [95,96]. Even Sikkim's acclaimed rural development program "Dhara Vikas", which revives springs to ensure water security in drought-prone villages uses local perceptions as a main data input [97].

In most expert interviews about hydropower impacts, on the other hand, vernacular knowledge was categorically dismissed as insufficient or invalid, rumors and "misconceptions" resulting from ignorance, illiteracy, or political motivations, and pitted against science as the only valid source of information. A common argument was that Sikkim's geology is "naturally" fragile and multiple other factors may influence hydrogeological processes. An official in the Rural Management and Development Department suggested that locals blame the tunnels because they produce sudden changes and are highly visible, but how sure can the locals be? "Actually, we need some scientific evidence" (8 May 2015). An engineer with the Central Water Commission got rather worked up by my question and the account of the villagers' perceptions:

> "After making the tunnels, it has not been observed anywhere that the resources have dried up. (. . .) How can it be? It's basically a foolish question. Those who are asking those questions, they don't have a basic knowledge of engineering. (. . .) There is no valid reason,

no engineering reason that water will be depleted. (. . .) People are either making false statements or it is just against hydropower. Unnecessary rumors are being created (. . .) Because in our village areas (. . .) the literacy rate [is] less than 10 per cent, people have not studied even 4th and 5th standard. (. . .) If you tell them that the sun rises in the west, they will be convinced by that" (8 May 2015).

5.2. Contesting Dominant Risk Discourses

Quantitative, techno-scientific representations of risk often have a depoliticizing effect on environmental governance, compromising public political deliberation and democratic decision-making. As Anderson [98] (p. 41) argues, by employing an "end-eschewing mode of argument" and presenting fundamentally political and ideological choices as technically complex, scientific issues, such discourses disqualify the scientifically illiterate from debates about risk, making risk "the exclusive province of the expert". Expert representations of environmental and technological risk may also serve hidden agendas of profit and power:

> "When a certain (warped) technical rationale is presented as the standard of rationality it is really an unacknowledged form of political domination, one that facilitates the selection of a particular kind of society as it obscures this end from public political discourse. Naturally, we find this mode of argumentation advanced by those who stand to lose the most from free democratic discussion—those who represent corporate and state power" (p. 43)

Equivalent arguments by political ecologists speak about the capture of environmental discourse and risk controversies in a "post-political consensus", concealing that what really is at stake in environmental politics is a democratic-ideological struggle between different socio-environmental futures [99,100].

Similarly, in India, the high degree of epistemic authority awarded to science vests experts with the exclusive power to determine which risks are real or unreal, allowing no room for lay knowledge claims to contribute even to problems associated with great scientific uncertainty. This erasure of risk by invisibilizing and excluding certain risks from the terms of the debate presents a major obstacle to public resistance against hazardous hydropower projects. The entire burden of proof is shifted onto affected households—often the most vulnerable social groups who have little to no means to consult expert opinions, mount campaigns or enter litigation and exert political pressure.

Yet, while uncertainty and knowledge politics lend themselves to manipulation, they also represent a fertile terrain for contestation. Research suggests that in the age of manufactured, diffuse or invisible risks [59–61], the reduced appreciation of science as an exclusive, authoritative source of knowledge gives alternative knowledge claims more influence over definitions and debates about risks—one reason for the growing number of risk conflicts [59,60,63–65]. As the struggle against the Lower Subansiri mega-hydro project on the Assam-Arunachal Pradesh border illustrates, influencing the production of knowledge about risk can be a most effective strategy for challenging expert representations of risk and the top-down imposition of hazardous technologies.

NHPC's 2000 MW Lower Subansiri HEP is among the largest of Arunachal's 160+ hydropower projects to be constructed on various tributaries of the Brahmaputra river. While most of these projects cause only limited displacement in sparsely populated Arunachal, the strongest resistance has come from civil society and political groups in downstream Assam, a densely populated state occupying the Brahmaputra floodplains. Conflict over Lower Subansiri started in the early 2000s. River-dependent communities in Assam were concerned about the dam impacting river flows and the floodplain ecology—livelihood base for a vast, rural population. They were also familiar with the dams' unintended, incalculable and uninsurable risks. The collective memory of the 1950 Assam earthquake, when the failure of a natural landslide dam on the Subansiri river caused catastrophic floods is still strong [101]. Since 2004, floods have been aggravated repeatedly by sudden excessive releases of water from hydropower projects in Arunachal Pradesh, Bhutan and Nagaland [27,102]. However,

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since Indian environmental policy includes no mechanism to account for downstream impacts of large dams, downstream-affected people were systematically excluded from negotiations over rehabilitation and benefit-sharing.

By 2006, an alliance of affected people and local student unions succeeded in pressuring the Government of Assam to commission a downstream impact study, conducted by an interdisciplinary eight-member expert committee from reputed Assamese universities. Their report, completed in 2010, gave scientific endorsement to the activists' concerns: operating the dam would cause dramatic daily flow fluctuations to be felt for hundreds of kilometers downstream. Another alarming discovery were flaws in the seismic-geological aspects of the project. Despite poor geological conditions and a highly earthquake-prone location, NHPC had made several modifications to the dam's original design parameters, which would reduce the costs of the project but increase its risks —including reducing the width and depth of the foundation, shifting the powerhouse underground, choosing concrete over rock-fill technology, and minimizing the project's flood cushion. The report triggered massive public support and the formation of a mass movement comprising affected communities, student and farmer organizations, and the state's major opposition party. In 2011, a road blockade temporarily shut down construction works. The project has remained suspended ever since.

The expert committee suggested to simply change the dam's design parameters. But NHPC, possibly concerned about additional costs and its reputation, mobilized its own group of experts from reputed national scientific institutions (some of whom had helped design and clear the project in the first place) to delegitimize the concerns raised against the dam and the validity of the claims by the Assamese experts [101]. This led to a highly politicized stand-off between the corporation and the movement and a more ambiguous group of national and regional politicians, bureaucrats and scientists between the two ends of the spectrum.

The government, responsible to take a final call on the fate of the project has since been under immense political pressure from both sides. The stakes are high: huge financial losses for NHPC; sacrifices in voter numbers; and powerful political interests at national level. Moreover, this being the first successful large-scale anti-dam protest of downstream communities in India, the decision will set an important precedent for hydropower conflicts in the country. Thus, instead of taking a clear stand on the issue, the state government has delegated expert committee after expert committee, each time engaging more senior and "qualified" experts, in hope of obtaining unambiguous evidence on the safety of the dam.

The effect has been the opposite: each round of expert scrutiny has not only revalidated the technical concerns already raised, but also revealed others. It has also made visible that science is not isolated from political pressures. The penultimate expert committee produced four Assamese votes against the dam and four votes by Central Government-appointed non-Assamese experts in favor [103]. Likewise, the latest expert-panel appointed by the MoEF stands accused of a possible conflict of interest, since its three members belong to institutions backing NHPC's position on the project in the past [104].

6. Discussion: Challenging the Production of Unequal Risk through Knowledge Co-Production

With this paper I have sought to explain why considerations of hazard potential and dam safety occupy a marginal position in the governance of Himalayan hydropower projects and their contestation, and how this contributes to the material production of uneven risks and vulnerabilities in hydropower-producing areas. My main analytical focus has been on two arenas of environmental governance: institutional mechanisms and knowledge politics.

While research on uneven geographies of risk has focused on the role of techno-scientific representations in shaping knowledge about risk [33–35], the findings from Sikkim point to a different type of knowledge politics: to legitimize complacency in the face of heightened hazard potential, the question of risk is discursively and institutionally erased and invisibilized. This "environmental denial" [24] (p. 15) by members of Sikkim's hydropower community (and beyond Sikkim [28,32,79])

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is facilitated by various types of uncertainty, related for example to the invisibility of large parts of the project infrastructure, the difficulty to expose below-ground hydrogeological processes, or the impossibility to predict future hydro-climatic hazards. Expert discourses and political decision-makers selectively mobilize these uncertainties, but also actively reinforce them, by discrediting alternative sources of knowledge and by influencing what type of knowledge is produced.

These insights speak to a community of research on the deliberate production, perpetuation and institutionalization of ignorance and scientific ambiguity—also referred to as agnotology, antiepistemology, or the strategic unknowns, among others [32,54,105]. Ignorance studies explore the use of ignorance as a resource to deflect, obscure, conceal or magnify knowledge that is dangerous or unpalatable to powerful interest groups [32,55], and fill an important theoretical void: they account for absences in knowledge production—knowledge, which gets lost or never gets made [39,106,107]—and counter the common assumption that knowledge is necessarily more powerful than ignorance [32,55]. As McGoey [32] (p. 5) argues,

> "We need less attention to the politics of knowledge and more to the politics of ignorance, to the mobilization of ambiguity, the denial of unsettling facts, the realization that knowing the least amount possible is often the most indispensable tool for managing risks and exonerating oneself from blame in the aftermath of catastrophic events."

In Sikkim, institutionalized ignorance about certain hydropower risks and impacts has enabled the unchecked construction of hazardous hydropower projects. Further, by undermining the assessment, prevention and mitigation of hydropower risks, it has helped to maintain uncertainty, obscure liabilities, and thus prevent policy amendments and other changes in the official "rules of the game", which could jeopardize the viability of hydropower investments and investment decisions. For example, establishing liabilities in the EIA or adjusting environmental clearance requirements would imply lengthier, more elaborate, and more costly clearance procedures. Obliging developers to acquire all land and rehabilitate all households physically impacted during the entire project cycle would make project costs spiral. Such measures could also increase the likelihood of (organized) resistance by affected communities, implying further delays and expenses.

Admittedly, the strategicness of ignorance about hydropower risks in Sikkim is debatable. As McGoey [55] argues, the power and success of ignorance is underpinned by the difficulty "of proving whether someone is actually ignorant or simply feigning ignorance" (p. 559). In the Himalayas, geological and seismic uncertainty and the unpredictability of certain earth system dynamics complicate the question of strategic ignorance. Rather than a "deliberately wielded tool", could ignorance here also simply be "an unavoidable handicap" (ibid.)? I would argue that deliberation becomes evident when one looks beyond what experts, hydropower professionals and decision-makers claim not to know, and at how they deal with risk and uncertainty. Rather than improving the state of knowledge and applying double precautionary measures, Sikkim's hydropower community has used ignorance as an excuse not to act. Whether this "blissful disinterest" is strategy or merely convenience, the lack of preparation it imposes on the state and its population is hard to justify. As the editor of a prominent local newspaper argues about Sikkim's disaster management culture:

> "Unprepared, is inexcusable for a population that has lived with slides and shakes since forever and specially not at this juncture when there is (. . .) a full-fledged department for Disaster Risk Management and earmarked funds as well. How can any area in Sikkim not have a risk reduction plan to limit the damage caused by landslides and earthquakes? (. . .) Unless one understands the causes, how can safeguards against such disasters in the future be devised? Preparation requires accepting that a threat exists and then understanding the reasons causing (it)" [108].

Further, this paper has shown institutionalized ignorance to be a central mechanism in relational processes of marginalization and facilitation, allowing for the material production and shifting of risk [33–35,52]. Investment incentives have encouraged a hydropower development model, which diverts public resources for private profit and consumption elsewhere, while externalizing environmental risks and costs, thus compromising on factors of socio-environmental impact and structural safety. The exclusion of certain risks from impact assessment and rehabilitation processes has jeopardized households and entire communities, up to the point of unforeseen displacement. The failure to investigate and communicate the causes of incurred damages has obscured the question of liability. Depriving affected communities of systematic, adequate and timely rehabilitation, and undermining the ability of state institutions, communities and households to anticipate and adapt to risk situations has exacerbated vulnerabilities and deepened social marginalization.

Clearly, marginalization and facilitation go hand in hand here: while the risks produced through strategic ignorance threaten the lives, livelihoods and living environments of people in hydropower-producing areas, they represent economic opportunities for powerful corporate and political interest groups. Not surprisingly, the latter are actors usually far removed from these local realities, indicating how the production of geographically and racially uneven hazardscapes perpetuates historical patterns of dependency and exploitation between the Indian state and its margins, but also within frontier spaces like Sikkim [25].

Finally, this paper has drawn on two different case studies to understand what determines compliance and resistance to the production and discursive erasure of risk. The Sikkim case study illustrates that institutionalized ignorance, which instrumentalizes scientific uncertainty is a challenge to public resistance. As Butler and Rest observed in Nepal, laypeople often "cannot marshal an opposition to dam construction (...) beyond supposition [and] having little evidence for their position, (...) can only warn about the danger of dam breach as a possibility rather than a likelihood" [24] (p. 23). The Assamese resistance against the Lower Subansiri dam is instructive because it has managed to overcome this challenge. While the impetus for public concern came from embodied experiential knowledge, based on the lived memories of flood disasters, the movement has successfully mobilized the epistemic authority of scientific experts to expose the malleability of science and to stake alternative claims about the dam's risks. This public contestation of the risk question has been so powerful that it has caught political decision-makers at state and national level in a bind for nearly a decade.

But how useful is the Assamese experience for those affected by risky dam construction in Sikkim? No doubt, troubled state–society relations complicate the question of resistance in Sikkim, where political pressure and authoritarian government tendencies have long curtailed opportunities for affected communities and civil society groups to challenge development decisions [11]. Interviews in project-affected areas produced multiple accounts of repressive tactics used by project developers and state authorities in response to individual complaints and collective protests, creating widespread fear of dissent. Likewise, several respondents from NGOs explained that they must take a politically neutral stand and cannot work "against the government" for fear of political retaliation. As a result, hardly any environmental NGOs or research organizations in Sikkim are willing to openly engage with hydropower development.

Moreover, questions of ethnic identity and minority politics have historically fractured social mobilization in the state. Like other states of Northeast India, Sikkim's population comprises of numerous ethnic groups, who compete for access to public resources through reservations [109]. While Assam is no less tormented by ethnic politics, the activists have not framed their struggle in ethnic-cultural terms. Unlike in Sikkim, Assamese activists could draw on a powerful culture of class-based resistance and a long history of peasant and student mobilization to build strength in numbers [110,111]. Thus, resistance, which initially emerged in response to individual dam projects eventually turned into a state-wide movement against dam construction on the Brahmaputra River.

It is doubtful whether such a mass movement, articulated in terms of environmental justice could ever materialize in Sikkim. And in fact, this is not to downplay the remarkable successes Sikkimese anti-dam movements have achieved by using ethnic and cultural particularism as mobilizing concepts because they do carry political clout. These achievements deserve greater recognition, as I have argued elsewhere [112]. Nevertheless, to resist "unavoidable externalities" like heightened ecological precarity, disaster risk and social marginalization by projects yet to be built/completed, the Subansiri case does provide a useful lesson: the power to define risks and their acceptability is not entirely monopolized by experts. Hegemonic expert discourses can be punctured and subverted, particularly when they bank on contested knowledges [62]. The activists in Assam have achieved this by entering the field of knowledge production and bridging the lay-expert divide [101].

More generally, the successful challenge this citizen–science alliance has mounted against institutionalized ignorance testifies to the need for a democratization of knowledge production: reconsidering the exclusive authority awarded to experts, and recognizing the value and particularity of the embodied, experiential knowledge, which comes from having to live with ecological precarity [25]. As experiences of human-made, capital-driven disasters—many dam accidents included—indicate, scientific controversies often come to light only in the aftermath of catastrophe, while public resistances based on experiential knowledge of the local climate, geology, hydrology, and disaster historiography can issue effective early warnings [6]. Such contestations therefore deserve more credence by environmental decision-makers, especially for complex governance problems with high political stakes and high uncertainty.

There are already multiple proposals for the co-production of knowledge out there, including post-normal science [113], citizen science [114], street science [115], or activism mobilizing science [116], among others. These approaches center on inclusive strategies, seeing citizens not "as passive receivers [but] as active partners in the production of knowledge" [59] (p. 71), and have proven particularly useful for environmental justice conflicts with uncertain facts, disputed values, high stakes and urgently required decisions [113]. By establishing new linkages between experts/science and citizens/activism, and by promoting alternative perspectives, knowledge co-production frameworks counter the technocratization and scientization of knowledge production [59], and the instrumentalization of scientific complexity and uncertainty for political purposes.

Despite the constrained political space for hydropower activism, Sikkim has potential for creating such citizen–science linkages. First, as mentioned earlier, local knowledge is already consulted and put to use in different development and environmental research initiatives [29,95–97], demonstrating a general appreciation of vernacular perspectives. Second, as this paper has demonstrated, not all experts are complicit in invisibilizing risk and in ridiculing vernacular perspectives. Many government and NGO-experts work closely with local communities, and given the limited influence regional state agencies have on hydropower governance decisions, some experts have openly professed their antagonistic relationship with hydropower developers and their disdain for corporate negligence in environmental management, siding with locals instead [25]. Finally, with Indian environmental activism shifting increasingly to the legal level, civil society groups may be able to push for improvements in the implementation of participatory tools, such as the EIA process or the veto power of the gram sabhas (village assemblies), which are explicitly designed to broaden the knowledge base for governance decisions by including local perspectives.

Nevertheless, to create powerful citizen–science linkages and mobilize Sikkim's extensive environmental research community, concerned scientists and other experts in the state must leave the comfort of alleged objectivity and challenge the power structures, which influence what environmental knowledge may be produced or not. Sikkim's contested hydropower future and its environmental ramifications are after all not technical, but fundamentally political questions, and engaging with or abstaining from these is a fundamentally political choice.

In closing, I want to point to three specific policy implications of strategic and institutionalized ignorance in the hydropower sector, particularly in a context of climate change. First, there clearly is an urgent need to reevaluate the viability and hazard vulnerability of Himalayan hydropower infrastructure. The latter has a significant bearing on the economic potential of new hydropower ventures, too, and for decision-making on future development pathways of Himalayan constituencies [24,74].

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Second, as this paper has illustrated, hydropower infrastructure and its neglectful governance can exacerbate climate vulnerability and complicate adequate climate action. Framing hydropower as a climate mitigating energy technology without due attention to associated risks is misleading and leads to maladaptation [117].

Finally, as Lord [57] suggests, with more powerful natural hazards to be expected in mountain regions around the world, and given the significant uncertainties over the looming impacts of climate change, the time seems ripe to take seriously "technologies of humility", such as micro-hydropower and other decentralized renewable solutions, and to dismiss the infrastructural hubris which has long driven risky hydropower investments.

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Article

Re-Linking Governance of Energy with Livelihoods and Irrigation in Uttarakhand, India

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Abstract: Hydropower is often termed "green energy" and proffered as an alternative to polluting coal-generated electricity for burgeoning cities and energy-insecure rural areas. India is the third largest coal producer in the world; it is projected to be the largest coal consumer by 2050. In the Himalayan state of Uttarakhand, India, over 450 hydroelectric power schemes are proposed or are under development. Hydropower projects ranging from micro hydro (run-of-the-river systems with generating capacity up to 100 kW) to large reservoirs (storage systems up to 2000 MW) such as the Tehri Dam are in various stages of planning, construction or implementation. Run-of-the-river hydropower projects are being developed in Uttarakhand in order to avoid some of the costs to local communities created by large dams. Stakeholders in this rapid hydropower expansion include multiple actors with often diverging sets of interests. The resulting governance challenges are centered on tradeoffs between local electricity and revenue from the sale of hydropower, on the one hand, and the impacts on small-scale irrigation systems, riparian-corridor ecosystem services, and other natural resource-based livelihoods, on the other. We focus on the Bhilangana river basin, where water dependent livelihoods differentiated by gender include farming, fishing, livestock rearing and fodder collection. We examine the contradictions inherent in hydropower governance based on the interests of local residents and other stakeholders including hydropower developers, urban and other regional electricity users, and state-level policymakers. We use a social justice approach applied to hydropower projects to examine some of the negative impacts, especially by location and gender, of these projects on local communities and then identify strategies that can safeguard or enhance livelihoods of women, youth, and men in areas with hydropower projects, while also maintaining critical ecosystem services. By assessing the Bhilangana basin case, we also offer hydropower–livelihoods–irrigation nexus lessons for headwater regions across the Himalayas and globally.

Keywords: hydropower; governance; livelihoods; gender; irrigation; ecosystem services

1. Introduction

Rampant urban and industrial growth and an agricultural sector increasingly dependent on groundwater pumping for irrigation have placed rapidly mounting demands on electrical power generation across South Asia. The Gangetic Plain and Himalayan headwaters in India and Nepal are witnessing rapid social–ecological change. Hydropower development is occurring on rivers where irrigation, livestock rearing, and other natural resource-based activities are already stretched in their ability to meet local residents' livelihood needs. Water is the central thread that interweaves energy (e.g., mechanically powered mills, electricity generation), agriculture (irrigated and rainfed crops, fodder for livestock), fishing, and ecosystems (provisioning of water, regulation of micro-climates)—a prime example of the water–energy–food nexus [1]. Yet, the integration of hydropower as the newcomer into local and basin-scale resource-use practices poses very significant governance challenges. Our purpose here is to identify strategies in the Bhilangana River basin in Uttarakhand state, in northern India, that safeguard or enhance the livelihoods of women, youth, and men in areas with hydropower projects, while also maintaining critical ecosystem services. By assessing the Bhilangana basin case in Uttarakhand, we also offer hydropower–livelihoods–irrigation nexus lessons for headwater regions across the Himalayas and globally.

Hydropower supplied about 16% of energy globally in 2014, on the rise since 2004 among countries in the Global South with the rising percentages of their growing populations demanding access to energy [2,3]. Hydropower is one component of the energy portfolio of India. It was estimated that in 2014, India used only 21% of its potential energy from hydropower [2]. Rural and urban electricity is highly subsidized by the central government. Electricity demand is increasing steadily. Most of the electricity consumers are either located in urban areas or in breadbasket regions where extensive groundwater pumping exerts electricity demand [4,5].

Low-income rural people must often make do with inferior sources of energy such as fuel wood, kerosene, animal waste and coal. They also do without power for oil expellers, rice hulling and wheat grinding, as well as for uses such as electrical tools, and dairy processing. Household needs that are often neglected are the blending of food, a fan for hot weather and lighting for use at nighttime for children's homework and to extend women's and men's productive hours.

The social impacts of the extraction of natural resources for energy production are often borne by rural communities. The urban populace, however, also pays for the current dependence on coal for energy production through very poor air quality; the capital city of Delhi has received the dubious distinction of the city with the worst air quality in the world [6]. Thus, urban and rural built environments, as well as ecosystems, are impacted by the water–energy–food nexus. As Rasul has argued [7] (p. 9):

> *Greater policy coherence among the three sectors (water, energy and agriculture) is critical for decoupling increased food production from water and energy intensity and moving to a sustainable and efficient use of resources. The nexus approach can enhance understanding of the interconnectedness of the sectors and strengthen coordination among them.*

The water–energy–food nexus is impacted by localized special interests that include hydropower developers, construction companies/contractors, landowners, village leaders, and others, each with their own agendas. A paradox related to the push towards hydropower for the production of energy in India is that it is a federal program, yet it is being executed in an ad hoc manner by usually private actors. Some of these private actors are based in areas distant from the villages impacted by the hydropower projects.

This paper examines the governance challenges of integrating hydropower with irrigation and other livelihoods by considering nexus dynamics in a headwater basin. This is set against the backdrop of rural–urban exchanges of energy through transmission–grid extension; agricultural production through market penetration; labor migration as a result of stark differences in wages and services; and a range of digital, financial, and other "divides" between plains cities and more remote headwaters regions. Based on this brief introductory framing, we proceed to discuss the case-study location, as well as its features of more generic relevance; present a social–justice conceptual approach centered on governance and institutions; analyze hydropower-impacted livelihoods; and conclude with a discussion of strategies to better balance livelihoods and ecosystem services.

2. Research Sites and Methods

Uttarakhand is a state in northern India bordering Nepal to the east and China (Tibet) to the north. Two major rivers of north India, the Ganges and the Yamuna, originate in Uttarakhand. These rivers and their tributaries provide the opportunities for hydropower generation. Uttarakhand has four ecological zones which, from South to North are: Shivalik, Lesser Himalaya, Great Himalaya, and Trans Himalaya. There are two administrative divisions: the Kumaon and Garhwal regions. This study was conducted in the Lesser Himalaya zone in the northwestern Garhwal division within the Tehri Garhwal district (refer to Figure 1). Eighty-nine per cent of the state of Uttarakhand is mountainous, which significantly restricts the area capable of sustaining agricultural production. In the mountainous terrain, factors such as deforestation due to climate change and heavy felling of trees for construction, other development projects and livestock grazing, have increased the incidence of landslides. Uttarakhand is also prone to erosion; 53 per cent of the state is categorized as severely or very severely eroded and dams in the state have experienced serious challenges with sedimentation [8]. Seventy per cent of the population in Uttarakhand is involved in agriculture, primarily subsistence agriculture [9]. The cropping intensity has been calculated at 160 per cent (i.e., all arable land is cultivated for at least one crop season, and an additional 60 per cent of this has a second crop). The average landholding in the hills per household is 0.68 acre (often divided into patches). The Tehri Garhwal district has a high poverty rate: more than 45 per cent of the population lives below the poverty line [8].

Figure 1. Map of Uttarakhand showing locations of Garhwal and Kumaon regions. Source: https://en.wikipedia.org/wiki/Garhwal_division.

Technocrats and policymakers in India in general and in the water-rich Himalayan states of Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir and Uttarakhand in particular,

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overwhelmingly believe that hydropower generation will have the least negative environmental impacts of any energy option, and it can also bring in state revenue. These states have been termed the "Power Banks" of India for their capacity to generate power for their own demand and that of other states [2]. As Reddy et al. have argued with respect to hydropower in Himachal Pradesh, the state northwest of Uttarakhand: "*the main winners are the state and commercial developers who have gained access to water for producing electricity*" [10]. Approximately 450 new hydropower projects are currently being developed in Uttarakhand to partially "fill the gap" between utilization and the state government's estimate of 27,039 MW of hydropower potential. The state and central (federal) governments, in joint ventures between public and private entities, or with private companies (nationally and internationally based) are coordinating these power projects.

Experiences with large and medium scale hydropower projects, the types that have largely been promoted to date in Uttarakhand, have been mixed [11]. The recent shift from large reservoir-based hydropower generation to run-of-the-river (ROR) projects, are seen by proponents to have tackled displacement and rehabilitation issues, as well as the environmental impacts related to the construction and management of dams. In India, there are 22 large dams with a height of 100 m or higher. In Uttarakhand, some of these include the Tehri dam (1000 MW capacity), Koteshwar dam (400 MW capacity) and Ramganga dam (198 MW capacity). The Tehri dam, completed in 2006, has a height of 260 m (855 feet). It is the highest dam in India (and only one other dam is over 200 m high) and fifth highest globally. This dam caused the displacement of 110 villages and over 100,000 people [12] and the severe disruption of livelihood systems [13]. In terms of climate change, large dams, especially those located in tropical regions, have been implicated in large greenhouse gas emissions largely from decaying organic matter [14], putting into question the green credentials of hydroelectric power production [15].

ROR hydroelectricity, unlike hydropower via large dams, requires little to no water storage. Instead, the natural flow or elevation of the river is used to generate electricity; the water is diverted from the river with a diversion weir or small dam and then channeled into the powerhouse to turn turbines (see Figure 2). Sometimes a small dam is created called pondage where a small area is flooded but this area is much smaller than with conventional dams. These systems produce little or no greenhouse gasses except during the construction stages and are thus considered to be carbon-neutral.

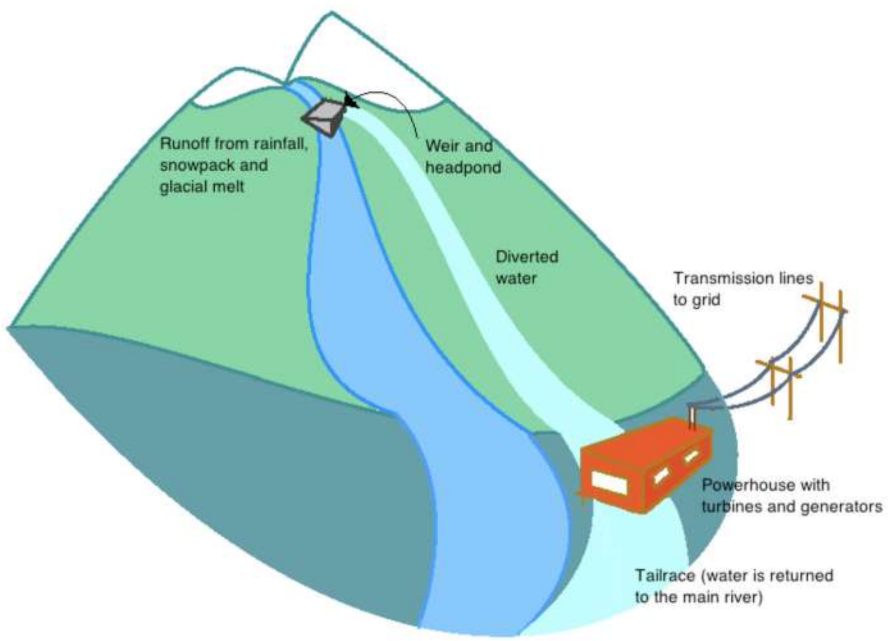

Figure 2. A small hydro, or run-of-river facility, drawing power from a mountain stream. Source: http://www.energybc.ca/profiles/runofriver.html.

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ROR projects have not been as effective in the redress of local environmental concerns. ROR can affect the health of a watershed. Partly this is because the abstraction of water from the river leaves an area downstream, between the weir and the powerhouse, without normal river flows. Sufficient environmental flows of water (in this case river water made available via management regimes) are critical for ecosystems and the environmental, economic and social benefits these ecosystems bring. A healthy watershed provides multiple ecosystem goods and services for human, animal and plant populations within its boundaries. Postel and Thompson summarize these benefits as [16] (p. 98):

> ... *water supplies for agricultural, industrial, and urban–domestic uses; water filtration/ purification; flow regulation; flood control; erosion and sedimentation control; fisheries, timber and other forest products; recreation/tourism; habitat for biodiversity preservation; aesthetic enjoyment; climate stabilization; and cultural, religious and inspirational values.*

Altering river flow leads to sedimentation, more turbidity, warmer water, and a change in nutrients that harms riparian biodiversity and the aquatic and animal populations dependent on the river [17]. Also, in Uttarakhand, water for ROR is often channeled through large pipes to achieve greater hydrostatic head (height difference between water upstream and downstream) and water flows to improve power production potential. The blasting techniques followed for constructing the tunnels through the mountains for diversions often leads to destabilization of the hillsides as well as detrimental effects on homes, cattle sheds and other infrastructure in the area.

Figure 3 indicates the location of Uttarakhand, the Bhilangana river basin, and the Tehri dam. The Bhilangana river is a tributary of the Bhagirathi river, which in turn is a tributary of the very large glacier-fed Ganges (known in India as the Ganga) river. The Bhilangana river basin is 2000 square kilometers in size. In April 2015 there were six operational projects, two under construction, six proposed, and nine identified sites for hydropower development in this basin [18] (fieldwork 2015). The hydropower projects are located in the narrow river valleys that are densely populated with villages and agricultural smallholdings on terraced land.

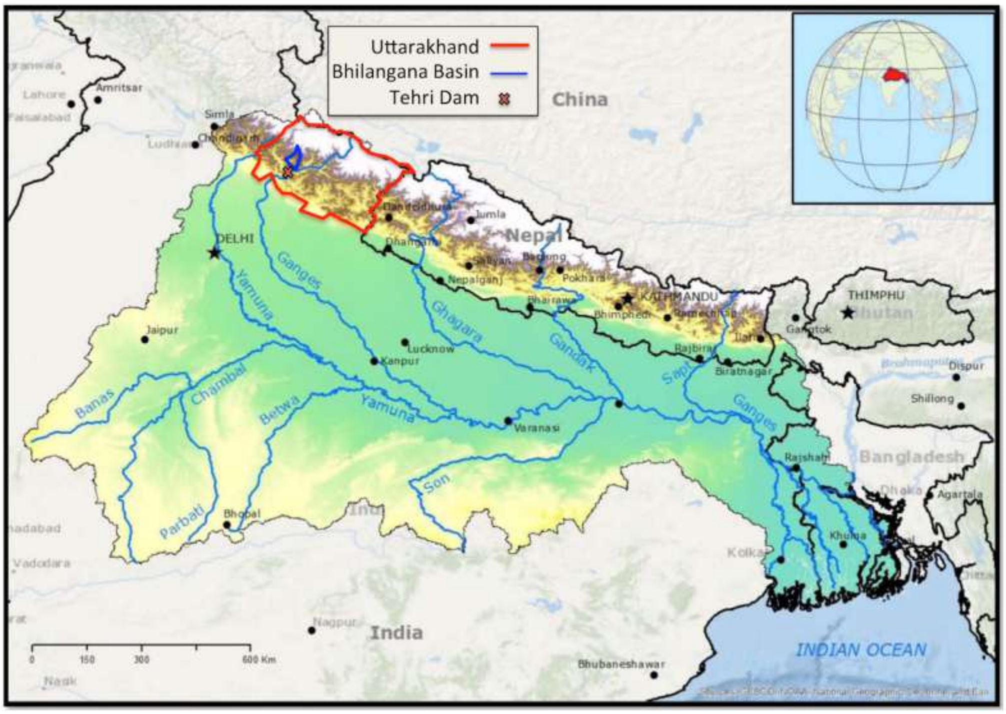

Figure 3. Study location in Uttarakhand. Source: Base map from Challenge Program for Water and Food (CPWF). http://waterandfood.org/river-basins/ganges-2/.

The research sites that include villages and their respective agricultural fields are located along the Bhilangana river and its tributaries including the Balganga river. These sites include villages impacted by the three operational run-of-the-river hydropower projects: Phalenda village (Bhilangana hydropower project with 22.5 MW capacity); Chakar Gaon and Devling villages (Bhilangana III with 24 MW capacity) and Chani village (Agunda–Thati with 3 MW capacity) (refer to Figure 4).

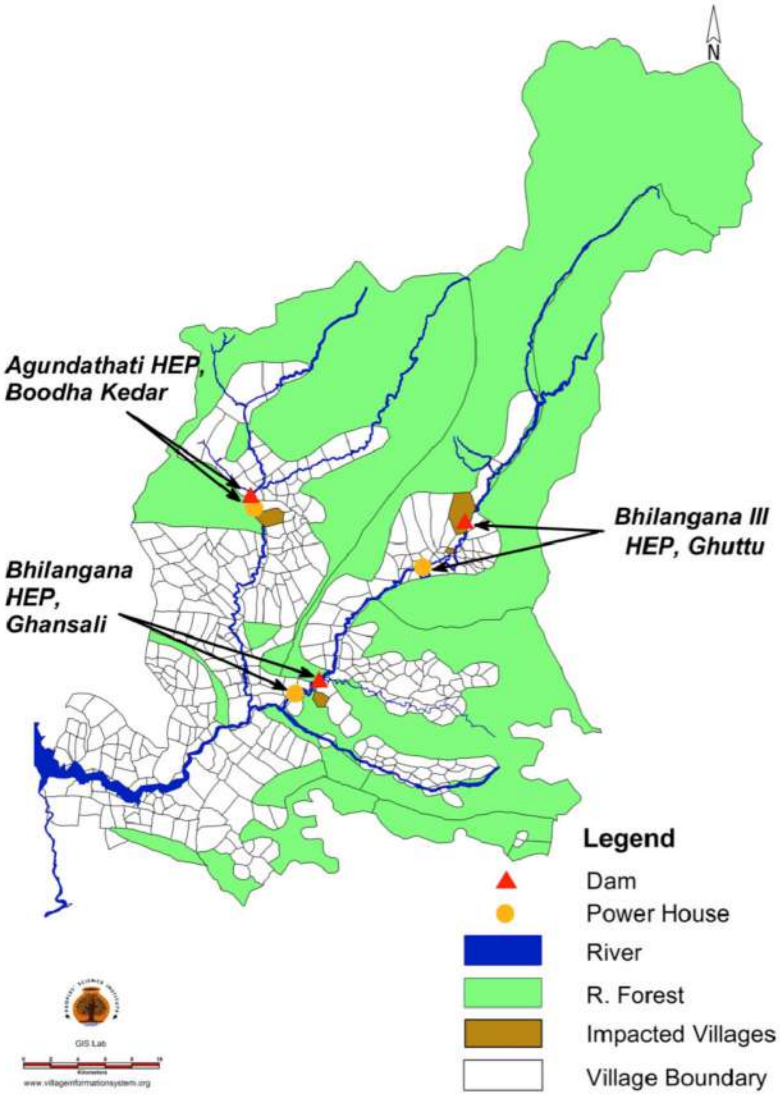

Figure 4. Research sites (impacted villages) and associated hydropower projects in the Bhilangana River Basin within Uttarakhand, India. Source: People's Science Institute, Dehra Dun.

Research methods utilized for this ongoing study include rapid rural appraisal (RRA), focus group discussions and household surveys (25 per cent stratified sampling) conducted between April 2015 and May 2016. Secondary research included a review of hydropower project related documents such as some of the detailed project reports (DPRs) on the hydropower projects, village agreements and writ petitions.

Urban-centered decision-making processes predominate in hydropower development. Pearce (2005) has argued, with respect to large dams in northeastern India, that [19] (p. 99): "Politically, they (large dams) have become a weapon for the rich, urban and powerful to take control of water resources away from the poor, rural and dispossessed". D'Souza's argument about the effects of large dams and other river diversions in India is also applicable [20] (p. 71):

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> ... *though announced as neutral technological artefacts, (large dams and diversions) are deeply implicated in several processes that have been integral to affecting types of enclosure, hydraulic transfer, the expropriation and elimination of other water management skills and traditions and inevitably the externalisation of real costs through displacement onto the most marginal and impoverished communities.*

In India, a large power gap exists between rural and urban residents. In 2012, those in rural areas consumed 7 kWh per capita per month whereas their urban counterparts consumed 24 kWh per capita per month [21]. Urban dwellers are thus benefitting more from hydropower development than rural peoples. However, previously energy-deprived rural populations are also deriving benefits in some cases. A range of actors including locally elected politicians, private developers, non-governmental organizations (NGOs), and others are actively working to secure funding for energy projects from Central and State government sources [22]. This is part of a general scramble for development projects in rural areas, a process that gained significant momentum with the National Rural Employment Guarantee Act, 2005 (later renamed the Mahatma Gandhi National Rural Employment Guarantee Act). Rural political leaders use the promise of such projects to bring development to their region. The desire to attract employment is an important component of such development projects. There is a rural employment crisis that has led to labor out-migration from rural areas. Gender is an important factor in employment and migration issues [23]. In the region studied in Uttarakhand, male migration is higher than female migration. Younger men migrate first for educational opportunities then for employment. The migration of women tends to occur more often after they marry to join their husbands. Ironically, migration to cities swells urban population, thus increasing urban demand for energy that contributes to a vicious cycle of rural expropriation (in this case of water) for largely urban energy use. It also has another societal cost: diminished food production in rural areas.

We take a social justice approach, especially as applied to energy projects [24], by contending that rural peoples should be given a stronger voice [25] than urban-based developers and political power brokers. This approach also leads to questions over centralized projects for resource provision and management, including hydropower in the case study we consider; however, centralized photovoltaic and wind-power projects are also limited in their capacity to meet social–justice criteria. Young [26] has characterized social justice as a condition in which the institutional context makes it possible for everyone to be included in governance processes and entails distributive results such as the satisfaction of basic needs. As Gross [27] (p. 2727) has argued with respect to fairness or justice in renewable energy projects (specifically, wind energy):

> *Questions of justice are* ... *at the heart of many environmental disputes, such as* ... *infrastructure development projects... While broad in scope these environmental disagreements share common characteristics which include how decisions are made and how public goods, such as power generation infrastructure, and environmental burdens* ... *are distributed.*

Questions of fairness in a social justice framework incorporate issues pertaining to project benefits and costs and how these are distributed by gender, social class/caste, and geographical location [28]. In India, these distributional issues have so far been largely studied as they are related to the effects of large dams [29–31]. An overarching distributional issue is that which is mentioned above, that is, urban elites' expropriation of river water from rural populations living and farming in particular locations in riparian areas. In India, no water law exists that confers water rights to local people; only land rights exist [32].

Innovative technologies and social and legal processes and rules can help rural stakeholders generate energy for their own benefit rather than for urban, centralized, politically powerful actors. Rural populations are demanding regular power supply from the government. Electricity in rural Uttarakhand is used for lighting (including energy-saving compact fluorescent lights (CFL) bulbs), charging cell phones, and for blenders, irons, televisions, and refrigerators (usually only a few per village). Some of the benefits they seek from connection to small hydropower generation include longer hours of power and/or more reliable power, as the centralized grid supply in this area is still very poor. Smaller ROR projects that use the water alternately during the day and night for power generation and irrigation can help ensure power and livelihoods for local needs.

A more equitable distribution of environmental burdens can also be achieved in more centralized ROR power projects. Governance related measures that would help ensure this include the following: compensation by the developer for damage done to local populations' property during the construction phase. Minimization of the environmental burden on local livelihoods during the lifetime of the ROR project via government regulations applied to power developers' operations. Such regulations would incorporate sufficient environmental flows. Finally, governance measures would include more equitable distribution of benefits through profit sharing.

Social justice issues related to water resources have emphasized that water for multiple different uses must be protected in any watershed. The concept described above of environmental flows helps bring to light the multiple human and non-human water needs in a particular, managed, area. Chowdhury and Rasul's argument [25] (p. 46) with respect to irrigation projects also holds true for hydropower's effects on agricultural and domestic water resource distribution and access across different socio-economic groups: "*(a project) ... may affect their initial water access and use rights, entitlements and affect their well-being differently*". As competition grows between different water users (agricultural, fishing and hydropower in this case study) due to increasingly scarce water resources, social justice issues will become an increasingly pressing area for policymakers to address.

3. Results

3.1. Main Actors and Governance Linkages in the Study Area

The main local actors in the Bhilangana basin involved in hydropower projects include: Village Councils (*Panchayats*), Farmers' Groups, Irrigation Users' Groups, Non Governmental Organizations, Trusts, Cooperative Societies, Producer cooperatives or businesses, Village Energy Committees, Forest Councils (*Van Panchayats*), Self Help Groups, Government Departments, village women's welfare groups (*Mahila Mangal Dals*, MMDs), and village youth welfare groups (*Yuvak Mangal Dals*, YMDs). According to the villagers in the rural communities studied, the hydropower developers and state energy department are the least significant and accessible in terms of services and benefits accrued; in Figure 5 below, this is indicated by the smaller size of the circles for the developers, state energy department and courts, and the distance of the circles from the hydropower impacted villages.

An environmental impact assessment (EIA) must be undertaken for hydropower projects by Indian law (the Environmental Protection Act passed in 1986). The Ministry of Environment, Forestry and Climate Change, through environmental appraisal committees executes the EIA for hydropower projects before they decide on whether or not to approve them. The assessment is used as a tool to identify the environmental, social and economic impacts of a hydropower project. Recently, however, the National Institute of Disaster Management (NIDM) recommended in a report that disaster impact studies should be part of the EIA. This recommendation stemmed from the common perception that hydropower projects have increased the damage in Uttarakhand caused by floods, especially flash floods and lake bursts from glacier-fed lakes, such as the catastrophic one that caused large loss of life in 2013. The NIDM study also pointed out that: "hydro-power projects are blamed for disturbing ecological balance in the sensitive fragile zone of Himalayas, leading to more landslides and other associated risks" (NIDM in [33]). Small hydropower projects of up to 25 MW with an outlay of less than Rs. one thousand million (i.e., one billion) are exempted from the EIAs but they do need to obtain all clearances from the corresponding state government.

Women are the cultural and economic backbone of life in the Garhwal Himalayas (as well as in the neighboring Kumaon Himalayas of Uttarakhand [34]). They do most of the farming and household work, which involves collection of drinking water, fodder, fuel wood and attending to the cattle (mostly cows and water buffaloes for their milk), besides all the daily household chores. Girls often

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work alongside their mothers. Male out-migration from the area has further heightened women's roles in agriculture such as in paddy (rice) cultivation, the cultivation of other grains and pulses such as lentils and the production of vegetables. Similar patterns have been documented in other areas of Uttarakhand state such as in the Nanda Devi biosphere reserve area [35], which is located to the northeast of the Bhilangana river basin research sites we studied. Women's welfare groups i.e., MMDs are therefore recognized as one of the most important institutions by the local communities and are therefore represented by the biggest circle. In all the impacted villages studied, MMDs were also reported to have actively participated in the protests against hydropower developers to fight for their rights related to land, forest and water. Therefore, these are perceived to be closer to the village in terms of their relationship with the villagers.

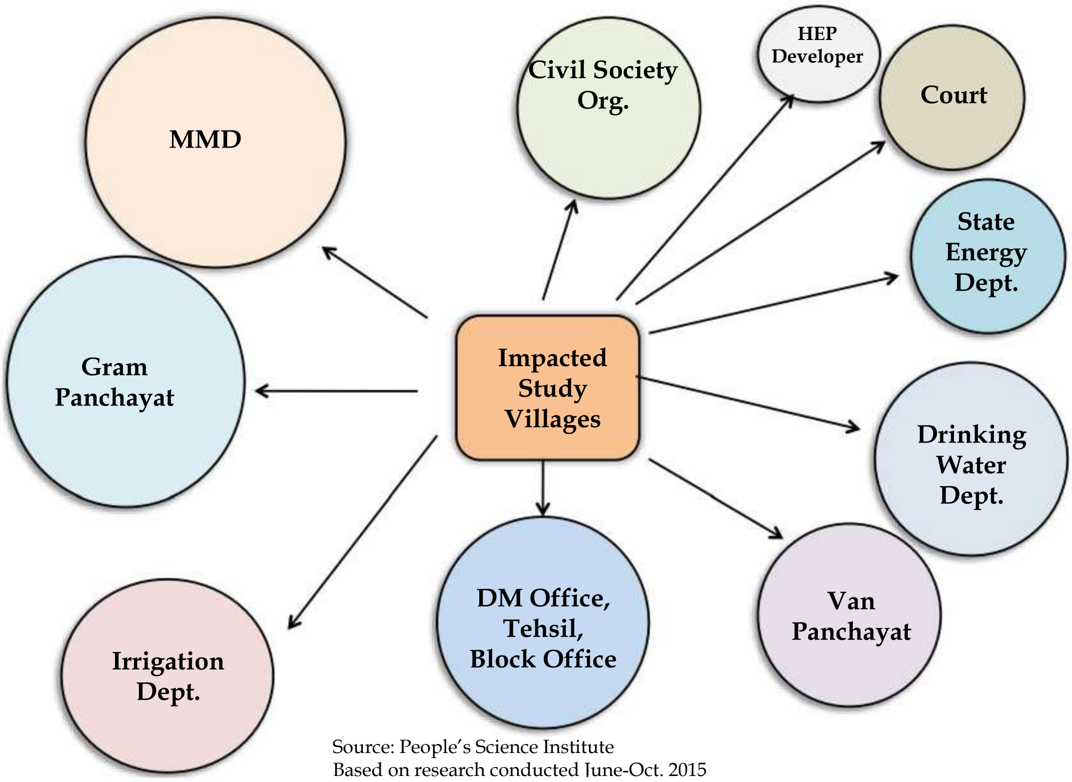

Figure 5. Stakeholder mapping: Bhilangana River Basin study sites.

An example of MMD's brave, active and prolonged (therefore costly) participation is reflected in the words of a woman who is a former member of the MMD of Phalenda village and was a leader in the protest:

> *We came to know about the ongoing construction plans only when we saw the machines. We led the group and reached the construction site. The moment villagers went to stop the construction, police were employed. The police would not even let us access our fields. We did not want them to take away the water used for irrigating our fields. So we started the protest that lasted for about a year. We would take turns going to our fields for work, attending to the needs of our children and also participating in the protest. For hours, groups of men and women would sit determined by the side of the road and would get up only when surrounded by the police. We participated in frequent hunger strikes. In my memory we stayed hungry for four days continuously one time and eight days another time. We were sent to jail at three different places three times. A settlement was reached after one year of tiring agitation, when we got water for irrigating our fields. However, if you ask me, the most important impact has been on our mental peace of mind and well-being, which can't be reimbursed (translation from Hindi ours).*

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Due to the prolonged agitation by the MMD, farmers of Phalenda managed to get a better share of irrigation water from the hydropower developers in comparison to other affected villages.

Gram Panchayat as an institution in the three-tier local governance system is the lowest institution in the hierarchy through which communities participate in the planning and execution of all village development activities. So, it is perceived as the second most important and still close to the village in terms of accessibility and usefulness to the villagers.

Yuvak Mangal Dal or the youth welfare's group is still active but heavy out-migration from the area has diminished its level of activity to a considerable extent. Among all the village level institutions, this is perceived to be least active.

The next set of primarily government institutions are mainly service providers and are approached only in case of need. According to the villagers' own words: "As and when these institutions are approached, our work gets done. However, we have no additional expectations from them". The irrigation and water departments are shown separately, as per their roles, but according to the villagers, the majority of the repair and maintenance work for the pipelines and *guhls* (irrigation canals) is performed by the villagers themselves via voluntary labor contributions. Therefore, the villagers' perceptions of their need for these organizations and these departments' efficacy is lower (represented by smaller circles) and they are placed further away.

Lastly, hydropower developers and the district courts are the two institutions that are perceived to be least important. The developers' main interest appears to be earning revenues from energy generation; local communities' interests do not come first within their agenda and often get sidelined. Similarly, the communities have had largely negative experiences with the courts in terms of resolving conflicts over benefits sharing and compensation related to hydropower projects. However, as we discuss below, the state and federal governments could play a role in mandating, through legal instruments, more equitable benefit sharing between the community and hydropower developers. This would also translate into a better balance between meeting the needs of rural and urban populations. The courts would then be responsible for upholding these legal measures aimed at achieving social justice and environmental sustainability. In addition, a stronger, more socially just water–energy–food nexus would be ensured because of the critical role rural populations continue to play in the production of food for both rural and urban areas.

3.2. Case Studies

Developers of ROR projects have frequently overlooked the energy and irrigation needs of the local communities. They have not allowed for sufficient environmental flows downstream of the ROR projects. This lack of transparency and coordination with local communities has translated into negative impacts on the livelihoods of female and male villagers neighboring the project sites, as highlighted below in the case studies of four villages in the Bhilangana basin in Uttarakhand.

3.2.1. Observed Common Social Impacts in All Studied Hydroelectric Project (HEP) Areas

The negative effects of hydropower development reported by villagers living and farming in the vicinity of these ROR projects include land destabilization, leading to infrastructure damage including cracks/seepage in houses and/or community buildings; and destabilization of slopes with greater chance of landslides, fissures and land subsidence (some of these effects are due to dynamite blasting of tunnels for the HEP project); as well as an accumulation of muck (rock and debris created by tunneling during the construction of hydropower projects) on grazing/agriculture land. There are also myriad water-related effects such as reduced water resource availability including defunct water mills (for grinding grains) due to less water in the river in locations where water has been extracted for the HEP; reductions in domestic and irrigation water supply due to spring sources disturbed especially by tunnel blasting; irrigation canals destroyed due to landslides or abandoned due to too little water available; water pipelines carrying spring water for domestic water use and home gardens destroyed; dry riverbeds during part of the year; more wild animal attacks on crops and livestock

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due to deforestation affecting food supply for these animals; and less water in the river; reduction in irrigated area; reduction in availability of fodder and fuelwood due to less vegetation along the river banks; reduction in manure due to less livestock kept because of decreased availability of fodder; loss of cremation ghats (riverside cremation grounds); and a reduction in fish population due to less water in the river and poorer water quality. These effects are not limited to the study area. Dry springs and increased vulnerability to landslides and deforestation, for example, were similarly identified as effects of hydropower projects in the Nanda Devi biosphere reserve in Uttarakhand to the northeast of the Bhilangana study sites [34]. Damage to and lack of water for water mills and irrigation canals was also reported in a study conducted on the effects of small ROR projects in Himachal Pradesh state, India [36]. These environmental burdens are experienced by agricultural communities that depend on natural resources for their livelihoods and reside in the ROR project areas. As will be seen, some local residents are affected even more than others.

3.2.2. Impacts Observed in the Case of Devling and Chakar Village, Bhilangana III HEP Area

Impacts of blasting for the construction of the tunnels for the HEP can be clearly seen at the Bhilangana III HEP areas. Some of the respondents expressed that: "The land beneath our houses would shake, as if an earthquake had hit the area. We couldn't sleep during those nights". In Devling village located near Bhilangana III HEP (24 MW), as many as 86 out of the 110 resident households observed visible cracks in their houses after the construction of the HEP started. In terms of their springs (also a source for irrigation), seven out of eight are reported to have subsequently partially or completely dried up. Due to the construction of tunnels, irrigation channels in the neighboring villages have been affected. The agricultural fields have suffered a loss of productivity due to reduced irrigation water availability, which also led to a reduced amount of fodder (straw) from paddy and wheat crops. Approximately 95% of the households reported a loss of productivity in agriculture. The reduction in irrigated area has affected food availability from farm and agricultural income. Agricultural land has also been affected through the dumping of construction material from the hydropower projects on this land. Dependency on the market for food grains has therefore increased.

Debris from the blasting of the tunnels for the hydropower projects has been dumped on grazing lands accessed by all households in the village. When asked how the hydropower project has impacted their daily life, a respondent immediately reacted by forcefully stating that:

> *They caused damage to our agricultural fields and did not compensate us for it. Our harvest has been reduced due to less water available for irrigation and a lot of dust from the construction. The springs feeding our guhls (irrigation channels) have disappeared because of the blasting. This pollution in the area has also impacted our grazing land. It's just not the same grass anymore and animals won't consume it. Many of us have therefore sold off fifty per cent of our milch (dairy) cattle.*

Households that earlier ran water mills from the mountain streams for additional monetary income and for food security, have now been affected by a loss of income due to greatly reduced water flows. As many as ten water mills have become defunct in Devling and Chakar villages.

The People's Science Institute's (PSI) field research team, together with residents of Devling village, carried out mapping of impacts on a village map of Devling, indicating present land use and land cover, which was available with the revenue official at the site (see Figure 6). A range of features including impacted springs, impacted irrigated/unirrigated area, houses that developed cracks, defunct water mills, land deposited with muck, etc. were marked after visual verification by the field research team.

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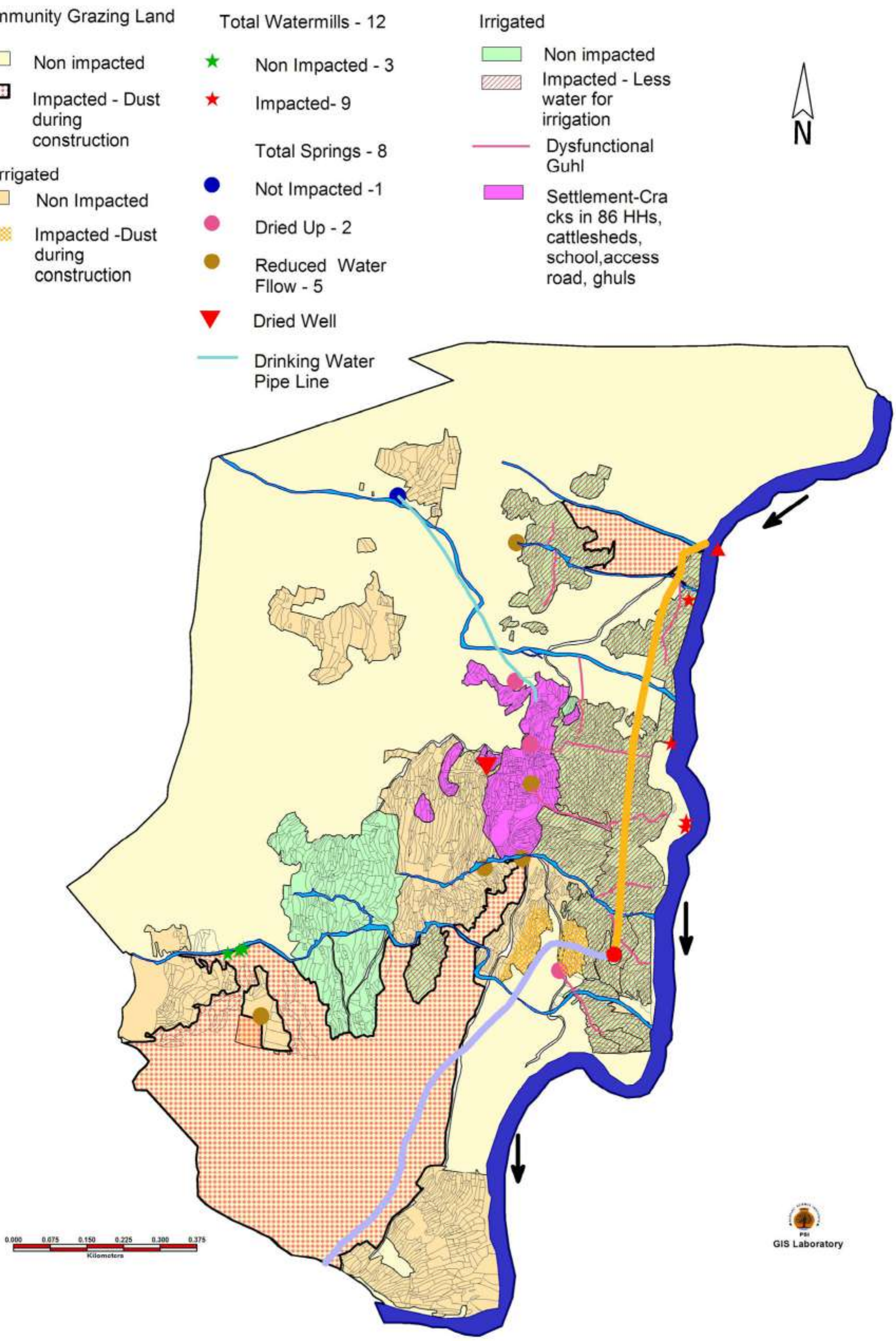

Figure 6. Map of Run-of-the-River (ROR) Project Impacted Areas in Devling Village.

The map shows the extent of the damage exacted on important livelihood-related infrastructure, privately-held and common lands and on water resources for domestic and agricultural use.

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Gendered Impacts

All hydropower projects have had gendered impacts; in the study area, in the case of all women interviewed, their workload related to the collection of water, fodder and fuelwood increased. Loss of fodder and fuelwood sources has forced them to go deeper into the forests for collection. More men were reported to have migrated in the post hydropower project period to make up for livelihoods-related losses from the hydropower project. Women have been left alone to tend to animals and to farms with decreased access to the means of production.

Villagers have responded by reducing their herds of cows, bulls and buffaloes, and/or by renting the use of bulls for ploughing. In Devling village, the average annual loss in income per household from milk has been around Rs. 14,000 since the HEP started functioning. In Chakar village near the Bhilangana III hydroelectric plant, women told our research team:

> *The forest is far away. Lower availability from other sources has increased our time and effort. There is a fear of wild animals in deeper nooks and crannies in the forest. We have no help from the men. So we have reduced the number of animals we keep.*

Thus, hydropower projects in this area have clear social–justice related implications for rural populations, revealed in gendered impacts on labor allocations, income and access to food.

Compensation for Losses

Some livelihood compensation has been offered by the hydropower projects but these vary across and within the affected villages causing a great deal of unhappiness. Very few households from the affected villages received employment at the hydropower projects, for example, only three from Devling. Only some households in the villages received monetary compensation and this compensation was reported to be inadequate. In Devling, only four out of nine households received compensation for defunct water mills. Land compensation rates for land taken over by a hydropower developer ranged from Rs. 40,000 to Rs. 95,000 per *nali* (50 *nalis* = 1 ha) for 20 households. No compensation was given for damaged houses and cattle sheds in any of the affected villages. A few households reported investing Rs. 15,000 to Rs. 20,000 for reconstructing cattle sheds. In some villages, pipelines have been built by developers from the sources of springs to the village. However, in Devling village, due to disputes over labor charges for villagers volunteering to help, pipelines were not installed. An ad hoc compensation of Rs. 1 lakh (Rs. 100,000) was given to the *Gram Panchayat* of Chakar Gaon village.

3.2.3. Impacts Observed in Chani Village, Agunda–Thati HEP Area Despite Signed Agreement

In Chani, a village affected by the 3 MW Agunda–Thati hydropower project, the villagers stated that they were warned by nearby villages in the area about the negative effects that they had endured. Villagers interviewed in adjoining Agunda and Thati villages said that they had turned down the hydropower developers' requests to construct a hydropower project in their location. As a result, the project was moved to Chani. The signed agreement stated that, aside from the land handed over on paper to the developers by the villagers, no other land would be affected. The signed agreement also assured that any individual in the *gram sabha* (i.e., all villagers over age 18) who suffered any kind of damage to their property during the HEP construction phase would be compensated by the company. Muck disposal would be done in the depositing yard, not on farmers' land. They were promised that any destruction to the canals, crops, paths and fields would be repaired. However, none of these promises were subsequently met.

The villagers explained that:

> *We have been living here for generations and now they have taken everything away. The developer belongs to the same district (but is now a large industrialist living in the large city of Dehradun). We told others: learn a lesson from our village.*

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Most of the landowners (127 out of 135 households) reported having irrigated land along the riverbank. This land of the village had become barren downstream of the power project due to the diversion of river water for power generation. In Chani village, families lived for six months near the river and farmed there and then moved up to higher elevation lands and lived and farmed there for six months. Now they must live up in the higher elevations year-round.

A reduction in the number and depth of pools in the river has caused fish populations to diminish, affecting male fishermen primarily and their household food and income security. A fisherman farmer from Chani village explained that fishing has been harmed by the Agunda–Thati hydropower project. He decried that:

> *I have seen three varieties of fish in the river. We call them as machibag, machhi, gadiyal locally. One of them is red and yellow in color. Earlier we would go for fishing in the summers. In the monsoon season, we would catch fish from standing water in the paddy crop (coming up from the river). Now, since most of the water is diverted in the hydropower channel, I do not see any fish in these waters. My fellow men and I from the village do not visit the river for fishing anymore.*

Nine fishermen households from Chani village reported an average annual economic loss of over Rs. 10,000 due to the fact that there are almost no fish in the river anymore due to inadequate flows in the dry season. These households attempted to intensify their agricultural production, but several factors have limited their opportunities to do so. Thus, fisherfolk are particularly vulnerable to the environmental burdens of hydropower projects, with clear social justice implications for their livelihoods and for household food security.

Wild vegetation used to grow on land along the riverbank in Chani but now it has been affected by the hydropower project construction debris and the lower volume of water in the river. This reduces the availability of proximate fodder for livestock. Since women and children (mainly girls) collect fuelwood and fodder, the intensity of women and children's fodder-collection labor has increased.

The residents of Chani realized that they were fooled and demanded that the developers should have at least abided by the signed contract. The villagers shared with us that: "our lawsuit focuses on compensation for our land, forest and water . . . How do we keep the youth here when what we have are land and water based which also has been taken away?" They contended that their skills as farmers and their farm-based livelihoods provide a strong degree of self-reliance and as a result are more respectable than urban-based menial jobs as laborers or hotel employees.

The villagers now obtain most of their food grains at subsidized rates from the ration store that is reserved for families living below the poverty level, or, for families above the poverty line, from the market. Even the hydropower project operator from the village complained about receiving low wages for his work from the developer. He is also pressured by the developer to tell the villagers not to protest otherwise he will lose his job. He thinks that the village should take over the project and he would work for them instead. Fear of retribution by developers or the government was also noted in a study of HEP projects in Sikkim state in Northeast India [37].

3.2.4. Impacts on Environmental Flows Observed in Phalenda Village, Bhilangana HEP Area

In a hamlet of Phalenda village there is a small hydel project (Bhilangana) of 22.5 MW. Villagers had protested the construction of the HEP for a long period, demanding benefits such as the construction of an access road and a school, in addition to a fair share of water for irrigation. Women and even children went to jail due to their active participation in the protests. Though the villagers here got a better share of irrigation water compared to villages affected by the Bhilangana III and Agunda–Thati projects, they reported a loss of productivity from their fields in the lowlands especially in the winter season (wheat crop) when HEP developers did not come through with a timely and adequate release of irrigation water. This community could possibly have benefitted from power generated for lift irrigation for their fields in the upland areas but due to a lack of community awareness

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no such demand was made during the protests or during the signing of the agreement between the HEP developer and the impacted residents.

Fifty to sixty houses of Phalenda, especially in the upper slopes, developed cracks in them from the blasting for the tunnel construction. Although in Phalenda there was a distribution of compensation for infrastructure-related damage, according to villagers, the distribution was not done properly and not all families got the same sum. In the words of a respondent: "the sum is not enough to get the repair work done. I had to take a loan from a neighbor to get it done". About seven springs were reported to be affected by the blasting operations, four of which were partially affected earlier by the 1991 earthquake. Only eight people from the village derived employment from the project.

The women and men in the villages have a keen understanding of the political, social, economic and environmental dynamics associated with the abstraction of natural resources from rural areas for the provision of power to urban areas. The diversion of water from the river for the hydropower project did not allow for sufficient environmental flows to sustain local livelihoods. A woman from Gawani hamlet (in Phalenda village) told us: "Food (i.e., power) is being prepared in our village but someone else is getting to eat it". In other words, their lived experiences with hydropower production have enabled them to understand the true costs of the expropriation of river water near their villages in terms of its effects on their access to water for irrigation and household use.

4. Discussion

4.1. Governance of Run-Of-The-River Hydropower

Studies conducted on the social and environmental impacts of centralized hydropower schemes in India have revealed negative gender impacts related to access and control over resources [30,38]. The risks to which women of affected communities have been exposed, through such projects, include loss of land, loss of houses, resettlement, loss of fisheries, loss of access to forests, influx of (male) workers, etc. Even the more recently commissioned Tehri (Uttarakhand) and Sardar Sarovar (Gujarat) projects seem not to have learned lessons from the past experiences of Bhakra–Nangal (Himachal Pradesh) and Hirakud (Odisha) dams [39–43]. This situation is not restricted to India, as the report of the World Commission on Dams [44] (p. 114) highlights how large hydropower projects all over the world have "*widened gender disparities either by imposing a disproportionate share of social costs on women or through an inequitable allocation of the benefits generated*". There have been no strategic efforts by the developers, either private or governmental, to involve women right from the planning process. A recent gender analysis of renewable energy projects in India states that there has been a "*lack of gender mainstreaming in the energy sector and a lack of understanding of how to incorporate gender concerns in a sector that has primarily been technology-driven*" [45] (p. 93). In other words, within the water–energy–food nexus, women's roles are not recognized even though they are the principal agricultural producers in rural communities in Uttarakhand.

Hydropower projects are also subjected to risks and damage from natural disasters including earthquakes and floods. The disastrous Koyna earthquake of 10 December 1967, is often attributed to reservoir-induced seismicity [46,47]. Questions are often raised about the earthquake resistance ability of the Tehri dam, the tallest dam in India, which has been built in a seismic zone [48]. The 2013 floods of Uttarakhand have highlighted that the design of most of the 24 existing and under construction hydropower projects in the Upper Ganges basin have not accounted for events such as cloud bursts, suffering not only damage but also aggravating the proportion of the disaster [49,50]. This has further raised concerns over the viability of such projects, especially in the context of a changing climate. Thus, one can argue that there are hardly any examples of centralized hydropower schemes in India that have been informed by more progressive gender and risk-based impact assessment.

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4.2. Benefits Sharing

The concept of benefits sharing in hydropower projects has evolved over time, starting from a notion that local communities would derive trickle down benefits of hydropower development initiated by a regional or national entity and then encompassing compensation to local communities for harm done to their property or livelihoods. Currently, though, as Shrestha et al. (2016) explain, there is greater potential for local communities to gain "*less conflict and greater voice as well as greater ecosystems services*" because "*benefit sharing is increasingly defined as going beyond the mitigation of project impacts and beyond compliance to a situation where the local affected population directly benefits from the project.*" [51] (p. 7). A benefits' sharing partnership enables the local population to have an equity stake in the project and to strive for more socially just project outcomes for villagers. Hydropower developers in the Indian Himalayan region need to be encouraged to invest in livelihood enhancing activities of local villages. According to hydropower developers in the study area in Uttarakhand, they allocate 1 per cent of project costs towards a local area development fund (LADF). Similarly, 3 per cent of generated power is to be given to the concerned Panchayti Raj Institutions of the impacted villages. However, discussions with local communities and members of Panchayati Raj Institutions (PRIs) revealed multiple discrepancies between such policy measures, signed agreements and ground realities (fieldwork, 2015). Village communities in the study area are largely unaware of such policies and contributions made to PRIs. This calls for revisions in institutional mechanisms and ensuring transparency in the process. It also requires enforcement of rules and legislation.

It is worthwhile to mention here that the neighboring country of Nepal is moving toward a new electricity act that would mandate that ten per cent of the shares of the hydropower project would go to the impacted local community, with the smallest bids considered first in a market-based bid allocation system [51,52]. Private companies are creating public companies to distribute shares in hydropower projects. Chilime, a 22.1 MW hydropower project in Nepal, distributed shares to the affected local people in 2010 for the first time in the history of Nepal. Since then, other ROR hydropower projects have also allocated 10% shares to affected communities [51] (p. 16). This is particularly salient in the context of the continued expansion of hydropower in Nepal, where the government has been actively promoting hydropower in order to reduce the country's power load shedding to zero. Nevertheless, the April 2015 earthquake had serious impacts on hydropower facilities and infrastructure of all kinds. With the urgent need for urban housing and commercial reconstruction, however, these delays in hydropower expansion may provide the opportunity to enhance integrated governance, including benefit sharing [51].

4.3. Decentralization

Decentralized Distributed Generation (DDG) through community managed small hydro projects can be a suitable method for the provision of electricity to the forest fringe and scattered villages in the Indian Himalayan region [53,54]. Operation and maintenance of these projects can be undertaken by the local community after formal training. Such projects have a short gestation period with minimum environmental impacts. In the mountain state of Uttarakhand, the Uttarakhand Renewable Energy Development Agency (UREDA) is a state agency, established in 2001 as a registered society under the Department of Alternate Energy, Government of Uttarakhand. Its primary purpose is to promote the development of renewable energy resources in Uttarakhand. It has constructed 44 off-grid and on-grid micro-hydel projects with a total installed capacity of 4.29 MW. Another 19 projects (2.315 MW) are under construction [18]. The off-grid projects are managed by committees of the beneficiary villages. These projects are meant for electricity generation for feeding into the central grid or for local domestic household consumption, in cases where they are not already electrified by the central grid. Small hydropower schemes with lower head can incorporate fish ladders, for example, that can protect fish migration routes and thus livelihoods derived from fishing.

Jansamarth, a Delhi-based voluntary organization with the goal of promoting local livelihoods, has helped in the installation of 17 micro-hydro power projects in the two Himalayan states of Jammu

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and Kashmir and Uttarakhand. One such example is that of a community-managed 50 KW capacity hydropower plant established in 2006 in Agunda village located in Balganga valley of the Bhilangana study area in Uttarakhand [52]. This multipurpose hydropower unit mechanically powers an oil press, rice huller and flourmill, creating livelihood opportunities for the village community consisting of 65 families. The same water is used to irrigate 6–7 hectares of land. The villagers are proud owners of the project, because they put in the labor for its construction and because it is now operated by trained community members. An older man from this village stated: "This project is ours—we brought it here. While we are living we won't allow any other project".

River basins can be glacial or spring-fed. The performance and life of hydropower projects located in the basins of spring-fed rivers depend on sustained discharge of springs contributing to the river flows. Over the last two decades a substantial decrease in spring discharge has been reported to be affecting flows in spring-fed rivers in the Himalayas [55,56]. This is mostly due to environmental degradation caused in the catchments of the springs due to anthropogenic activities and more recently due to climate change. Spring-shed development can help revive springs. Sustained flows are essential to sustain hydropower projects, especially those with a smaller capacity and those run by spring-fed rivers. Spring development therefore needs to be incorporated into hydropower planning in Himalayan states. Springshed development involves hydro-geological mapping, delineation of the concerned aquifer, seasonal monitoring of spring discharge, identifying the potential recharge area, formation and capacity building of spring user group, planning and implementation of treatment measures in the recharge area with community's participation, and subsequent monitoring and impact assessment. Treatment measures include a combination of tree plantation, staggered trenches, brush wood check dams, etc. which reduce surface run off and increase infiltration leading to spring recharge [57].

People's Science Institute (PSI), a research and development organization based in Dehradun in Uttarakhand, together with other non-governmental organizations such as WWF-India, ACWADAM-Pune, and Arghyam–Bangaluru, assisted the government of the state of Sikkim in the eastern Himalayas in India to successfully launch the Dhara Vikas (Springs Development) initiative in 2008. This spring-shed development initiative was launched under the centrally sponsored Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme, covering a total area of 400 hectares and resulting in an annual groundwater recharge of 900 million·L. The scheme led to the revival of five lakes and fifty springs. PSI is in dialogue with Uttarakhand and other Himalayan states concerning similar initiatives to link hydropower with livelihoods, taking into special consideration ecosystems and climate change.

4.4. Planning for a Basin with Decentralized and Centralized Distributed Generation Solutions

Decentralized power projects cater to energy requirements that transcend local needs. However, these projects have their own limitations in terms of accessibility (high cost of transmission lines and maintenance) and quality (reduced supply hours and poor load), especially in remote areas as evident in the Himalayan region of India. In such cases, there is a clear need for integrating decentralized projects with centralized schemes. This would result in a more cost effective delivery of power in addition to a decrease in undesirable environmental and social impacts. Apart from the above, such decentralized projects could open up new and enhance existing economic activities as demonstrated by the small-scale, community-based hydropower projects established by Jan Samarth in India. Integration of centralized and decentralized projects would involve (1) proper estimation of energy requirements at the basin level and even beyond considering different sectorial needs such as household lighting, potable and irrigation water supply, health and sanitation, education, communication and economic activities; (2) identification of vulnerable areas within the basin which cannot be reached by centralized supply; (3) identification of alternative energy sources which could be owned and run by vulnerable communities; (4) participation of local communities especially women in the planning/decision-making of centralized solutions to minimize detrimental effects and ensure access to natural resources; (5) strengthening of local institutions (such as *panchayats* i.e.,

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local governance bodies) for ensuring just flow and sharing of benefits for affected communities; and (6) robust institutional mechanisms at various levels within the basin involving various stakeholders to monitor and evaluate benefit sharing activities in the impacted areas. This also calls for the establishment of a grievance redressal mechanism for negotiated settlements of disputes benefiting local communities as well as developers. Thus, integration of centralized and decentralized power schemes needs "adaptive, multilevel, and collaborative institutional arrangements" [58] that are decentralized and account for local conditions [59].

5. Conclusions

Multipurpose, run-of-the-river hydropower development can contribute to a healthier water–energy–food nexus in the Himalayas. However, at present, the benefits are skewed in favor of urban populations and hydropower developers. The study, based on a social justice approach, illuminated imbalances in decision-making power between these urban interests and rural villagers who are dependent on agriculture and from whom river water has been expropriated. Mountain communities are caretakers of ecosystem services. Run-of-the-river hydropower, especially larger projects, has been causing environmental harm (albeit less harm than large dams) that in turn has gendered livelihood impacts. A social justice approach and the inclusion of the exact words of villagers interviewed shed light on the desires of local populations with respect to hydropower projects and the areas where social equity in hydropower governance could be enhanced. Rural populations desire local hydropower for livelihood activities, irrigation benefits, household chores and the education of children. Locally controlled, smaller HEP projects in Uttarakhand have enabled rural peoples to be prime decision-makers in the control over power generation and water allocations.

Where the HEP project will negatively impact environmental flows for agriculture and fishing, fuelwood and fodder, and will damage village infrastructure, populations in Uttarakhand are demanding compensation and, increasingly, benefits sharing. Women are strong actors in these protest movements. This is largely due to the fact that women bear an unequal burden within their rural communities when irrigation and household water, land, and forest resources are reduced due to hydropower, climate and land intensification-induced changes. Rural men and youth are migrating to urban areas at a higher rate than before, partly because of diminished income from agriculture and livestock rearing due to HEP impacts; this migration is adding to urban energy demand and adding to rural women's work. These HEP impacts on labor reduce rural food production; they thus also exact a cost for the central government in terms of increased urban demand for services such as energy, and declining rural food production at a time when it is necessary to feed growing urban populations. Perhaps, if more women were involved at the global level in renewable energy issues, these regional water–energy–food nexus challenges could be addressed. At present, at the global scale in energy governance institutions, only 4% of the top World Energy Council (WEC) chair positions are women and only 18% of the secretary positions in WEC are women [60].

Participatory governance and clear guidelines and mechanisms for benefits sharing are essential at the local, basin, and transboundary scales. Following the example of neighboring country Nepal, higher rates for benefit sharing between hydropower developers and local communities near the hydropower project could be instituted and enforced to ensure greater equity. State and federal governments could play a role in mandating, through legal instruments, more equitable benefit sharing between the community and hydropower developers that would be enforced by lower courts. If disaster impact assessments were mandated as part of environmental impact assessments carried out by the Ministry of Environment, Forests and Climate Change, disaster could be redefined to include the negative effects found in the villages in this study of the Bhilangana river basin. Such assessments would ideally contain a greater emphasis on gender-related assessments to avoid both greater workloads for women and girls and negative impacts on household food security and income.

These measures would also translate into a better balance between meeting the needs of rural and urban populations. Springshed development has shown promise in other regions in India and could help prevent some of the harm to water sources for irrigation and household use for riparian communities in Uttarakhand. Small hydropower schemes, built and operated by local populations and that meet hydropower generation and irrigation needs, can reduce the negative impacts and increase the benefits of hydropower for rural communities, as can a combination of decentralized and centralized schemes.

Future research needs include an examination of how local, state and central governments can support the local management of hydropower schemes and how springshed development and other initiatives shown to be successful in one area can be adapted by communities in other states to meet their needs. Other research topics that need to be studied include analyses of hydropower–agriculture tradeoffs and an examination of HEP effects on female and male youth's labor-related decision-making to gain a clearer vision of future scenarios for these rural communities and possible policy responses.

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Abbreviations

The following abbreviations are used in this manuscript:

DPR	detailed project report
EIA	environmental impact assessment
HEP	hydroelectric project
LADF	local area development fund
MMD	*Mahila Mangal Dal* (women's village welfare groups)
NIDM	National Institute of Disaster Management
PRI	Panchayati Raj Institution
ROR	Run-of-the-river
YMD	*Yuvak Mangal Dal* (youth welfare groups)

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ENVIRONMENTAL IMPACT ASSESSMENT OF HYDROELECTRIC POWER PLANT

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ABSTRACT

This paper attempts to assess the environmental impacts due to Hydropower projects development in Indian Himalayan state, Uttarakhand.

Forest clearance for hydroelectricity development is the major issue for environmental degradation. Uttarakhand alone accounts for 5391.17 Ha of forest area diversion for Hydro projects since 1980 to June 2013. Beside this, land cover and land use change degrade environment of mountain region like Uttarakhand at a faster rate.

Keeping in view of the economic development of the nation and to meet the energy need, India has to increase the generation of electricity. The challenge is to produce required power in a sustainable manner.

Hydropower project has some advantages and positive impacts as it is a clean source of power with almost "no cost" of resources, improves living standards, generates employment and creation of reservoir, multifunctional in nature, can be used for irrigation, flood control, drinking water, supply sufficient electricity at the pick demand season etc.

Despite of some positive impacts, it has significant adverse impacts in many folds such as reduce forest carbon stock (above and below ground) and carbon sequestration, increasing in temperature, decrease in rainfall, alter rainfall pattern, forest fire, glacial melt, disastrous flood, decrease agricultural production, reduce water security and so on.

Hydro is renewable but electricity generation from hydropower projects might not renewable. Most of the environmental impacts are negative, long-term, irreversible or permanent in nature.

Uttarakhand has Renewable Energy (RE) potential of 16800 MW. Solar, 1708 MW. SHP and 534MW. Wind @80m hub height as on 31-03-2016. There is a scope for off-grid/on-grid and rooftop solar

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with the good sunshine hour and wind power with moderate wind speed @80 m hub height in the ridge.

Research & analysis based on historical/statistical data, physical observation and communication with local household, came to a conclusion as, to meet the upcoming electricity demand and at the same time, to overcome these adverse situations or to minimize the further adverse environmental impacts, we may stop the activities related to development of hydropower project and replace it with Renewable Energy sources like solar and wind energy with no or very negligible environmental impact.

Keyword: Power scenario, Hydro energy potential, RE potential, Forest clearance and deforestation, Environmental impacts, Wildlife, Health, Alternative sources.

INTRODUCTION

ENERGY SCENARIO OF INDIA: The economic growth of a country is inextricably linked to and driven by energy either in the form of finite resources such as coal, oil and gas or from non-conventional sources such as hydropower, wind, solar and biomass. Electricity generated from energy is one of the basic constituents for the economic growth of a country.

In the country like India, our future is fully dependent upon equitable access to energy. It is mainly due to rapid growth and improved efficiencies in the agricultural sector to increase the supply of food leads to population growth, improvements in manufacturing with a rapid growth in the automobile sector, mining, road & transport, airport & port, healthcare and education with the advancement of science and technology etc.

India is accounting for 3.4% of global energy consumption and energy demand grows at an average of 3.6% per annum over the last 30 years and ranks as world's 6th. largest in terms of both an energy consumer and power generation. (http://indianpowersector.com/home/about/)

The country is presently facing energy crisis as the demand for electricity has always been more than the supply. More than 40% household that has lack of electricity and around 400 million people have zero access electricity (India's looming power crisis, Feb 19, 2016, The Economic Times, Thermal). India's power demand is likely to soar more than 300 GW if the country continues to 8% economic growth in the next10 years and by 2031- 32 (By Mc Kinsey & Co. Powering India, The Road to 2017), and needs to increase its primary energy supply by three to four times and its electricity generation by five to six times of the 2003-04 levels (India's looming power crisis, Feb 19, 2016, The Economic Times, Thermal).

To minimize supply lag or power supply deficit, the dependence on imported fuels are on the rise to increase the primary energy supply sources. Table (1) shows the import of coal, oil and petroleum and the growth rate in 2014-15 over 2013-14 are tabulated below--

Fuels Import (in MT) in India

	2005-06	2013-14	2014-15	Growth Rate in 2014-15 over 2013-14
Coal	38.59	166.86	212.10	28.05 %
Oil	99.41	189.24	189.43	0.10 %

Table: 1

Energy Potential of India: *India is presently focused on non-conventional sources (mostly on Hydro, Solar & Wind), more emphasizes on RE (Renewable Energy) to generate electricity and to become a part against GHG (Green House Gas) and Global warming.*

India uses 83% of its water withdrawal for agriculture as compared to the global average of 69%. About 5% water used for drinking and balance for industrial and ecological purpose.[1]

Hydropower Potential: India is blessed with an immense hydroelectric potential to the tune of 148 GW, which will be able to meet a demand of 84 GW at 60% power load factor (PLF)[2]

RE Potential: The total potential for renewable power generation in the country as on 31.03.16 is estimated at 1198856 MW. This includes wind power potential of 102788 MW (8.57%) at 80m hub height, wind power potential of 302235 MW (25.21%) at 100 m hub height, SHP (small-hydro power) potential of 19749 MW (1.65%), Biomass power of 17,538 MW (1.46%), 5000 MW (0.42%) from bagasse-based cogeneration in sugar mills, 2556 MW (0.21%) from waste to energy and solar power potential of 748990 MW (62.48%) assuming 3% wasteland is made available.[3]

Energy Potential of Uttarakhand: Uttarakhand has a high potential for renewable energy. Uttarakhand is going to develop as an 'energy state' and it is growing at rapid pace.

Hydropower Potential: Uttarakhand of Indian Himalaya has a hydropower potential of the order of 27,000 MW(Table:2)[4] *against which only about 3,942MW has only been able to harness (in operation)so far through 45 hydropower projects of different capacities in the central and private sector.*[5]

Potential of Hydropower: Installed Capacities Of HEPs In Uttarakhand
(Commissioned, Under Construction and Under Consideration)

Sl. No.	Project Status	Micro-Mini			Small	Medium	Large	Total MW
		≤ 1 MW	> 1 ≤ 2 MW	> 2 < 5 MW	≥ 5 < 25 MW	≥ 25 < 100 MW	≥ 100 MW	
1	Commissioned	11.96 (54)	7.15 (5)	31.3 (9)	121.6 (9)	246.15 (5)	3206 (10)	3624.16 (92)
2	Under Construction	2.78 (15)	3.5 (2)	20.4 (5)	76.5 (8)	175 (2)	3014 (6)	3292.18 (38)
3	Under Consideration	22.28 (59)	34.75 (19)	108.25 (30)	1390.05 (106)	2429.8 (66)	16138 (40)	20123.13 (320)
Total		37.02 (128)	45.4 (26)	159.95 (44)	1588.1 (123)	2850.9 (73)	2235.8 (56)	27039.4 (450)

Table: 2.

Source: iCED Jaipur-July, 2015. Under Consideration (Awaiting Clearance & Survey and Investigation stage)

RE Potential: *As per Energy Statistics 2017 (www.mospi.gov.in), Source wise, estimated the potential of Solar energy in Uttarakhand is 16800 MW followed by Small Hydro Power (SHP)1708 MW, Wind power @80m of 534MW (Fig:1), Biomass Power 24 MW and Waste to Energy of 5 MW.*

Fig: 1

Policy (Uttarakhand): Uttarakhand is richly endowed with natural renewable resources for generating electricity. Most of this could be harnessed through the environmentally clean Medium & Large Hydroelectric Projects (i.e. projects with capacity in excess of 25 MW); it is estimated that a capacity of more than 20,000 MW is yet to be tapped through these sources. In addition, the State has significant Renewable Energy (RE) Sources that includes sites for developing Micro (up to 100 KW), Mini (100KW-5 MW) & Small (5-25 MW) Hydropower projects) as well as sources for generating electricity through Biomass/Agro residue, Wind power, Solar energy, Cogeneration etc. This policy aims at expeditiously harnessing these sources of energy that are non- polluting and are useful for electrification of isolated and remote habitations in Uttarakhand. It is felt that more than 1,000 MW electrical powers could be tapped through these sources before 2020.

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Policy Objective: To create conditions conducive to Private Sector/Community participation in power projects based on RE Sources in the State. In particular,

1. To harness the environment-friendly RE resources and enhance their contribution to the socio-economic development of the State.
2. To meet and supplement minimum rural energy needs through sustainable RE projects.
3. To provide decentralized energy supply to agriculture, industry, commercial and household sector.
4. To improve the quality of grid power through such projects, as a consequence of tail-end generation and feeding.
5. To enhance the use of energy sources that assist in mitigating environmental pollution.
6. To support efforts for developing, demonstrating and commercializing new and emerging technologies in the RE sector and, to this end, help establish linkages with national and international institutions for active collaboration.
7. To create conditions conducive to the involvement of private investors in RE projects.
8. To create public awareness and involve users/local community along with their capacity building in establishing, operating and managing RE projects.
9. To create direct and indirect employment opportunities in the State.[8]

***Impacts of Hydropower*:** Indian rivers carry more than 2/3rd. of their annual flow during three monsoon months. We are wasting this huge amount of water flowing continuously which can be converted to energy. Thus, Hydropower source is one of the best forms of energy security and can control flood as well as drought.

Clean & efficient Source of Power: India has the huge opportunity to optimally harness the hydropower potential towards energy security and green growth.

Hydropower is the most efficient means to convert energy into electricity. It can be developed over a wide range of scales, from kW to GW Typically 85%-95% of water energy can be converted into electricity. For others. it is 15%-20% for PV solar, 35%- 45% for wind, and 30%-45% for coal.[6]

Small hydro plants (up to 25MW) have least environmental impacts or most environments friendly. Environmental impact of SHP (small hydropower) is 300 times lower than with lignite, 250 times less than with coal, 125 times lower than with uranium and 50 times less than with natural gas for per kWh of electricity production and it is ideally suited for rural electrification especially in remote areas.[2]

Immune to the variation in the cost of fossil fuels like oil, coal and natural gas, the hydropower is most suitable and clean source for the generation of electricity.

Cost of Resources & Improvement of the Living standard: The cost of this (hydro) renewable source is almost "no cost". It does not consume resources or there is no net loss of resources (river water) in compare with power generation from other conventional sources of energy. Electricity generation by utilizing hydropower may reduce the environmental cost. The generation cost is inflation free and may reduce over time.[2]

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Being located in remote regions, hydropower installation leads to develop remote and backward areas with respect to education, medical, road communication and is significant for the rural electrification especially located in difficult terrain thus improve human development index (HDI).

Employment generation: The result from the analysis (A case study by Prof. Andreas Loschel, Heidelberg University) shows the employment generation creates as Direct (including initial effect), Indirect and Induced effects.

In the construction phase, 25 % of the total employment growth is due to the initial effect. 15 % of overall job creation occurs in the directly related supply sectors, 13 % result from further indirect effects due to intermediate linkages and 47 % of the total annual increase in employment during the construction phase of the hydropower plant is induced by the additional income. The initial effect mainly creates employment in the manufacturing industry, whereas the induced income effect increases demand for consumer goods.

The study estimates that approximately 30,000 jobs per year during the six-year construction phase (Table: 3) and around 2,530 jobs during the operational phase (Table: 4) are created over the useful life of the plant.

Employment Effect Per Year During Construction Phase

	Highly Qualified	Medium-skilled worker	Un-skilled worker	TOTAL
Service Sector	1563	3132	2910	7605
Manufacturing Sector	638	3009	6321	9968
Agriculture Sector	242	2902	9443	12587
Total	2443	9043	18674	30160

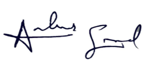
Table: 3. Source: KFW Position paper, January 2013

Employment Effect Per Year Over The Useful Life Of The Plant

Initial effect	First round effect	Indirect effect	Induced effect	TOTAL
420	450	450	1210	2530

Table: 4. Source: KFW Position paper, January 2013

Creation of Reservoir and its multifunctional nature: Dams and reservoirs are designed to last over hundred years. While in contrast, another type of energy sources has no such long life. Reservoir- based hydroelectric projects are sustainable, multifunctional in nature thus economically lucrative. Large impoundment of water due to damming of the river can be used for irrigation, flood control, drinking water and can supply sufficient electricity at the pick demand season. Soil nutrients and soil quality are increased and improved adjacent to the large reservoir. With the increase of both temperature and humidity, the organic carbon turnover into the soil is more thus improve the quality of soil resulting an increase in crop yield.[7777]



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OBJECTIVE

a) The objectives of this study are to assess the adverse environmental change in terms of increasing temperature, humidity and less seasonal rainfall which leads to climate change.

b) Also to guess the economic loss in terms of less agriculture, loss of asset, effects on wildlife and increase of harmful diseases which can take human lives.

ENVIRONMENTAL IMPACT ASSESSMENT

RESEARCH METHODOLOGY

Study Area: Tehri Dam Region and Dehradun.

Study Period: November 2016 and October 2017.

Method of Data collection: The methodology of this study initially based on the adverse environmental impact and risk for HEP development through extensive literature review and field visit for confirmation of those risk factors and impact assessment.

Primary data collected during numerous field visit and through some personal interviews in random sampling basis (which includes the people either some way related to hydro projects or among the affected due to the projects) with the help of some pre-selected, semi-structured questioner (which covers the time frame right from pre construction phase to post commissioning of hydropower projects) was used as a tool for further confirmation of these adverse impacts and gathering information on climate change and environmental aspects like weather change (temperature, rainfall etc), forest cut and tree felling, land slide, agriculture, wildlife, pollution, health, economic development etc.

During the study, a number of individuals from government and private sources which include- Hydro Power Project construction companies like THDC Ltd. etc, Meteorological department, State Electricity Authority, State Pollution Control Board etc. were contacted for their inputs and views.

The secondary data collected through extensive literature/article and document reviews, historical and statistical data.

Analysis: Compiled all the key information from collected primary and secondary data, then analyzed the acquired data and interpreted to conclude as a simplified presentation.

LITERATURE SURVEY

The article '*Energy and Employment: Case Study Hydropower in India by Dr Henrike Koschel, January 2013*'describes and evaluates the methodology and results of the induced (gross) employment effects created by the construction and operation phase, but not the long-term effects of an improved electricity supply taking into account all direct, indirect and income-induced effects.

Article "OCEANS AND AQUATIC ECOSYSTEM, Vol. I- Environmental and Social Impacts of Reservoirs: Issues and Mitigation" by J.Manatunge. et all", -- aim this paper to discuss environmental and social impacts of dam construction and how mistake from the past can be rectified for better implementation of HE projects. Acknowledging the benefits, the author(s) discussed details of the negative impacts too, in order that these adversities are lessened and dam construction can be utilized as a positive development objective without hampering the well-being of the society, environment, and their interrelations.

"Environmental hazards of dams and reservoir" by Walter et. all Wildi Institute and University of Geneva, CP 416, CH-1290Versoix, Switzerland" --This chapter briefly reviews a large range of potential impacts and hazards linked to the exploitation of dams and reservoir.

The Paper "Uttarakhand Disaster and Land Use Policy Changes by Genta Nakano et. all, Chapter 13,December 2017, DOI: 10.1007/978-4-431-56442-3_13" emphasizes on unplanned constructions, encroachments, and blockade of surface drainage that are observed to pose a serious threat to the stability of the hill slopes and suggests, Land use/land cover change studies can help in better developmental planning and in keeping identified vulnerable areas, particularly in the proximity of rivers and in the recharge zone of water bodies, free from human intervention.

The article "Damming rivers in the tectonically resurgent Uttarakhand Himalaya ***b****y K. S. Valdiya (Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore 560 064, India) CURRENT SCIENCE, VOL.106, NO. 1658 12, 25 JUNE 2014"---describes as*--A very large number of big and small dams are being constructed and planned in Uttarakhand at seismically and tectonically active belts which recurrently ravaged by excessive rains and resultant landslides. The author suggests that, if the idea is to have environment-friendly power projects, then the planners and dam builders must not ignore the geological reality of the geodynamical sensitive region. Better sites for dams can be explored far upstream of the Main Central Thrust Zone and The well-being and socio-economic security of the people should be the overriding consideration, not the cost.

"RESEARCH ARTICLE: MICROBIAL BIODIVERSITY OF TRIBUTARIES OF RIVER GANGA IN UTTARAKHAND by Nidhi Singh et. all, Department of Microbiology, Himalayan University, Naharlagun, Itanagar, Arunachal Pradesh. International Journal of Recent Scientific Research Vol. 6, Issue, 10, pp. 6888-6891, October 2015."-- During the study through bacteriological analysis of six bacteria, they observed that the average values showed that three species i.e. Escherichia coli, Enterobacteraerogenes, Staphylococcus were found to be dominating in river Alaknanda than the river Bhagirathi at Devprayag. All samples were positive for E. coli, which indicates faecal pollution of water and exceeding the standard limit.

A leading scholar Harsh K.Gupta on his topic *"Earthquakes Caused by Dams: 'Reservoir-Triggered/Induced Seismicity' 2002"*defines the earthquakes occurring in the vicinity of artificial water reservoirs as a consequence of impoundment. The author describes the consequences related to impoundment in detail.

"Land Use / Land cover change detection in Doon valley (Dehradun Tehsil),Uttarakhand: Using GIS & Remote Sensing technique by Tiwari Kuldeep , Khanduri Kamlesh"--The aims of this study are to detect land use changes between 2000 to 2009 using satellite images and to produce a land use/land cover map of Dehradun valley in order to detect the changes that have taken place particularly in the built up land and forest areas and finally to predict the changes in urban habitats and land use/land cover changes occurred.

"Slow onset events, Technical paper, United Nation, FCCC/TP/2012/7, 26 November 2012". The objective of this technical paper is to generate a knowledge base on approaches to address loss and damage associated with slow onset events in developing countries that are particularly vulnerable to the adverse effects of climate change due to hydropower development.

In the paper "Dams, Rivers & People VOL 10 ISSUE 3-4-5, APRIL MAY JUNE 2012"---the study focused on several impacts on environment and livelihood in connection with dam building on river and like to emphasize the need for understanding and protecting and restoring the Systems using existing govt schemes can be made to restore the invaluable traditional systems with low-cost.

*"Thermal Pollution Caused by Hydropower Plants. Chapter 2, By Alaeddin Bobat. Springer International Publishing Switzerland 2015 A.N. Bilge et al. (eds.), Energy Systems and Management, Springer Proceedings in Energy, DOI 10.1007/978-3-319-16024-5_2"—the study shows that the t*hermal pollution is the change in the water temperatures of lakes, rivers, and oceans caused by man-made structures. These temperature changes may adversely affect aquatic ecosystems especially by contributing to the decline of wildlife populations and habitat destruction. Any practice that affects the equilibrium of an aquatic environment may alter the temperature of that environment and subsequently cause thermal pollution. This paper aimed to reveal the causes and results of thermal pollution and measures to be taken in HPPs.

In this article "Hydropower Generation and River Water Pollution in India by Shweta Agrawal 2Swati Singh Sikarwar. INTERNATIONAL JOURNAL OF APPLIED RESEARCH AND TECHNOLOGY. ISSN 2519-5115 IJART-Vol-1, Issue-2, December 2016" the author discussed as Hydropower dam operations are responsible for the extinction and near-extinction of a number of species, and are a major contributor to the significant loss of aquatic biodiversity. Hydropower dams are a significant source of water pollution caused by altering the temperature and harming the biological integrity of river ecosystems. The cumulative impacts of multiple hydropower dams are often much greater than the simple sum of their direct impacts.

Govt. initiation/intervention through regulation, execution, monitoring and awareness is an essential part to control the pollution and to protect the natural environment.

ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT PLAN FOR JELAM TAMAK H.E.PROJECT UTTARAKHAND. Prepared for: THDC India Limited. CENTRE FOR INTER-DISCIPLINARY STUDIES OF MOUNTAIN & HILL ENVIRONMENT UNIVERSITY OF DELHI, DELHI. EXECUTIVE SUMMARY, JUNE, 2012" –Jhelam Tamak H.E. Project is proposed to tap hydropower potential of Dhauliganga between Jhelam and Tamak villages. The main objective of the present study is to carry out the Comprehensive Environmental Impact Assessment (EIA) for the proposed Jhelam Tamak HE project and based on the impacts, to prepare various mitigative plans and also to meet the Environmental clearance criteria of Ministry of Environment and Forests (MoEF), Government of India.

"Article Re-Linking Governance of Energy with Livelihoods and Irrigation in Uttarakhand, India Stephanie Buechler, Debashish Sen, Neha et. all, 2016, 8, 437; DOI: 10.3390/w8100437. www.mdpi.com/journal/water" –The author(s) on the Bhilangana river basin, where water dependent livelihoods differentiated by gender include farming, fishing, livestock rearing and fodder collection. We examine the contradictions inherent in hydropower governance based on the interests of local residents and other stakeholders including hydropower developers, urban and other regional electricity users, and state-level policymakers. We use a social justice approach applied to hydropower projects to examine some of the negative impacts, especially by location and gender, of these projects on local communities and then identify strategies that can safeguard or enhance livelihoods of women, youth, and men in areas with hydropower projects, while also maintaining critical ecosystem services. By assessing the Bhilangana basin case, we also offer hydropower–livelihoods–irrigation nexus lessons for headwater regions across the Himalayas and globally.

PHYSIOGRAPHIC

Uttaranchal, presently known as Uttarakhand came into existence on 9^{th} November 2000 as an Indian Himalayan state, which was carved out of a mountainous north-west region of Uttar Pradesh. The state lies between Longitude $77^{\circ}34' 27''$ to $81^{\circ}02' 22''$ E and Latitude $28°53' 24''$ to $31^{\circ} 27' 50''$ N. It stretches across an area of 53,485 km^2 with 13 districts and it is bordered by the Indian state of Himachal Pradesh to the north-west, Tibet Autonomous Region of China to the north-east, Nepal to the south-east, the Indian state of Uttar Pradesh to the south & south-west and a tiny segment of the Indian state of Haryana to the west. Out of 13 districts, 9 districts are mountainous and the substantial portions of remaining 4 southern districts are plain. There are two administrative divisions: The Kumaon and The Garhwal regions. The total population of the state is 10,116,752(Census of India, 2011). Primarily, it is a rural state with 69.5% of the people living in around 15, 761 villages located mostly in the mountain districts.[9]

Major peaks- Nanda Devi (25,646 ft. asl) the highest peak of Uttarakhand, Mount Kamet (25,446 ft. asl) the 2^{nd}. Highest peak of India, Abi Gamen, Mukut Parvat, Chaukhamba, Trishul, Kedarnath, Neelkanth, Shivling, Nilgiri and Bandarpoonch etc.

Major Rivers- Ganga, Yamuna, Bhagirathi, Alakananda, Kosi, Mandakini, Pindar and Saryu

Major Glacier- Maiktoli Glacier, Kaphini Glacier, Ralam Glacier,, Sunderdhunga Glacier, Chorabali Glacier, Gangotri Glacier, Khatling Glacier and Nandadevi Glacier.

The mountains, rivers and forests also provide a habitat for rare and threatened species of both plants and animals.

Uttarakhand is a part of Western Himalayan physiographic division and the state divided into five transverse zones:

i) *The Trans Himalaya:* To the north of the snow- clad ridges.

ii) *The Inner (Great) Himalaya:* The north zone of the MCT including permanently snow-clad Peaks at
height ranging up to just below 8000 m.

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iii) *The Middle (lesser) Himalaya:* Between the MBF and MCT (Main Central Thrust) with Ridges at high as about 3000 m.

iv) *The Doons:* Between the Main Boundary Fault (MBF) and the Shivalik (Outer Himalaya)

v) *The Terai:* South of the Himalayan Frontal Fault.

Uttarakhand is the birthplace of two major rivers the Ganges and the Yamuna, These Rivers and their tributaries provide the vast opportunities for hydropower generation.[12]

SOIL

In Uttarakhand, the northern hills support forests and southern faces are generally naked. Thus the soil in this state is mountainous forest soil and is divided into five types. These are a) Quartzite soil. b) Volcanic soil. c) Brown or grey soil. d) Alluvial soil and e) Tertiary soil.

But, the above soil quality gets negatively affected in various ways due to hydropower development in the hilly terrain. There are two main impacts of dams and reservoirs on soil quality.

Firstly, salinisation may occur in arid conditions in relation to irrigation, mainly due to the maintenance of a high groundwater level when evaporation and evapotranspiration are strong.

Secondly, contamination of soil in the floodplain by reworked contaminated reservoir sediments during floods may be expected. This mechanism is linked to the accumulation of contaminants in reservoirs.[11]

Development of multiple hydro projects and damming on river within a short river stretch are one of the major responsible factors of climate change which alters rainfall pattern during monsoon, contributes to increased run-off resulting into soil and river bank erosion in hilly terrain of Uttarakhand and increase of sediments in the river bed turning the river shallow and reducing their water carrying capacities[10] and it may further enhance the soil erosion in the catchment area.[12]

Shrubs are suitable for soil conservation and it acts as a resistance to high wind velocity and can be used for bio-fencing. Some shrubs, by fixing nitrogen, increase soil fertility. Massive deforestation for Hydropower project development and afforestation by pine trees destroys the shrub’s growth which further initiates soil erosion, reduces soil fertility and increases the intensity of forest fire to some extent which further initiates soil erosion.

The reservoirs are the causes of the suspended particles to settle into it thus it limits the flow of sediments downstream, which hampers agricultural activities on floodplains due to limited nutrient-rich sediments. [9]

SEISMICITY

Uttarakhand is known as a multi-hazard-prone state. The Indian plate is moving toward the northeast with the convergence rate of 55 mm per year.[13] The region is under seismically and tectonically active belts and recurrently ravaged by excessive rains, resultant landslides[14]. As per earthquake zoning map of India, the entire State can be divided into two zones, Zone V and Zone IV. The State has experienced many earthquakes of small and large scale with their epicentres located within the Himalayan region

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There are four districts (Pithoragarh, Chamoli, Bageshwar and Rudraprayag) of the thirteen of the state fall completely in Zone V, Five other districts (Uttarkashi, Tehri-Garhwal, Pauri, Almora and Champawat) fall partially in Zone V and partially in Zone IV and the rest four districts (Dehradun, Hardwar, Nainital and Udham Singh Nagar) fall totally in Zone IV of the seismic risk map of India.[10]

Between the period July 1720 to January 2009, there are around 3052 earthquake occurred in and around Alaknanda and Bhagirathi Basin within the magnitude 1.1 to 8.0.[16](Fig: 2)

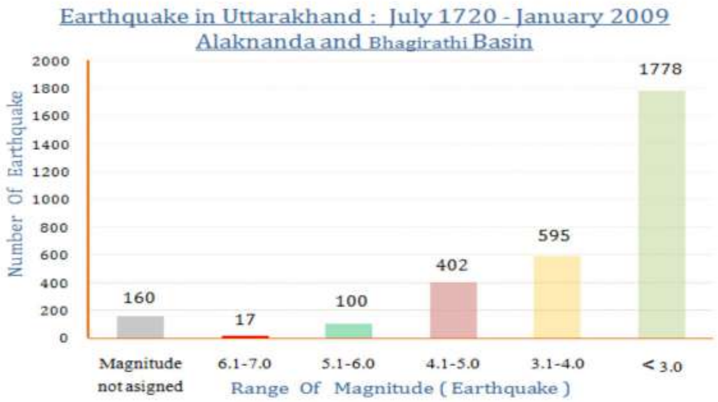

Fig: 2

Damming on Himalayan River and Seismicity:

Alaknanda and Bhagirathi river valley are affected by several tectonic features and has a potential of high/moderate magnitude of earthquake. It has been observed that around the hydro power project sites in those valleys that are highly earthquakes prone ($M \geq 6$) which generates from the potential Seismo-genic sources.[16] (Table: 5)

Hydro power Project	Projects On the River	Location District/Village Or Town	Seismicity		
			Seismic Zone	Seismo-genic Source	Observed M_{max} (M=Magnitude)
Kotlibhil IA	Bhagirathi	Tehri Garhwal/Muneth	IV	MBT & NAT	7.0 -
Bowala Nandprayag	Alaknanda	Chamoli/Bowala	IV	MCT, MBT & Martoli Thrust	7.0 -
Bhairon-Ghati	Bhagirathi	Uttarkashi/Bhatwari	IV	MCT & Kaurik Fault System	8.0
Pala Maneri	Bhagirathi	Uttarkashi/Maneri	IV	MCT.	7.5 -
Tapovan-Vishnugad	Dhauliganga	Chamoli/Tapovan	V	MCT, MBT, Alaknanda Fault & Indus Suture Zone.	7.5
Koteshwar	Bhagirathi	Tehri Garhwal/Tehri	IV	MBT & NAT.	7.0 -
Tehri	Bhagirathi	Tehri Garhwal/Tehri	IV	MBT & NAT. Lies between MBF & MCT	7.0

Table: 5

Reservoir triggered seismicity (RTS): Artificial water reservoir triggered earthquake has grouped into two categories: a) Rapid Response category and b) Delayed Response category. The tectonic loading on the active fault due to local seismicity coupled with the reservoir loading and unloading may generate earthquake and cause additional seismic risk in this

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critically stressed region.[20] It has been seen, around Tehri, in the year 1995 there were 229 local events which are maximum during this period and the year 2005 shows minimum around 76 local events which were significant. (Fig: 3)[17]

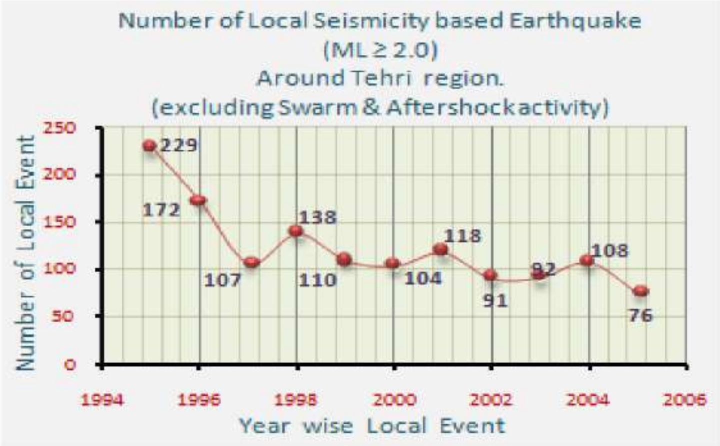

Fig: 3

Reservoirs can increase the frequency of earthquakes in areas with a previously low occurrence of the seismic activity.[18] In recent past, during the period 2012 to April 2017(< 6 years period), it has been observed that there are 74 earthquakes occurred in the Uttarakhand region with the magnitude ranges $2.5 \leq M \leq 5.8$ as per record of Indian Meteorological Department (IMD). Table: 6

UTTARAKHAND Districts & India(Uttarakhand)-Nepal Border	2012	2013	2014	2015	2016	2017 (Till 10 th April)	**TOTAL**	Magnitude (Range) ≤ M ≤
Chamoli	3		1	6	2	2	14	3.2 ≤ M ≤ 5.1
Uttarkashi	2	5	1		5	2	15	2.5 ≤ M ≤ 4.8
Bageshwar	1	1	1				3	2.6 ≤ M ≤ 4.1
Pauri	1						1	M = 3.6
Pithoragarh		2	3	3	5		13	2.7 ≤ M ≤ 4.8
Rudraprayag		2	2		1	6	11	3.2 ≤ M ≤ 5.8
Dehradun		1			4		5	3.0 ≤ M ≤ 3.9
India-Nepal Border	1	2	1	1	2		7	2.8 ≤ M ≤ 5.2
Almora-Pithoragarh Border					1		1	M = 3.2
DNS(Districts not specified)		1		3			4	3.2 ≤ M ≤ 4.3
TOTAL	8	14	9	13	20	10	74	

Table: 6

The seismicity is likely to be more widespread and deeper for a large reservoir than for a smaller one. The depth of the water column and the reservoir volume are two important factors that control the triggered earthquakes.[19]

LAND USE & LAND COVER CHANGE

The main drivers of the land use/cover change are economic development, population dynamics and climate change resulting of environmental changes which further change the livelihoods of the mountain people and increases environmental vulnerabilities.

Hydro project development – Land Use, Land Cover Change and Its Implications: The Union Ministry of Environment and Forests (MoEF) estimates that almost 45,000 ha of forestland have been diverted to non-forest uses in Uttarakhand since 1980 (www.downtoearth.org). Around 40% of this forest area has been converted to HEPs, transmission lines and for road construction (Fig: 4). It is around 30,000 ha of forests have been diverted to non-forest use in Uttarakhand since the formation of the state. [13, 21].

Fig: 4

LCLUC for the development of hydro projects leads to several environmental problems such as deforestation, soil erosion, water pollution etc. Water pollution is increased due to increased use of fertilizer in agriculture to meet the upcoming demand as well as the decrease in cultivable land, municipal solid waste and sewage etc. More intensive agricultural practices are vulnerable to soil erosion/loss of soil. Soil erosion and water run-off reduce soil nutrients/fertility, destabilizing mountain slopes and contributing to more intense and frequent landslides and floods. [23]

Massive hydroelectricity generation plants installation and other related development further accelerate natural phenomena which in turn drive changes that would impact the natural ecosystem. Increasing density of build-up area is found in Uttarkashi Tehri, Hardwar, Dehradun (Fig: 5) etc. with the considerable increase in settlements. One of the major reasons for the increase in built-up area in Hardwar and Dehradun is rehabilitation for hydro projects.[22]

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Fig: 5

These environmental impacts are irreversible or which is beyond mitigation.

FLORISTICS & FOREST TYPES

The recorded forest area of Uttarakhand is 34,520 km.^{2} which are 64.54% of the state's geographical area. The total forest area is divided into three parts (by status) namely, the Reserved Forests (71.1%), Protected Forests (28.5%) and Un-classed Forests (0.4%). Most villages also have smaller forests within their boundaries.

There are four major forest types are observed in the state Uttarakhand:

a) *Tropical Moist Deciduous Forest:* Mainly found in the sub-Himalaya terai-bhabar belt.
b) *Subtropical Pine Forests:* These forests are found at lower elevations of the lesser Himalayan belt.
c) *Moist Himalayan Temperate Forests:* They occur at elevations between1600m and 2900m.
d) *Sub-Alpine and Alpine Forests:* Exist at altitudes of 2900 to 3500 m. The tree line is about 3200m.Temperate and tropical grasslands exist inside forest areas.

The dominant species in this region are Sal (*Shorea robusta*), Khair *(Acacia catechu)*, Sheesham *(Dalbergia sissoo*,. chir pine *(Pinus roxburghii)*, Oak (banj, *Quercus leucotricophora)*, Rhododendron (burans, *Rhododendron arboreum)*, Cedars (deodars, *Cedrusdeodara*), Blue pine (kail, *Pinus wallichiana)*, Fir(*Abies spectabilis)*, silver fir*(Abies pindrow)*, junipers *(Juniperus squamata, Juniperus indica) etc.*

Consequences of deforestation due to development of Hydropower projects: Forest clearance or forest area diversion in the Himalayas to develop hydro projects has increased the severity of floods during the rainy season and reduced stream flows and dried up springs during dry seasons and responsible for local climate change.

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Increases Temperature: It disrupts watershed processes, including the infiltration of precipitation into soils. Intensify the hydrologic cycle, causing dry regions to become drier and wet regions to become wetter. The temperature variation[10] changes the microclimate increases the intensity of snow avalanches and accelerates melting of the snow and glaciers at high altitudes at a faster rate which impacts on water security.

Alter Rainfall pattern: During periods of limited rainfall, soil gets dried and heavier rainfall results in greater and more rapid runoff, thereby increasing flooding and nutrient loss, resulting in reduced food production. [24] Change in rainfall pattern reduced stream flows and dried up springs during dry seasons.

Decreasing Carbon stock & Carbon sequestration rate: Massive deforestation and fragmentation of forest decrease above ground, below ground & soil carbon stock and carbon sequestration rate decreases due to a reduced number of trees due to nation's development like the development of hydro projects.

WATER ENVIRONMENT: AQUATIC ECOLOGY & FISHERIES

Impacts of HEP on River Water Environment: One of the main reasons of pollution, started from upper reaches of the rivers in Uttarakhand is the development of hydroelectric projects[27]resulting disturbance of ecosystem and loss of marine life.

Variation in discharge (or velocity) from the reservoir decrease DO (Dissolved Oxygen), may affect water quality by altering the self-purification capacity of the river[28] which is indifferent, permanent and irreversible in nature.

Turbidity increases due to suspended solids from construction and Eutrophication by sediment, nutrient leaching and fertilizer residues [29] which affect the river water quality and river ecology.

Construction of reservoir and tunnels changes the hydrological balance due to evaporation loss from the reservoir and drying or low flow through entire stretches from reservoir/ tank to powerhouse. [29]

Disappearance or dry up of original flows are visible over the entire stretch due to one after other projects are building upon the same river.[30]

A different set of dynamics begin impacting species that traditionally grow, nest, feed, or spawn in these areas due to inundation of the dam.[31]

Changing water levels and a lack of streamside vegetation can also lead to increased erosion. Increases in erosion can also increase the amount of sedimentation behind a dam. [31]

Impacts of HEP on Aquatic biodiversity & Fisheries: Hydro Electric Projects often have major effects on fish and other aquatic life. The net impacts are often negative because the dam blocks upriver fish migrations and the downriver passage through turbines or over Spillways is often unsuccessful. Alteration of river flow hampers critical life events like phenology of reproduction, spawning behaviour, larval survival, growth patterns, affects aquatic food chain and impacts on the structure, distribution and composition of fish communities in the region.

Change in environmental flow is one of the major causes of habitat fragmentation. There are three kinds of adverse impacts on the aquatic biodiversity are expected because of changes in

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the natural flow due to HEPs in the Alaknanda and Bhagirathi Basin: (a) Stagnated water in the submersible zones of HEPs which are not conducive for snow trout and Himalayan loaches, (b) Less or no water flow in the dry zones of HEPs affects adversely on the aquatic biodiversity. (c) Changes in the natural flow impair the aquatic biodiversity to breed or maintain annual life histories.

Submergence of rivers would act as nutrient traps. Changes in the nutrient flow would adversely affect the downstream fishes and would affect the overall composition of the fish community.

Dam or any construction across rivers is always a barrier especially for the migratory fishes and affects the breeding cycle leads to disappearance or decline of major migratory fish species.

Deforestation increases siltation of the river and increased turbidity thus deteriorates water quality. Even a few centimetres of sediment layer over the natural substrate is enough to affect the foraging and spawning fishes negatively.[32]

Hydropower development may alter the temperature of water environment and subsequently cause thermal pollution. It changes its ambient temperature. As the temperature of water increases, dissolved oxygen contenting in water decreases. If the water temperature rises by 1–2°C, some species may be eliminated entirely since the metabolism requires oxygen (O_2). It also affects the feeding and spawning of fish, increase Algae growth and kills plants thereby disrupting the web of life dependent on the aquatic food chain. [33, 34]

FLORA & FAUNA

Many of the hydropower projects in Bhagirathi and Alaknanda basins are entirely or partially inside Gangotri National Park, Kedarnath Wildlife Sanctuary and Nandadevi wildlife Sanctuary, Valley of Flowers, National Park (both UNESCO World Heritage sites of Outstanding Universal Values). They will threaten 16 globally threatened fish species, 5 rare and endangered mammals (including Snow Leopard, Brown Bear, and Mouse Deer), 5 rare and endangered bird species, and 55 rare and endangered plant species, over 300 medicinal plants and hundreds of plants which are used by locals in varied ways. These are among the known damages. There are likely to be other unknown collateral damages.[30]

HEPs are usually located in the presence of a range of ecosystems including mountains, grasslands, subtropical and temperate broadleaf forests, mixed coniferous forests and alpine meadows.[29] Riverine system changes the biological and ecological conditions of rivers and alteration occurs in the floral and faunal characteristics near the dammed site. [37]

The hydro project construction would require the acquisition of forestland. All the vegetation on the land of the large area to be cleared off for construction of project component. In addition, there is a potential impact of tree cutting by the migratory labour force that would have fuelwood requirement and timber requirement for heating, furniture etc. [38]

AIR POLLUTION

During hydro project development, air pollution occurs mainly due to excavation activities, massive vehicular movement and operation of project machinery and equipment in the construction phase.

Construction works of roads, burning of fuel woods and increased vehicular movement are main agents of air pollution levels of SPM, NO_x and SO_2.

The process of excavation, tunnelling, quarrying, dumping and transportation of muck and road construction would increase the level of SPM in many folds and it might increase to 400 – 500 $\mu g/m^3$ during the construction phase. The significant increase in the vehicular movement and operation of a large number of types of equipment and machine would increase the level of NO_x, SO_x and CO in the surrounding area. The main sources of SO_2, CO are burning of fuels such as oils, coal and fuelwood used by the construction labour.

Hydropower projects associated with large reservoir/dam in the tropical region have been implicated in large greenhouse gas (CO_2 and CH_4) emissions largely from decaying organic matter due to impoundment of large forest area leads to air pollution along with other major environmental impacts.[38,29,41,42,43]

WATER POLLUTION

The spillage of muck generated from construction work is mostly disposed off along the river bank which will lead to water pollution. Sewage from workers colony/construction camp during peak construction period can lead to serious water pollution.

The intermediate river length between barrage and powerhouse become dry or running with low flow throughout the year which impacts on the water quality adversely thus alter the aquatic ecology and change the fish habitat altogether.

Enrichment of impounded water with organic and inorganic nutrients with the decomposition of vegetative matter and phytoplankton productivity will be the main water quality problem immediately upon commencement of the operation. [38]

NOISE POLLUTION

Majority of the environmental impacts attributed to construction works of hydro projects and it extends into several years. Even though the impacts due to construction are temporary in nature, they could be significant due to the nature and intensity of the impacts.

Increasing movement of heavy vehicles (trucks, dumpers etc.) to transport construction material along with vehicles (jeeps etc.) for the movement of manpower in that area, operation of construction machinery and equipment, operation of DG (Diesel Generator) set for electricity requirement, blasting operations for tunnelling and quarrying through explosive and crushing to have small aggregate during construction phase and high noise & vibration for the running of turbine during operation phase generates noise pollution and pose a significant impacts on population nearby, workers inside the power house and wildlife in the area.[38]

IMPACTS ON AGRICULTURE & HORTICULTURE

Hydropower development is occurring on rivers where irrigation, livestock rearing, and other natural resource-based activities are already stretched in their ability to meet local resident's livelihood needs as 89% of the state is mountainous and 53% is severe to very severe erosion prone zone. Deforestation and heavy felling of trees for construction dams in this region extending the situation resulting further loss of agricultural land and irrigation water and restricts agricultural productivity.

The damming on river changes the hydrological balance. The up-stream elevates the surrounding groundwater level leading to salinisation and marshland and at the same time reduces the source of groundwater recharge in the lower reaches of the dam base, affecting gravity condition, which makes the adverse effects on irrigation.

Blasting on slop to divert river water through tunnel, quarrying, road construction are the cause of the disappearance of an irrigated channel as many of the springs are become dried. Indiscriminate muck disposal disrupts irrigation channel and irrigated land along the riverbank downstream become barren due to the diversion of river water. All these affect agriculture thus reduce agricultural production.

Hydropower projects require deforestation which affects horticulture by accentuating flood and drought events and destabilizing soil. It also attributes air pollution, decreased precipitation, water percolation and lack of moisture in the soil and fugitive dust from blasting operation impairs photosynthesis process which affects rich horticulture, reduce agricultural crop and fodder production in entire area due to non-availability of horticultural & agricultural essential imputes. [43,46,47]

IMPACTS ON HEALTH

The vectors of various diseases breed in shallow areas thus, there would be an increase in the potential breeding sites for various disease especially mosquitoes who can fly up to 1 to 2km from the breeding site, transmit malaria to the major habitat reside within 2 km from the dam site up to an elevation of 2000m asl.[42]

Water-related Diseases arises mainly due to changes in water quality, eutrophication, weed growth and the increase in areas of stagnant water on the proliferation of insects or other vectors of water-related human and livestock diseases. There is a risk of introduction of new pathogens and disease vectors which may transmit from local carriers to immigrant labour and staff and vice-versa.[29]

Wastewater generation from natural activities of human and other hydro project construction activities increases pathogens such as bacteria, viruses and parasites, reduce self-purifying capacity significantly, the cause of different infectious diseases like diarrhoea etc.[50]

Fugitive emission and dust from loose muck due to crushing operation and muck disposal increases SPM level which creates serious health hazards and photo-retardation among the local population.[49]

Psychological trauma to people and animals has been observed due to the repeated blasts and for other noise pollution during construction of the projects. Older persons and children are mostly affected.

FOREST FIRE

Fire is a common feature in the forests of Uttarakhand especially in between 1000 m to 1800 m mostly covered by Chir-Pine forest.

In recent past, on Feb. 2016, around 1890.79 hectares of green cover in this region have been destroyed by forest fire. The worst- affected districts were Chamoli, Pauri, Rudraprayag, Tehri, Uttarkashi, Pithoragarh, Almora and Nainital. Generally, the frequency of forest fires is 2-5 years, while 11% of forests of the region experience fire every year.

Implications of the forest fire: Almost all the fires are man caused. Development of multi hydropower projects and other related infrastructure are one of the major causes of the forest fire. The contributing factors are:

A) Massive deforestation reduces the soil moisture, alters the normal rainfall pattern, reduce rainfall and excessive water withdrawal cause draught. Alteration of seasonal rainfall pattern and significantly increased temperature may further aggravate forest fire events in the region.

B) Blasting for tunnelling, road building etc. leads to drying of water sources, depleting topsoil moisture and reduced the living grasses and shrubs (which resists and control the wind flow) in the forests resulting dryness and provides an ideal ground to develop more intense fire.

C) Choice of pine tree species instead of broadleaf or broadleaf mixed forest for afforestation or plantation increases the intensity of forest fire as the pine trees and pine needles are highly fired prone.

D) The indirect effect of forest fires are the loss of soil fertility, soil erosion, loss of employment, drying up of water resources and loss of biodiversity. These fires forms black carbon shoot after burning, spread over the extended area, increase warming by absorbing heat and restricting reflection and finally changes microclimate of that region significantly in the form of soil moisture balance, increased evaporation, increased probabilities of snow/glacial melt.[39, 40, 22 35, 20]

NON BIODEGRADABLE WASTE

Solid waste disposal: Littering of solid waste like biodegradable as well as non-biodegradable on hill slopes generated by hundreds of workers, officers and technical staff during construction of HEPs, creates serious land and groundwater pollution.

Hazardous and biomedical waste disposal: Hazardous wastes are generating during construction phase from machinery and equipment using fuel, lubricating oil, batteries, etc. Empty oil drums, used oil, maintenance/cleaning clothes, used batteries, transformer oil etc. Biomedical Waste are generating from the dispensaries set up to take care of workers medical needs.[38]

After commissioning of HEP, the site becoming a tourist spot. Trekkers and tourist population at these locations becoming more and more. A huge amount of non-biodegradable waste like plastic cups, plates bottle and glasses, juice can, wafer wrapper and polythene bags etc. are disposed of at the surrounding mountain area at an alarming rate and wreaking havoc with and is posing a big threat to the fragile ecosystem.

Plastic and other non-bio-degradable waste absorb heat, which along with global warming, raises the overall temperature in the local mountain region, melting glaciers and creating glacial lakes thus posing the threat of glacial lake outburst flood in the future. [36]

WATER CONSERVATION

Though some of India's most important rivers originate here, the water conservation remains a burning issue in Uttarakhand. A large number of natural springs that dotted the hillside have been damaged and dried up due to the cutting and bursting of slopes for road construction, tunnelling for dam construction, Quarrying operation for aggregate acquisition or other unplanned activities. These have adversely affected the underground water table at many places and pose an adverse impact on water security.[25]

IMPACTS ON PAs & WILDLIFE

As per Ministry of Environment & Forests, Lucknow, 80,826.91 ha of forests have been diverted to non-forest use in Uttarakhand since 1980. The diversion for hydropower production is 5312.11 ha. Most of the diversion for roads and hydropower projects development. Additional forest land is lost for transmission lines.

As per record, we observed that most of the commissioned and proposed HEPs are either located inside the protected area (PAs) or in the buffer zone of the Nanda Devi Biosphere, Askot Musk Deer Sanctuary, Kedarnath Musk Deer Sanctuary etc. and many others are in or around the protected area.

The areas are the home for a large number of rare, endangered and endemic plant, bird and animal species including snow leopard, musk deer, Asiatic black bear, cheer pheasant and the blue sheep and so on. The loss of plants will disrupt the food chain for birds, small animals, deer and bear among other animals. The habitats of the larger animals will be fragmented while birds and small animals may lose their nests and holes.

The life cycle of HEPs has significant impacts on forests and terrestrial biodiversity. During pre-construction phase land required for quarrying, construction of access roads, housing colonies, project offices, stores and equipment warehouses and disposal of debris and muck leads to deforestation. Reserved forests and village forests are both affected by cutting thousands of trees during road construction and to meet the fuelwood needs of the labourers which are far beyond the officially sanctioned limit. Additionally, more trees are damaged or destroyed by rolling down the large boulders and debris through the mountain slopes during road construction. The overburden of muck disposal affects Shrubs and undergrowth. Air pollution from various operations and dust blown from the dumping grounds reduces photosynthesis activity of vegetation in the surrounding areas and hence decreases the biomass productivity thus affects biodiversity value. Hydropower project development in these protected areas can fragment and destroy wildlife habitats significantly.[26]

WILDLIFE AND ILLEGAL WILDLIFE TRADE

As per WII assessment, 2012, Out of 70 HEPs, 17 are commissioned, 14 are under construction and remaining 39 HEPs have been proposed in Bhagirathi and Alaknanda basins. It includes loss of large area of forest land and submergence due to the creation of the reservoir. (Table: 7)

HEPs Status with No.	Total Loss of Land (ha)	Loss of Forest Land (ha)	Land Under Submergence (ha)
Commissioned: 17	7126.46	2705.04	4421.42
Under construction : 14	539.59	442.36	97.23
Proposed: 39	1828.64	467.86	1360.78

Table: 7

Loss or Extinction of Wildlife species: Deforestation in connection with HEP development creates a negative impact on wildlife and wildlife habitat. It leads to the direct elimination of crucial habitats for terrestrial species. It also adversely affects the faunal species residing in these areas and which are dependent on the floral species of these regions which were lost due to project development.

Due to impoundment to create a reservoir, all terrestrial animals disappear from the submerged areas and populations decrease within a few years in proportion to the habitat area that is lost. Drying of long river stretches due to the creation of dam and diversion of the river also has negative impacts on terrestrial biodiversity and might affect the occupancy of the nearby areas by the terrestrial species due to water scarcity leading to degradation of habitat quality and affects as migration.[27] By building dams on rivers may permanently alter river systems and wildlife habitats [44]

Corridor effect: Deforestation or loss of forest land leads to a destruction of vital animal/plant corridors which ultimately effects migration and gene dispersal. Dam acts as a barrier to terrestrial animal movement and plant dispersal, particularly reduction of the riparian zone as a migration corridor. Large reservoirs may also disrupt natural migration corridors. The Dhauli Ganga sub-basin encompasses critical habitats and corridors for large mammals such as snow leopard, brown bear and Tibetan wolf.

Corridors, connecting Protecting Areas (PAs), upper reaches of the Dhauliganga sub-basin mainly Mallari and Tamak form an extremely rugged, wind-swept and frost-bitten cold desert habitat presenting a unique ecosystem. Snow leopard and Himalayan brown bear are heavily reliant on such marginal habitats making these as critical habitats. Additionally, the brown bear's easternmost distribution ends in this region.

Impact of Proposed HEPs: Out of 39 proposed HEPs, 16 would to loss of forest land either for land intake or will be under submergence. Of the 16 HEPs, 7 are located in areas that are >2.500m which are the home of wildlife habitats for many RET species and also includes critically important areas for these species. These seven HEPs that have been proposed would result in a loss of about 172.48 ha of land that includes 146.34 ha as forest land take and 26.14 ha under submergence.[32]

As the proposed barrage site and upstream area have been identified as corridors of wildlife. The project activities may affect them adversely especially breeding activities. Thus the likely impacts on the wildlife are negative, permanent, local and irreversible.

Disturbance of Wildlife: The operation of various construction equipment and blasting is likely to generate noise and the increased human interference may disturb wild animal population and may lead to marginal adverse impact.

Illegal Wildlife Trade: Many Hydropower projects are located either within 10 km from wildlife park/protected areas, in the core area or inside the protected area or in the buffer zone which are home for the snow leopard, brown bear, musk deer and many other threatened species. Due to these project activities, the forests area is fragmented and the wildlife movement in this area increases the risk of poaching. During the construction phase, the hydropower projects and approach road heightened the risk of poaching of wild animals for consumption and for trading through smugglers, thus increases the illegal wildlife trade. This impact further increases due to aggregation of labour population.[42,29]

These HEPs would directly as well as indirectly impact upon the remnant wildlife habitats and consequently the species, particularly the snow leopard, brown bear and musk deer. Hydropower development in these basins will significantly alter the habitats of these species of very high conservation importance.[32]

We are already experiencing loss and extinction of wildlife species due massive HEPs (Commissioned & Under construction) in Alaknanda and Bhagirathi basin of Uttarakhand. If all the 39 proposed HEPs will complete, it would further gift us the more severe impact on our environment with respect to wildlife habitat degradation thus adversely affects on ecological balance.

RESULT & DISCUSSION

After reviewed various article/document, evidence collected through field visit and documented response of the local household in the selected study area, I have seen that hydropower project developments are the main responsible factor for microclimate change in Uttarakhand, India and in turn pose a valuable contribution on global climate change.

Large forest area submergence for the formation of reservoir, fragmentation of forest, forest cut, alteration of river flow, drying of river bed or springs along with springs use as irrigation channel, land cover/land use change and continuous landslides as a direct and indirect effect including other dam building activities are the major responsible factors for the adverse impacts of increase in temperature, decrease in rainfall, alteration of rainfall pattern, decrease/disappearance of fish and wildlife population including RET species, reduction in agricultural production in various ways (includes loss of agricultural land, soil nutrients and irrigation facilities), reduced water security, adverse impacts on health of wildlife species and humans, infrastructural damages etc. These are effects in both ways either short term but significant or irreversible and long-term.

Considering route cause of environmental degradation due to HEP development is forest clearance, for 25 proposed HEP (listed, as given in IMG report) out of 197 (21212.78 MW) proposed HEP, the calculated forest loss (considering the relation—1) Dense forest loss=0.28

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ha/MW. 2) Forest areas submerged=0.53ha/MW. 3) Forests loss due to other dam-building activities=0.59 ha/MW. 4) Non-forest land submergence, 0.67 ha/MW) [46] are placed as under. (Table: 8)

Large HEP (17): 3291 MW
Small HEP (8): 140.30 MW
} 3431.30MW(Ins Cap)

Forest Land Submerged in ha. (0.53ha/MW)	Loss Of Dense Forest in ha. (0.28 ha/MW)	Forest loss due to others Dam Building Activities in ha. (0.59 ha/MW)	**Total Forest loss In ha. (a)**	Non Forest Land Submerged In ha. (0.67 ha/MW) (b)	**Total Loss Of Land In ha (a+b)**
3431.30 x 0.53	3431.30 x 0.28	3431.30 x 0.59		3431.30 x 0.67	
1818.59	960.76	2024.47	**4803.82**	2298.97	**7102.79**

Table: 8

Already we are experiencing the forest area diversion of about 18000 ha (40% of 45000 ha) since 1980 for HEPs, transmission lines and for road construction in Uttarakhand and we have already lost a major amount of forest carbon stock. As per estimation, we may lose additional 4804 ha of the forested area by completing only 25 proposed HEP. It may increase further due to the transmission line,
rehabilitation and for other requirements related to
HEP as an indirect effect.

Project proposal includes afforestation to get the FC (forest clearance) permission along with other parameters. But it has been observed that afforestation not done as per recommendation (proportionate area, species etc.).

It may be suggested that the afforestation should start at least 6 years prior to pre-construction stage with same tree species needs to be cleared for the project and area should be 4/5 times of the deforested area to maintain the proportionate carbon sequestration rate some extent.

As per study through collected historical/statistical data related to climate change, it has found that over the last 60 years (1951-2010) the winter and post- monsoon temperature has increased 1.2°C (Fig:6) and 1.8°C respectively with the mean maximum temperature trend 0.02°C/year.(Fig:7)

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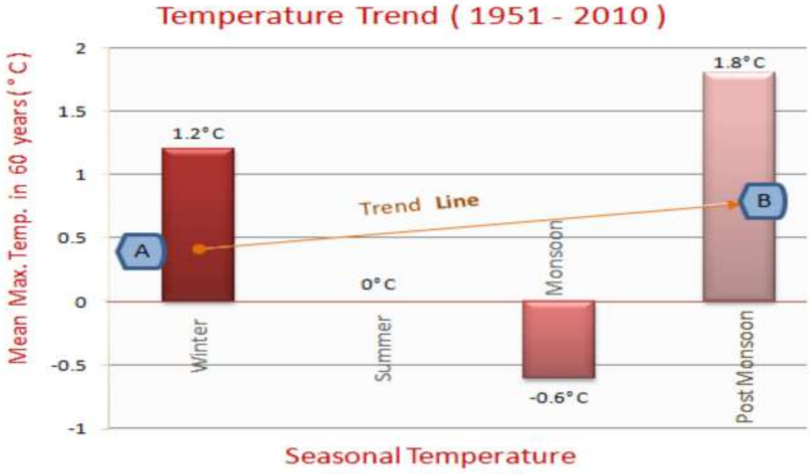

Fig: 6

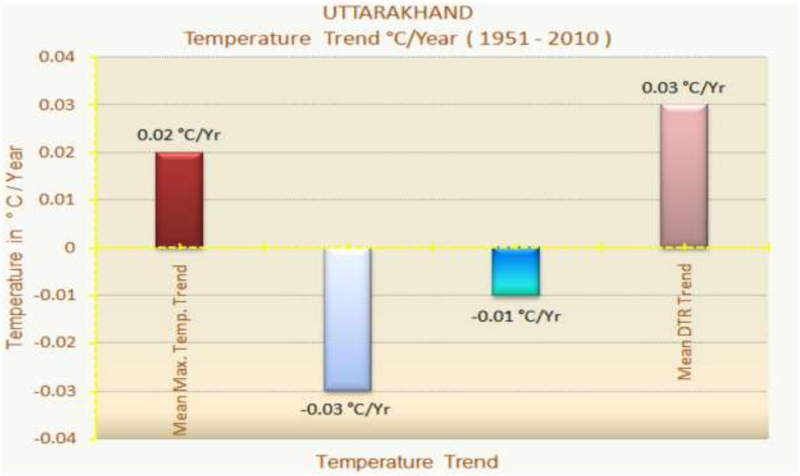

Fig: 7

A decreasing trend (1951-2010) of annual rainfall is also found, on which decrease of monsoon and post- monsoon rainfall is significant. (Fig: 8)

After analyzing the rainfall data of recent past (2001-2016), we found decreasing trend at a faster rate (Fig: 9). The remarkable change in rainfall pattern and change in seasonal rainfall has also been observed.

Forest area destruction due to hydro project coupled with the reduction of forested land due to rehabilitation, agricultural land, continuous landslide, drying of spring fed river bed in long stretch due to drying of spring etc. are one of the major responsible factors for increasing mean maximum temperature, decreasing rainfall and drastic seasonal change in temperature, humidity and rainfall.

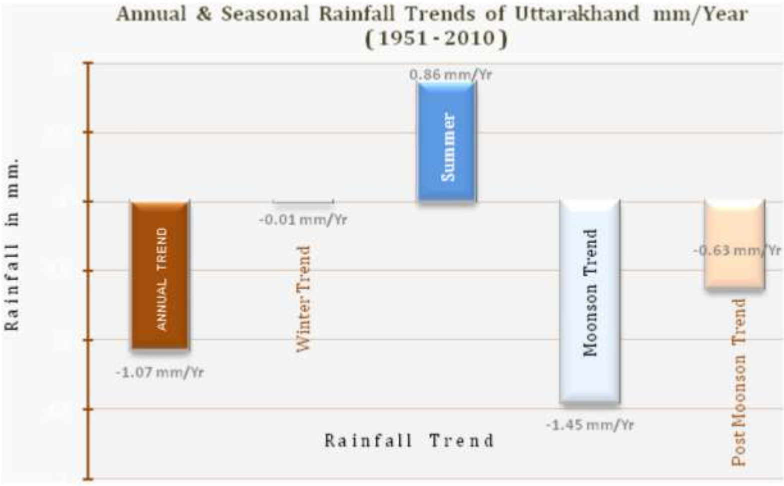

Fig: 8

Data Source for Fig: 6, 7 & 8: State Level Climate Change Trend in India, 2013. Ministry of Earth Science (IMD), GOI

Considering 100 yrs (1911-2012) rainfall data (A. Mishra, December 15, 2017), it has been observed decreasing trend in all the district of Uttarakhand except Hardwar. In five districts (Champawat, Pithoragarh, Bageshwar, Almora and Nainital), the decreasing trends are more significant. (Fig: 10)

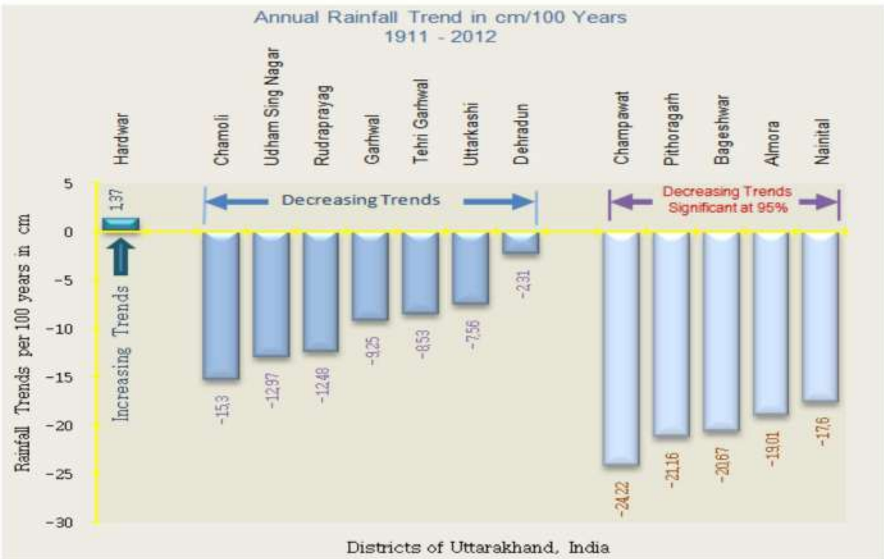

Fig: 10

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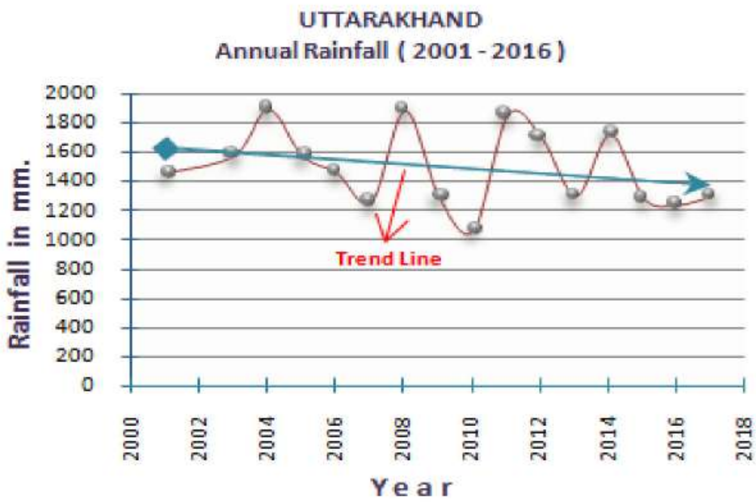

Data Source: 1. Statistical Year Book, India 2016. 2. Uttarakhand State at a glance, Vol-1(5), 2015. 3. Annual Climate Summary 2011, IMD, GOI.
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Fig: 9

If it continues with the above rate, then we may predict the temperature will rise to 2.2°C in 2060 (considering the base value of 2010) and rainfall will decrease to 115.7 mm in 2060 (considering the annual decreasing trend in rainfall from 1951). This prediction considers the other parameters stands constantly.

The environmental impacts with respect to temperature and rainfall for further development of only 25 proposed HEP(out of 197 proposed HEP), will increase and decrease further from the estimated value and it will not follow the previous trend, it might more than the above trend due to cumulative impact on environment as a result of this development.

CONCLUSION

Uttarakhand Himalaya is experiencing massive deforestation (for hydro projects) and fuelwood, fodder collection (to meet daily need of population and livestock) reduces forested area resulting the decrease in forest carbon stock and reduce CO_2 absorption. On the other hand, fuelwood burning emits CO_2. As a result, the CO_2 emission increases and CO_2 absorption (sequestration) decreases leads to microclimate change and in turn takes a part of Global warming.

Electricity generation from hydropower plants are not at all the suitable way to limit the adverse impacts on environment (includes climate change and economic loss in terms of agriculture, water security, wildlife, health etc.) at the same time to meet the power deficit or upcoming electricity demand in this region as a result of economic development.

Uttarakhand has a huge potential of solar power with the good sunshine hour and wind power with moderate wind speed in the ridge and mountain pass region. As per record, the potential is limited to 16800 MW for Solar and 534 MW for Wind power @80m hub height till date.

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Further research/study may result more solar energy potential and Wind energy @ 100m hub height.

After assessing the potential adverse impacts of HEPs in Uttarakhand for commissioned, under construction and proposed (not all listed), this paper concludes as a solution to utilize the potentially rich Renewable Energy like Solar and Wind as suitable alternative sources for electricity generation.

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Construction of Calamities in the Uttarakhand Himalaya

SHRUTI JAIN

Hydropower projects on the Uttarakhand rivers have proven to aggravate the severity of floods, making them calamitous. In addition, these projects have also increased the vulnerability of the mountain villagers towards disasters, while giving these an unsettling everydayness and a spiralling effect. Projects have evaded accountability and responsibility for such disasters by opportunistically deeming these as *devi aapda*, or natural calamities, even as the line between natural and human-made calamities has become more blurred than ever.

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"Company gaya" or "the company is gone" are the anticipative cries one hears in the videos that the villagers settled at heights could take of the "toofan," the towering surge of sludgy waters proceeding through the gorges of the Rishi Ganga river towards the Rishi Ganga Power Project. It was obvious to the villagers that the surge would take down any kind of obstruction constructed in its path. After wiping out this project in seconds, the waters barrelling through Dhauli Ganga reached and swept away the barrage of the Tapovan Vishnugad project, about 8 kilometres (km) downstream, near Joshimath town in Chamoli district of Uttarakhand. The villagers did not wish that these companies, the hydropower projects, of which there are 450 in the Uttarakhand mountains, had come near their homes in the first place. They could apprehend and have experienced that the heavy blasting by use of explosives that the companies employ for construction, large-scale deforestation, and the muck they dump by the riverbanks prove to be disastrous.

When the coming of these projects, however, was forced down upon them, many had to give up their agricultural and forestlands and were made to feel obliged for getting temporary jobs of constructing the tunnels and barrages of these projects or for other small "favours." Their lives have got inevitably tied up with these projects despite their fear of and disagreement with such an intervention, projected as development. They have turned into labourers for constructions that have literally shaken the foundations of their homes and have forced many to leave behind their homes in search of work and secure habitation. It is these very projects which also became the cause of the workers being washed away or buried under the sludge on 7 February 2021. The flood caught them unawares, with only their fellow villagers calling and whistling to alert them of the waters rushing towards them.

Such floods, irrespective of the reasons behind them, and other such occurrences that involve the natural play of snow, ice, sun, river, rain, and topography of the Himalayan region, are bound to happen. Much remains beyond predictability and only in the domain of speculations. Uncertainty is increasing due to the climate crisis, resulting in receding glaciers, altered river flows, and increased incidence of glacial lake outburst floods. The disaster prevention and minimisation systems are found wanting more often than not. In such a scenario, hydropower projects in such regions where earthquakes, landslides, heavy monsoon rains, cloudbursts, avalanches, etc, are not uncommon,[1] should not get a go-ahead.

Quite unlike their appearance, the geography of these mountains-in-the-making is fragile, as is their ecology and geology. Hydropower projects come as an onslaught on these fragile conditions. They generate as well as amplify the intensity and viciousness of disasters, not just damaging the environment in the process, but also affecting the mountain people, who have shaped their lives over the years to try and attain a balance with their surroundings.

Exacerbating Disaster Potential

The Ravi Chopra Committee (2014) that was formed under the direction of the Supreme Court to study whether the hydropower projects exacerbated the floods of June 2013, had established such a connection between the dams and worsening of floods. The massive floods in 2013 had damaged more than 24 hydropower projects in various river valleys of Uttarakhand, which intensified the destructive impact of floods on the local villages and led to the deaths of thousands. Crucially, the committee had explained how the projects getting built in the paraglacial region, that is, at elevations above 2,200–2,500 metres, of which there are 76 projects of more than

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3,100 megawatt (MW) capacity in Uttarakhand, are more dangerous.

The paraglacial zones are sediment hotspots that remain in a continuous process of adjusting to the changing environmental and climatic conditions, the committee report has explained. These are the zones that get formed after the receding of glaciers. In such zones, the rivers are capable of mobilising tremendous amounts of sediments from the morainic material left behind. In the situation of floods, the rivers then cause havoc in the vicinity of the hydropower projects, as was witnessed at Jaypee's Vishnuprayag project barrage site, near Joshimath, during the June 2013 disaster. Both the Rishi Ganga and National Thermal Power Corporation's (NTPC) Tapovan Vishnugad projects affected by the 2021 flood were also in the paraglacial region.

After both the floods, of 2013 and 2021, the governmental narratives around the dams focused on the damages caused to these and the way they contained the floods, rather than their damaging impacts on the local villagers and workers of the projects.[2] However, in both the calamities, it was clear that blockages in the path of such a surge and huge amounts of debris generated after the collapse of blockages compounded the severity of the flood. Rivers burst through with greater force after obstructions, preventing the flood from subsiding in the normal course after reaching wider riverbeds and gentler slopes. And it is not only one project that obstructed the flow and added to the debris, but a cascade of projects on each river.

It was, in fact, the presence of these projects that generated the calamity, as they became the reason for human casualties. Not only the project structures but also labourers' tin sheds were built by the river, as against the traditional wisdom of having human settlements away from it. Officers' townships remain at a safe distance while labourers are pushed to bear the risks without even basic systems in place, like a siren system to alert them or basic safety equipment. The projects fail to take such basic steps despite projects like that of the NTPC having suffered damages in floods of 2012 and 2013 as well.

In the case of the 2021 floods, despite the heavy machinery at hand, the tunnel or barrage sites' clearing process remained most inadequate, even as the families kept waiting for some news or remnant of bodies of their kin trapped in the sludge. It also showed the inefficiency of the project companies in addressing disaster situations, and their lack of cooperation with the relief and rescue operations. Their negligent attitude is also reflected from their failure to maintain proper records related to workers' provident funds or insurance. Such an attitude of disregard for the workers' lives and safety has also led the local leaders to demand that a criminal case be filed against them.

Compounding Vulnerabilities

Most projects, like the Rishi Ganga and Tapovan Vishnugad projects, being constructed in the Himalayan regions, are deceptively promoted as "run-of-the-river" (RoR) projects. These projects, instead of using the natural flow of the river and natural elevations as any RoR project would, use dam structures to divert the rivers in tunnels and drop it a few kilometres downstream in order to get a head to produce electricity. The riverbed stretch between the diversion dam and the powerhouse remains mostly dry, as tunnels extend from 10 km–20 km and rivers get channelised in these. The Tapovan Vishnugad project had a proposed tunnel of 12 km. The Ravi Chopra Committee report (2014: 35) notes how a series of dams every 20–25 km of each river in Uttarakhand could convert the rivers into a "series of ponds (reservoirs behind the dams) connected by pipes (tunnels)" and "lead to synergistic cumulative impacts, especially when the zone of influence of one dam overlaps with that of the neighbouring dams."

These projects' practices of blasting for construction as well as the irresponsible dumping of muck generated by the excavation of tunnels, add to the vulnerability of people and the whole region, making them more susceptible to bearing damages.[3] According to the rules, muck disposal sites are to be developed as usable terraces that are covered with fertile soil for plantation, to protect the loose soil from eroding or to enable habitat development. These rules are openly flouted and muck gets dumped by the riverbanks. Often retaining walls are not suitable. Such violations have been noted by CAG (2010) and the Ravi Chopra Committee report (2014). The latter also identifies muck disposal mismanagement as an important reason for the destruction caused in 2013. The local people also related to the author that the projects like Jaypee's Vishnuprayag project identified muck disposal sites after the calamity.[4]

The raised riverbeds, due to the huge quantities of muck, reduce the capacity of containing the increased mass of slush and sediment that the rivers in such regions inevitably carry in flash flood events, while the muck increases their destruction potential. Due to excessive use of explosives for constructing tunnels that often pass below the villages, slopes have weakened, homes have cracked and even collapsed, and fields have developed fissures or subsided. This is seen in the entire Garhwal region wherever hydropower projects are coming up. What chances will such rocks and villages, shaken to the core, have to withstand any disaster?

Further, due to blasting-induced disturbances, water springs have disappeared, and agricultural lands have lost their moisture. Fruit-bearing trees die and the milking animals stop giving milk, with the associated livelihoods getting destroyed. The wild animals due to blasting and loss of forests have started frequenting the villages. Human–animal conflicts have increased as they attack humans and destroy crops. In so many ways, these projects have pitted humans against nature. Villagers also have lost access to forests, rivers, pastures, and cremation grounds (Jain 2016). Disasters, thus, have assumed an everydayness in the villages where hydropower projects are coming up. Like their rivers, however, the carrying capacity of the people, that is, their bearing potential for any disaster has been stretched to such an extent that most express a wish to migrate away from the *pahars* (mountains).

The impacts of these hydropower projects increase manifold due to the presence of not just numerous such projects, but also other mindless construction activities like the Char Dham highway project with its similar heavy deforestation, blasting, and muck-dumping practices. Further, the impacts of such activities in mountain villages are often not immediate but are more permanent with a spiralling and cumulative effect. It may also not be immediately clear whether a land subsidence happened due to monsoon rains, or blasting done for a road or drawdown effect of a power project reservoir. While the project authorities argue that land sinks and landslides happen even in the areas where the projects are not sited, they ignore the fact that these are necessarily taking place in all the areas where projects have come up. Valdiya (2014: 1663) explains how the project sites are situated in the zones of high seismicity and close to active thrusts, and that these tend to sink due to blasting,

> The belts of active faults are made up of deformed rocks—many-times folded, sheared, shattered and even crushed rocks. These rocks understandably easily break-up, fall-off, creep and slide or slump down when excavated or shaken by earthquakes and explosions, and sink under loads. These incidences are bound to pose a threat to the various structures built in the project areas.

Due to the heavy presence of such projects in the Himalayan region and their impacts on its ecology and village life, as well as the impacts of the climate crisis, again generated by humans, the line between human-made and natural causes of calamities is much blurred. For instance, the Ravi Chopra Committee (2014: 36) report observes,

> It is speculated that when large fractions of river lengths go dry due to multiple projects on them, changes in the micro climate may occur. The temperature in the river valley may increase … In the long run it may also speed up the melting of nearby glaciers.

But the project agencies have been able to evade accountability and responsibility towards the calamities they have created, either in the form of cracked homes and disappearance of water springs or in the form of intensifying floods, by opportunistically terming these as natural calamities. The villagers have found it exceedingly difficult to establish the link between hydropower project practices and their impacts, even as this burden is put on them. In people's minds, the linkage of project construction with disasters is clear, but they are not able to hold the companies accountable, and the links become visible to the outside world only in the case of calamities like the floods of 2013 and 2021.

For instance, the villagers of Chayeen, where many homes and fields had caved in or developed fissures, related to the author how the Jaypee company deposited a sum of a mere ₹80 lakh from its corporate social responsibility (CSR) funds to the district authorities and distributed blankets to fulfil its responsibility towards them. It depicted this as a natural calamity, *devi aapda*. Many such examples are available in the case of other projects as well. Even in the case of storage dams like the Tehri dam, the impact is not just immediate submergence, but the cracks in homes, land subsidence and landslides due to the drawdown effect of the reservoir lake. By identifying damaged homes on the mountains along the rim of the reservoir as "collateral damage," the company has absolved itself of any accountability to rehabilitate them as other project affected and displaced. Compensation is provided citing devi aapda as a reason, and only to individuals, not to the village, further creating an opportunity for arbitrariness and corruption (Jain 2016). Moreover, the disaster potential of the so-called "small" projects in the mountains is also not less, as was evident in the case of the Rishi Ganga project.

'Small' Projects

The Rishi Ganga project that compounded the flood impacts in the case of the Chamoli flood, was operating on the Rishi Ganga river that joins Dhauli Ganga at Reini village, about 23–24 km upstream of Joshimath. The Dhauli Ganga joins the Alaknanda river near Joshimath. The project site near Reini village falls within the Nanda Devi National Park and its buffer zone, and is a United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage site. This region near Joshimath with the Lata and Reini villages is an important site of the Chipko movement. In fact, it is seen as the epicentre of the Chipko movement in the popular discourse, and for some time now has become the epicentre of hydropower projects.[5]

The locals of this region question how a destructive project could have been allowed there, while they are not allowed to beat their traditional drums, take away simple herbs, graze their animals, or cut grass in this region, as it has been declared a protected zone. Not only was the project allowed, but it was also allowed to undertake excessive blasting, stone crushing, tree felling, illegal mining, and reckless dumping of muck next to the riverbed. These practices continued despite the project changing three owners in the last 15 years, all three businessmen who had no experience or history of running hydro projects,[6] leave alone in such a sensitive zone. The Reini village petitioned in the high court in 2019 and also approached the National Green Tribunal (NGT) seeking the stoppage of such destructive practices, but did not get much in the way of relief (Mazoomdaar 2021).

The conservation-related regulations in this region have meant the severing of the organic link of the villagers with their environment, and curtailment of their livelihoods depending on it. Moreover, the push for such development here defeats the purpose of the conservation efforts. Eventually, many of the descendants of the Chipko movement, the symbols of ecological consciousness and conscience, have been reduced to become small-time contractors or being employed as workers for destructive projects. Battered after the 2021 disaster, the villagers are afraid to live in Reini and are demanding to be relocated.

Technically, the Rishi Ganga at 13.2 MW was a small project (less than 25 MW). Small projects, however, are but a smaller version of the large projects in Uttarakhand, with the same design of dams diverting rivers in tunnels, causing riverbeds to dry, and involving the same practices of blasting, deforestation, and muck dumping that makes them equally hazardous. Like the large "RoR" projects, they also involve excavating for diversion, main, and adit tunnels, and construction of road networks, cofferdams, diversion dams, residential structures, and powerhouses. Thus, even a small project built in this manner involves what Valdiya (2014: 1663) terms as excessive "tampering with the natural balance" in these zones of "very weakened rocks." From the projects that are getting built in Uttarakhand, neither are the large ones green, nor the small projects benign. Both "RoR" and "small" projects remain but an appropriation of the language of alternatives to create confusion and gain some legitimacy for these.

Small projects do not reflect the essence and spirit of small as visualised by the socio-environmental movements, that is, projects owned and run by the community that remain accountable for them, and whose design and functions suit and emerge from the local conditions and needs. Instead, smallness in the case of "RoR" projects has been used only as a convenient excuse for exemption by the private players from the environmental impact assessment (EIA). The draft EIA Notification, 2020 has further diluted conditions by providing that such small projects will need neither EIA, nor public consultation, alongside paving the way for them to come up within the buffer zone of the protected and eco-sensitive areas (Pradhan 2020).

Further, these projects compound the disastrous impacts of other small and large projects. The smaller mountain rivers are not more manageable or controllable, for which such projects strive. Even small rivers tend to carry with them large silt loads, constituting rocks and big boulders, which they mobilise flowing through steep slopes. In the 2013 disaster, the debris carried by the Khiron Ganga led to the destruction of the Vishnuprayag project. Similar was the story of the Asi Ganga river in Uttarkashi during the 2012 flash flood.

Tapovan Vishnugad Project

The flash flood of February 2021 destroyed the barrage of the 520 MW Tapovan Vishnugad project, getting built near Tapovan and Dhaak villages, about 14–15 km uphill from Joshimath. It flooded its tunnels with debris, where hundreds of labourers were working. The arrangements by the company of keeping a tab on the exact number of workers, alarm systems to alert them of the danger, or ensuring their safety were missing.

The NTPC, a thermal power company, has been invested in the construction of this hydropower project for more than 15 years. Its practices have remained rather irresponsible and show a lack of thoroughness in appraising the geological conditions of the region. Moreover, it has employed different private companies for different activities, like barrage construction and excavation of tunnels, enabling it to shirk off its responsibilities on to these sub-players. In the initial period, it employed the use of a tunnel boring machine (TBM), which has been stuck at one end of the tunnel since 2009. Meanwhile the company switched to excavating the tunnel from the other side. The TBM had punctured an aquifer that discharged "about 60–70 million litres daily, enough to sustain 2–3 million people" (Bisht and Rautela 2010: 1271), wasting away water that must have accumulated over years under the Auli oak forests.

Its EIA report shows how it conveniently ignored expert opinions. It has been noted therein that the Geological Survey of India (GSI) advised it to shift its site downstream after encountering hot water springs during drilling. GSI was apprehensive that hot water springs would be encountered during the driving of the tunnel. However, the company reports that it did not follow this suggestion as it would have caused loss to the project of about a hundred megaunits (MU) (National Thermal Power Corporation Ltd 2004).

Hearing a plea of the residents of Tapovan against muck mismanagement by the NTPC in 2019, the NGT directed an expert committee with the Uttarakhand Pollution Control Board (UPCB) as the nodal agency to conduct a site visit (*Gram Pradhan & Residents of Tapovan v State of Uttarakhand* 2020). The UPCB, after observing non-compliance of the actions suggested by it, fined the NTPC ₹57,96,000 on "polluter pays" principle, for violating muck disposal site maintenance norms that resulted in "severe mass erosion" and damage to the environment. This was upheld by the NGT in an order dated 18 February 2021 (*NTPC Limited v Uttarakhand Pollution Control Board* 2021).

During my doctoral fieldwork in this region in 2015 (Jain 2016), local people had related that due to the company's muck dumping practices, at places, the width of the Dhauli Ganga had decreased to one-fourth of its size. The company had devised a dubious method of evaluating the impact of blasting when met with complaints by the villagers of cracks in their homes. It pasted strips of glass at the cracks and told people that the breaking of these strips would prove if blasting had any impact on the creation of such cracks. After this exercise, never again did the company come back to check the strips, and people eventually plastered the gaps themselves.

In a few villages, women complained that milking animals gave less milk as they consumed the blasting powder on the grass and many of the pregnant animals aborted. Water springs had dried at many places after the project work started. Faced with acute water shortage, they were provided with temporary arrangements of water supply with hose pipes, which people complained was not clean. In the Dhaak Tapovan area, villagers had complained of significantly reduced yields of potato and *rajma* (kidney beans), falling to even one-fourth of the earlier yields. Valdiya (2014: 1663) explains that the tunneling procedure is like opening the underground drainage that significantly alters the groundwater regimes of the mountains. This results in "drastic lowering of groundwater table and attendant drying up of springs and dwindling of surface flow in streams." Bisht and Rautela (2010: 1271) also explain how this happens,

> sudden and large scale dewatering of the strata has the potential of initiating ground subsidence in the region … Reduced ground moisture regime would result in depleted biomass availability and crop produce … It would also impact floral and faunal diversity.

Like other projects in the area, the NTPC also ignored the concerns and opinions of the local people in the public hearing held in Joshimath. There, however, remained a strong opposition to the NTPC project in the town of Joshimath, as well as in the affected villages. The company employed many strategies to break the protests. Police cases were filed against many. The youth of many villages were initially given and then expelled from work. Gifts were distributed in the villages and to the eminent persons of Joshimath by the company to smoothen its work ways (Jain 2016).

Protesters in Joshimath banked on the Mishra Commission report, that way back in 1976 had said that the town and the surrounding villages have settled on an ancient landslide that is sinking (also reiterated by Valdiya [2014]); it is a deposit of sand and stone, not hard rock that could hardly take the pressure of the township itself. The report had recommended restrictions on heavy construction work, blasting, heavy traffic, felling of trees, and even on agriculture (Jain 2016). However, despite the geological and environmental vulnerability of the area, many hydropower projects were planned around Joshimath. The tunnel of the Tapovan Vishnugad project "traverses all through the geologically fragile area below Joshimath" (Bisht and Rautela 2010: 1271).

Deception of Development

Over the years, as the work of a hydropower company persists and proceeds, along with the protests, compromises also get materialised. Often in remote areas, project companies gain entry by promising basic amenities that the government has failed to provide, for instance, a health facility, or a stretch of road, and more importantly, promises of providing work, so that men need not migrate. However, these projects have provided neither appropriate or required employment opportunities nor electricity to the villagers. Even though the projects become operational, the feeling of fear and apprehension in this calamity-battered region and the discontent attached with their opportunist strategies to gain entry and operate in the area means that the project companies never really gain legitimacy in the area.

These projects have been pushed hard as development by the state government despite all kinds of disasters and difficulties that they have resulted in. That most paharis (mountain dwellers) wish to flee from the pahar or are forced to migrate in search of livelihoods and safe places to stay, is a deafening pronouncement of the failure of the development path taken by the state, and frustration of the aspirations behind the movement for statehood. The high rate of outmigration, the existence of thousands of "ghost" villages (Kapur 2015), and development that remains unconcerned with the local concerns and needs, and unsuitable for the locale makes one wonder if, in the long term, the mountains will stand only to showcase the technological ingenuity and development, as "sterile monuments bereft of people who trodded on them lightly" (Berreman 1983).

The hydropower projects by becoming a cause of cracks in homes, weakened slopes, and subsidence of village land, have made the pahar and paharis more vulnerable. The trauma of events like that of 2013 and 2021, and the images of damages caused to their kin and homes haunt them and it becomes difficult for them to feel at home in their villages. Monsoon months have become a nightmare for most villages as landslides and cloudbursts have become more common, especially in the Garhwal region with its numerous "RoR" projects and the Tehri dam.

When calamities like the 2021 flash floods strike, understandably the demands of scrapping projects in the sensitive Himalayan region become loud. Questions also get raised, for instance, by Bhatt (2021), on the brazen mindlessness of pushing for colossal structures like the 315 m high Pancheshwar dam on the Mahakali river in the Ganga basin. Bigger than the Tehri, this 5,040 MW dam will affect lakhs of trees as well as protected areas, as it involves impounding an area of 116 sq km in this region of high seismicity and ecological sensitivity. Such disasters-in-making ought to be stopped when it is clear that even impacts of the Tehri dam are still unfolding as the reservoir has led to destabilisation of the mountains on its rim on which hundreds of villages reside.

Calamities like the Chamoli flash floods make some dangers of hydropower projects visible to the world. But the everyday disasters that the villagers are facing ought to be accounted for as well. By stalling such projects that are taking away from people their livelihoods, water sources, the safety of homes, and rivers that are crucial for dwelling as well as letting go of their dead, a bigger disaster can be prevented in Uttarakhand. This disaster is the fear that the paharis now feel in their own homes and the erosion of their identity and sense of belongingness with the pahar.

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NOTES

1 This particular area of Chamoli district has already seen the highest magnitude flood of the last 600 years in the Alaknanda floods of 1970 (Ravi Chopra Committee 2014) and an earthquake of 6.8 on the Richter scale in 1999.

2 For instance, the union power minister who reached the site after the floods claimed that the Tapovan Vishnugad barrage mitigated the damages and work on it should start soon (*Hindustan* 2021). Similar claims were made for the Tehri dam in the 2013 floods. The chief minister in his tweet of 8 February 2021 also defended the projects by saying that such calamities should not become a reason for "propaganda against development."

3 For instance, in the 2013 floods, thousands of cubic metres of muck piled by the riverside by the Srinagar project buried the houses of Srinagar town.

4 Such observations throughout this article about project practices and impacts are made on the basis of the doctoral fieldwork conducted during 2012–15 by the author in Uttarakhand. This multisite ethnographic work included the area affected by the Tehri dam and the projects coming up on Alaknanda and Mandakini rivers, amongst others (Jain 2016).

5 The Rishi Ganga has two proposed projects, Rishiganga I (70 MW) and Rishiganga II (35 MW) in addition to the damaged project. In addition to the Tapovan Vishnugad project, the NTPC also has the proposed Lata Tapovan Project (170 MW) upstream, whose work has not progressed due to a stay by the Supreme Court. Other bumper-to-bumper proposed projects on the Dhauli Ganga upstream of the Lata Tapovan are Malari-Jhelum (114 MW), Jhelum-Tamak (126 MW) and Tamak-Lata (250 MW). The Alaknanda has many projects in different stages, with a few being the Vishnuprayag project (400 MW) near Joshimath, and the Vishnugad Pipalkoti project (444 MW) and Srinagar project (330 MW) downstream.

6 This holds true for most hydropower projects in Uttarakhand, where project companies are from backgrounds that have nothing to do with hydropower. Further, project trading like this absolves the seller company of any irregularities carried out in clearances and payments as well as its responsibilities towards the affected villagers.

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Sustainability of dams on river Alaknanda

Dr. Rajesh Kumari

Abstract
The Indian Himalayan region is abode of three major river systems *viz* Indus, Ganga and Brahmaputra river system. These river systems provides with large volumes of water. This large volume of water has harnessed the present basic needs like availing water for the irrigation, domestic, industrial purpose and for the development of hydropower potential. The development of dams serves as a basic tool for properly channelizing these basic needs. Based on the importance of development of dams, the sustainability of construction of dams on the river Alaknanda has been analysed in this paper. River Alaknanda is one of the two head streams with river Bhagirathi which joins together at Devparyag in Uttrakhand forming the river Ganga. The river Alaknanda basin consists 82.2% of the area to be mountainous ranging between 1000 to 4000 m above sea level. These mountains consists three tectonically separable major litho-stratgraphical units known as Dudhatoli group, the Garhwal group and the Central Crystaline group. The Garhwal group consists of several shear and fracture zones which makes these region fragile to hold the large dams. The development of dams in the fragile and geo-dynamically sensitive zones will result in increased landslides, drying of the river or floods. In return it will result in ecological disturbances, loss of biodiversity, loss of productive lands, damage to forests, social and cultural change, change in socioeconomic status, etc. Thus this study focuses on the sustainability of construction of dams on river Alaknanda by analysing dams being built on river Alaknanda. Measures for sustainable development of dams should be taken care for constructing dams in Himalayan region.

Keywords: Indian Himalayan region, dams, sustainability, river Alaknanda, Garhwal group

Introduction

The Indian Himalayan Region with its major river systems has vast potential for hydropower development. Recognizing this potential, the Government of India in its recent initiative for 50,000 MW power generations proposes to develop several hydropower projects in the Indian Himalayan Region (Agrawal, Lodhi and Panwar, 2010) [1]. Based on the understanding of the prevailing policy framework of the country for hydropower development. The Uttarakhand catchment is endowed with vast hydropower potential, as per Central Electronic Authority Uttrakands potential is of 18175MW hydropower (THDC India Limited, 2009) [18]. Thus for development of hydrel power plants Dams are also built, these dams serves a major purpose for development of this region. But the question arises are these dams sustainable in this region which is tectonically active and most commonly prone to seismic activities.

Damming of a river has been called a cataclysmic event in the life of a riverine ecosystem (Gup, 1994) [9]. The hydroelectric projects interrupt and alter the river's important eco logical processes by changing the flow of water, sediment, nutrient, energy and biota. According to the United Nations, 60% of the world's 227 largest rivers are already severely fragmented by dams, diversions and canals, leading to the degradation of ecosystems (World Commission on Dams, 2000) [20].

The present study focuses on the sustainability of construction of Dams on river Alaknanda by analysing the dams being built on river Alaknanda and its consequences. The measures for sustainable development of dams in this region has been suggested.

Study area

Location: The study area includes the River Alaknanda catchment area (fig 1). Alaknanda catchment is located between 30°0′N to 31°0′N and 78°45′E to 80°0′E, covering an area of about 10,882 sq. This catchment area covers the following districts; Chomali, parts of Puria and Tehri districts and fringes of Kumoun Division of Uttrakhand state of India. As the elevation of the study area ranges from 1451 m to 8000 m.

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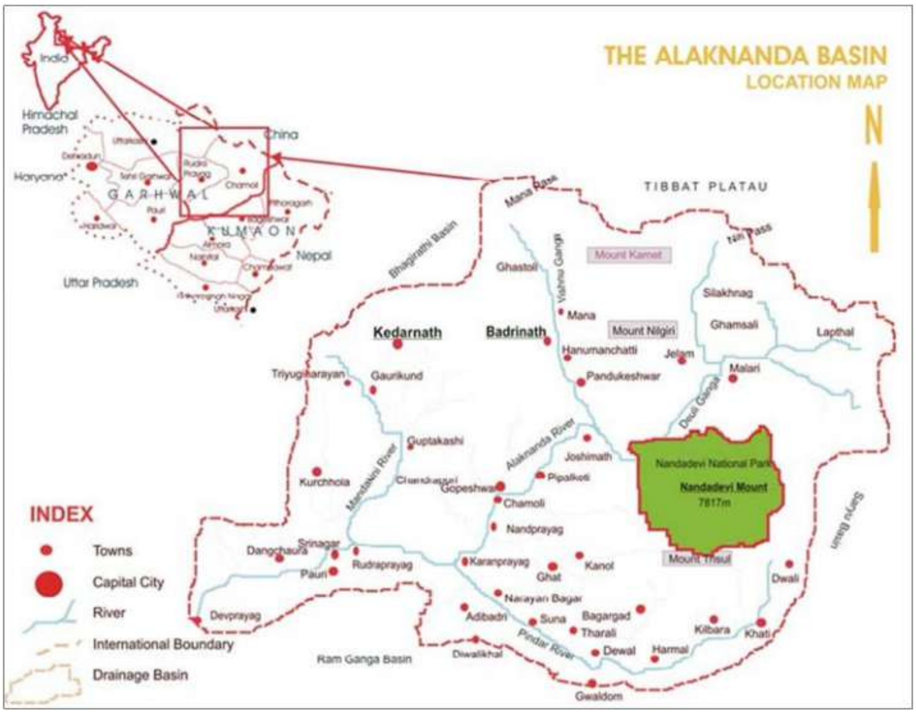

Fig 1: Alaknanda Basin

Geology: The Alaknanda River catchment is underlain by both sedimentary and highly metamorphosed gneissic rocks. In its upper course, the Alaknanda flows through the Central Crystalline zone (Fig. 2.a and Fig 2.b), which is composed of migmatized and granitized Archean metasediments. After passing the Central Crystalline, the river traverses through limestones, marbles and quartzitic sequences of the Tejam and Berinag Formations. Before its confluence with the Bhagirathi, the stream passes through the limestone and dolomite-bearing Uttarkashi Formation and the outcrops of phyllite and micaceous greywackes of the Chandpur Formation. The tributaries of the Alaknanda also flow through a varied terrain of quartzites, limestones, shales and slates.

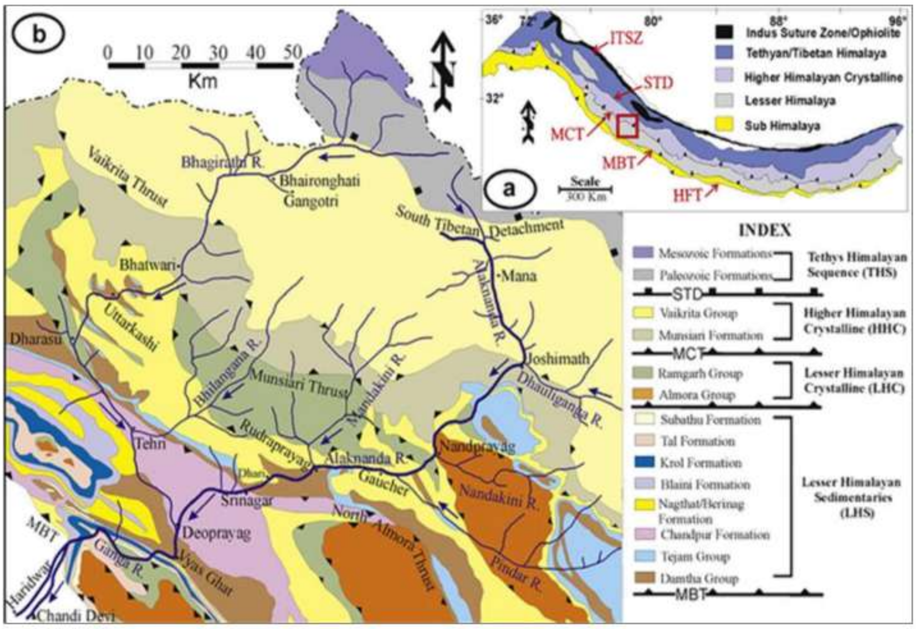

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Fig 2: a) Geological map of the Alaknanda- Ganga river catchment in the Himalaya, b) Geological cross-section as exposed along river

Drainage: River Alaknanda, which originate at an elevation of 3641m from Alkapuri Glacier.

Alkapuri glacier is combination of snout of Bhagirath kharak glacier and Satopath glacier. At Vishnuprayag (1372m) this river is meeting by Dhauliganga which originates near Badrinath peak (3300m). Afterwards Alaknanda flows down through Chomali (914m) confluence with Bhiri), Nandprayag (850m) confluence with Nandakini river(which originates from Nandadevi glacier,6000m), Karanprayag (795m) confluence with the Pindari (which originates from Pindari glacier, 5500m), Rudraprayag (610) confluence with the Mandakini (which originates from Kedarnath glacier, 3700m), and finally to Devprayag (472m) to merge with Bhagirathi river (which originates from Gomuk glacier,3900m) and contributes to the formation Ganga river system. River Alaknanda is approximately 229km in length before its confluence with Bhagirati in Devprayag and its flow of gradient from its origin to Vishnuprayag is 27.54m whereas from Vishnuprayag to Devprayag it flow gradient reduces to 6.93m.

Climate: The altitudinal differences coupled with varied physiography contributes to climatic variations in the Alaknanda basin. The climate varies from sub-tropical to alpine. Despite diverse physiographic characteristics, sub-regional variations in the average seasonal temperature are not striking. Temperature varies from season to season and from valley regions to highly elevated regions as highest temperature is recorded in Srinagar in the month of June (30°C) and lowest in Tungnath in the month of January (0.5°C). The Alaknanda basin receives heavy snowfall about 3-4 months during winter above 2000 m altitudes. Rainfall mostly occurs during monsoon season from June to October. It also varies from the valley regions (low) to highlands (high) and north-facing (leeward) to south-facing (windward) slopes.

Flora and Fauna: The vegetation is dominated by Pinus roxhburghi (1400–700 m), Dalber gia sissoo and Acacia spp. (700 m) and its distribution is governed by the altitude and slope aspect. The Alaknanda valley comprises a highly diversified ecological region since it covers a wide range of climatic conditions under altitudinal variation. Thus, the entire region is provided with a great variety of landscape, which has resulted in diverse flora and fauna. And faunal diversity, the Alaknanda river itself is rich in aquatic diversity. The river sustains about 39 fish species from 15 genera and 5 families. Of these species, 14 are abundant whereas 7 are vulnerable, 15 are at lower risk level and another 2 fall under the endangered category.

Socio-economic profile: District Chamoli is bordered by Tibet in the north - east, district Pithoragarh of Uttarakhand in the north – east, district Uttarkashi in north-west, district Rudraprayag in west, district Bageshwar in south –east and districts Pauri and Almora in south. District is divided into 7 sub-divisions (tehsils) namely Chamoli, Joshimath, Pokhari, Karanprayag, Gair Sain and Tharali. The total population of district Chamoli is 3,70,359 with a sex ratio of 1015. About 86.3% of the total population inhabits the rural areas. Total literacy rate of district is 75.4% with maximum in males. Joshimath is one the largest tehsils of Chamoli district in term of area. It is comprised of 93 villages and 27 notified wards. Total population of tehsil is 39,919 with a sex ratio of 774. Literacy rate of Joshimath tehsil is 78.8%. About 62.7% of the total population is rural.

Cultural setting: The valley is also famous for its mythological importance. There are several heritage sites within the study area like Badrinath Dham, Hemkund Sahib, etc. The holiest of the four main Hindu shrines, 'Badrinath' is situated along the left bank of river Alaknanda. With the splendid Neelkanth mountains as the backdrop, it is an important destination on the sacred itinerary of every devout Hindu, astonishing beauty attracts a large number of tourists every year. In addition, Auli adds to the list of important tourist destinations in the area, which is now popular for snow sports.

Materials and Methods

The Feasibility reports and Environmental Impact Assesment Reports of the hydropower projects being constructed on river Alaknada has been analyzed. The detailed Report of the CEC on Kotlibhel Hydro Electric Project, Uttarkhand has been studied and various other literatures has been analysed based on the field survey of the region has been done.

Analysis

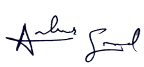
The dams have been constructed to manage the power generation and production of electricity, to create irrigation facility and to store the river water for dry period (World Commission on Dams, 2000). The Hills of Uttrakhand are thirsty and need better water management systems.

Question arises that "is it sustainable to build dams in geo-dynamically sensitive regions."

There are four problems which question marks the sustainability of dams on river Alaknanda

1. Landslides: Landslides occur when hill side or valley side slope falls due to certain geological, climatic and biotic factors (Sandhya, 2012). Geologically the Alaknanda valley consists of three tectonically separable major litho-stratigraphical units- Dudhatoli group, the Garhwal group and the central crystalline group (fig.2.a and fig.2.b). The Garhwal group which is separated by the Main Central Thrust existing in NW-SE direction consists of several shear and fracture zone *viz* Kalliasor, Nandprayag and Belakuchi which have highest frequencies of landslides. The Northern Zone extending from Vishnuprayag to the village Manna and its environs along the river Alaknanda and Dauliganga consists of schist, gneiss and granite of the Central Crystalline Group which rests over the Garhwal Group. All the Thrust Zone have a general trend of NW-SE just parallel to Himalayan ranges, but the Alaknanda river flows in a NE-SW direction. With the result the Thrust faults are lying almost perpendicular to the river Alaknanda (Saxena, 1987). Similar case happens with the tributaries of Alaknanda river joining it almost perpendicularly (ranging from 60° to 90°), thus this area is susceptible to landsliding, which may destroy the dam structure.

Geomorphologically the valley consists of three distinct land forms from high hills, hill slides and river valley formations (incised meanders and benches).High hills are generally conical shaped peaks ranging above 1500m. They also become overhanging scraps near the Thrust faults. The high hill landforms generally behave like watersheds of the major tributaries of the Alaknanda, consequently rills, gullies and seasonal channels have been developed to make terrain more dissected. The vegetable cover is very scant and hill tops are necked. The hill side landforms between hill and the river valley ranging from 500 to 1500m. The hill sides generally consists of talus or screes. They have repose slopes near thrust where they are fully developed. The hill-sides have thick vegetable cover but become scant due to redundancy of landslides caused by thrust zones.



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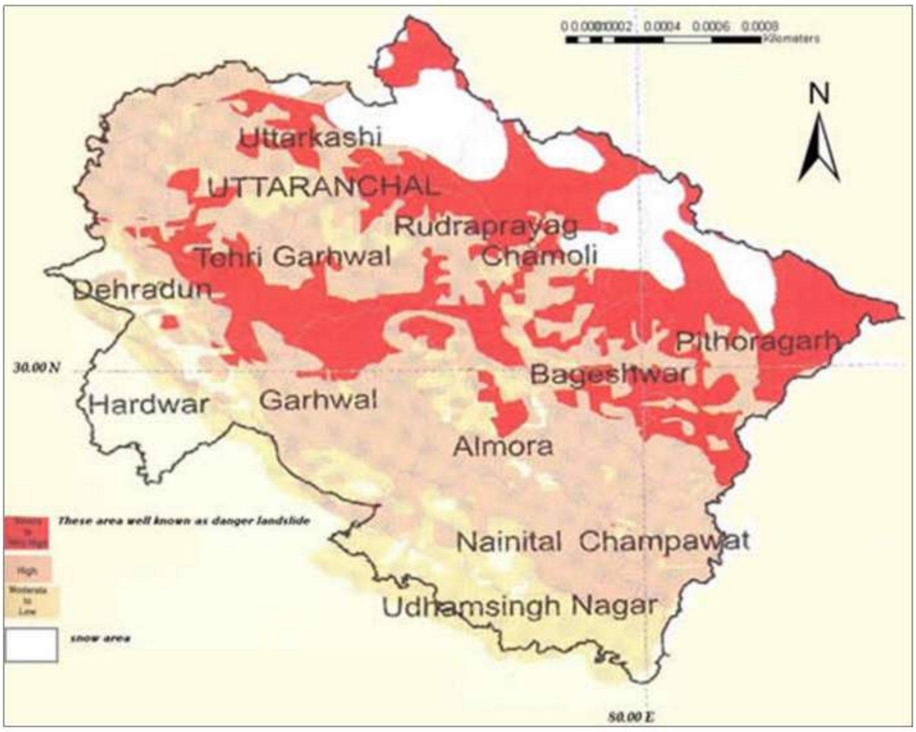

Fig 3: Landslide Zone of Uttrakahand (Source: Govt. of Uttrakhand, Disaster Mitigation and Management Center)

The river valley formations consist of incised meanders, river benches of 500m and below it. The incised meanders have gentle slopes with thick vegetal cover and steep slope with scant vegetal cover. The drainage system is highly related with the geomorphological formations. The main tributaries of Alaknanda like Dauliganga, Nangakini, Pindar and Mandakini rising from the high hills isolated watersheds contribute their water to the Alaknanda forming unparallel drainage. Consequently the hillside slopes have been transversely gullied and dissected. Several streams of the Alaknanda River contribute their water to it through underground passage which activates the conditions for landslides. In addition the temperate and sub-temperate conditions of the Himalayas activate weathering and under cutting action of running and ground waters of the drainage. The average annual rainfall is 150cm. thus the greater moisture content in the soil and air as observed and they are more richly causes the moistened landslides.

Table 1: Density of Landslides in Alaknanda Valley

Density of landslides per kms	Name of the villages(area)
7 to 10	Pipalkoti, Helang, Belakuchi and Chamoli
3 to 6	Hanuman-chatti, Dhak, Tapovan and Pandukashwar
1 to 3	Kaliasor and Rudraprayag

Source: A geographical study of landslides in Alaknanda Valley (Garhwal Himalayas) (Sharma, 1982) [15]

Thus all these factors show that this region is prone to severe landsides (fig. 3.) and this may damage the dam structure built in landslide prone area. As we move down with river the density of landslides reduces and also stability of the Himalayas rises, thus it is more sustainable to construct dam on the lower streams of the river.

2. Earth-Quack: Entire Himalayan domain is geodynamically very sensitive and Uttrakhand lies in the zone IV and V region (fig 4) which is very high damage risk zone. In its seismicity all along the faulted zones are quite active. By active faults it is meant that horizontal or vertical movements on the faults have taken place in the geologically recent times. The snapping and slipping of rocks on faults generate shock waves and the passage of ground wave causes damage and destruction. Many of the faults and thrusts of the Himalayas have given rise to earth quacks. Intriguingly, the much faulted central sector of the Himalayan Arc-Himachal, Garhwal and Kumaon have remained seismically for quiet some time with regard to higher magnitude earthquacks.

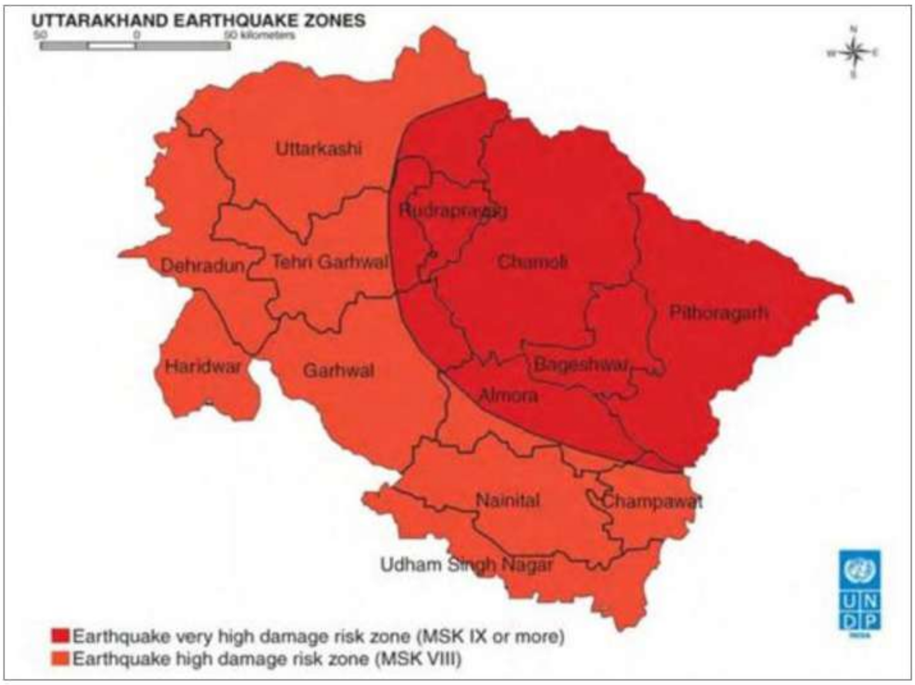

Fig 4: Earthquack Zones of Uttrakhand by UNDP (Source: Govt. of Uttrakhand, Disaster Mitigation and Management Center)

But in this region, the stresses are progressive building upside, as the sediment is being strongly pressed and prodded by the subcontinent. The Uttrakashi, Tehri and Chamoli region lying directly in this line of the ridge is in a critically stressed condition. The Srinangar Thrust crosses the terrain in NW-SW direction. And the whole mountain range repeatedly upliftment and squeezed up between the Main Boundary Thrust and Srinagar Thrust in the geologically recent times. And this can cause large scale earth quacks in this area. Thus it is not sustainable to build dams in earthquake prone areas.

3. Flash Floods: Flood has been a problem in long history of Uttrakhand. The first biggest flood of Alaknanda was in 1894, in which the famous Birahi Lake was destroyed and entire township of Srinagar was washed out. Important flood of Alaknanda in 1924 in which remnants of Srinagar were totally swept away. The biggest flood Alaknanda observed in July 1970, which washed away the Halting station, destroyed 6 motor bridges, 16 foot bridges, a road length of 30 km, 604 houses and 200 ha of standing crop. River Alaknanda is prone to flash flood, which have very high intensity, thus building of dams is not sustainable it can get washed away with these flash floods and will also add to increase the intensity of these floods and destruction will increase.

4. Global Warming: With the accelerated glacial melting the dams are likely to see huge increase in inflows initially and then highly reduced inflows in subsequent decades. This effect is likely to threaten the safety and economy of the dams being constructed.

Consequences of development of dams on river Alaknanda

Drying of the River: Due to dense allocation of hydropower projects in the study area, water released from the tail of the tunnel would enter the reservoir of another hydropower project. Thus hydro power project would cause practical drying up of the river, especially during the lean season flow period. As a result, the velocity and volume of flow would change suddenly in stretches and this would have serious implications for the aquatic ecology of the cold water fisheries of the region.

Dam Failure: As the Main Central Thrust and Main Boundary Thrust lines traverse along the entire Himalayan region, the area is susceptible to high seismic risk. And Alaknanda catchment lies in the geo-dynamically sensitive Himalayan region (Seismic zone V), thus naturally prone to disasters. Earthquakes of magnitude of 8.5 on Richter scale have been recorded in the Himalayas. It needs to be noted that the kind of developmental interventions associated with hydropower projects, serious manmade disaster due to failure of dams may occur. The reasons of the dam failure could be technical flaw in the design or extreme rain fall event, etc. However, it is beyond argument that huge destruction of life, property and environment is expected. According to the EIA guidelines of MoEF, dam break analysis for disaster management planning is required for individual projects, wherein, there can be no consideration for other dams in upstream and downstream, ignoring the cascading effects of dams proposed in a series. However, in real world situation, if a single structure is failing, that will trigger chances for failure of another structure in the downstream and so on.

Degradation of Natural Beauty: With the development of Dams fr hydropower projects, the natural flow of the river will be fragmented and would also disappear into the tunnels causing tremendous loss to the panoramic landscape of the region. Besides this, construction of Dams which is related to hydropower projects will also lead to modernization of the area and in turn will cause degradation of the natural beauty of the valley that is characterized by scattered small hamlets spread over the mountain slopes with intermittent agricultural fields and herds of domestic animals being bred by ethnic communities attired in traditional dresses. In brief, the development of dams in the region would certainly affect the tourism potential of the area.

The extremely important confluences of spiritual and historical value such as Nand Prayag (Alaknanda and Nandakini), Karna Prayag (Alaknanda and Pindar), Rudra Prayag (Alaknanda and Mandakini) and Dev Prayag (Bhagirathi and Alaknanda) of the Ganga with its various tributaries stand to be destroyed by these projects.

- **Extinction of Culture (impact on sociocultural setting of the area):** Construction of the projects will lead to an influx of outsiders – labourers and contractors in the region, and this would lead to the dilution of the culture of the pastoral communities. Further, development of dams will helping providing irrigation facility thus it will cause change in land use pattern and this may significantly affect the availability of already limited pasture land (on account of increasing number of livestock and also increase in land under agriculture) to the pastoral communities.
- **Human induced Flood:** Dams bring human induced floods, as role of dams is to store water during rainy season (mostly at the end of monsoon) these dams get filled with water upto the danger mark and under excess rainfall conditions the authority opens the gates of the dam. And this sudden release of water in large quantity leads to flood situation in the river (mainly the lower areas)
- **Submergence:** building of dams may lead to submergence nearby low lying area like all vegetations, agricultural lands, mineral deposits, existing roads or transport network in the lower valley.
- **Increase in seismicity:** Construction of big dams may increase seismicity of region because of transmission of additional heavy load due to weight of the retained water in reservoir to the strata below.

And also heavy blasting and mining operations were performed during the construction of Dam and others, vast areas became unstable. The unending pressure on the fragile ecosystems of high hill regions by indiscriminate blasting for multipurpose projects, dams and highways, accelerate the dynamic forces which are equally responsible for soil instability. The vast devastation by the recent(Oct, 1991) earthquake in Uttarkashi, particularly near to Maneri Bhali dam and adjoining areas, may be are due to the earth's dynamic processes and to human interference in these dynamic processes.

- **Change in ground water scenario:** because of detention of water in reservoir and consequent seepage of water will lead to immediate changes in ground water conditions.
- **Change in physiochemical parameters of water:** mainly the flow speed, transparency, temperature, and dissolved oxygen of dam's water shall change. Thus planktonic and benthic life and fisheries of river in dam will be depleting.
- **Siltation:** Reservoirs may get silted quickly because Alaknanda brings large amount of sediment load.

The fate of the five holy prayags: The holy Devprayag would be submerged under at least 10 m high standing water of Kotli Bhel 2, the holy Rudraprayag would remain submerged under water from the proposed big 860 MW storage project at Utyasu. The holy Karnaprayag

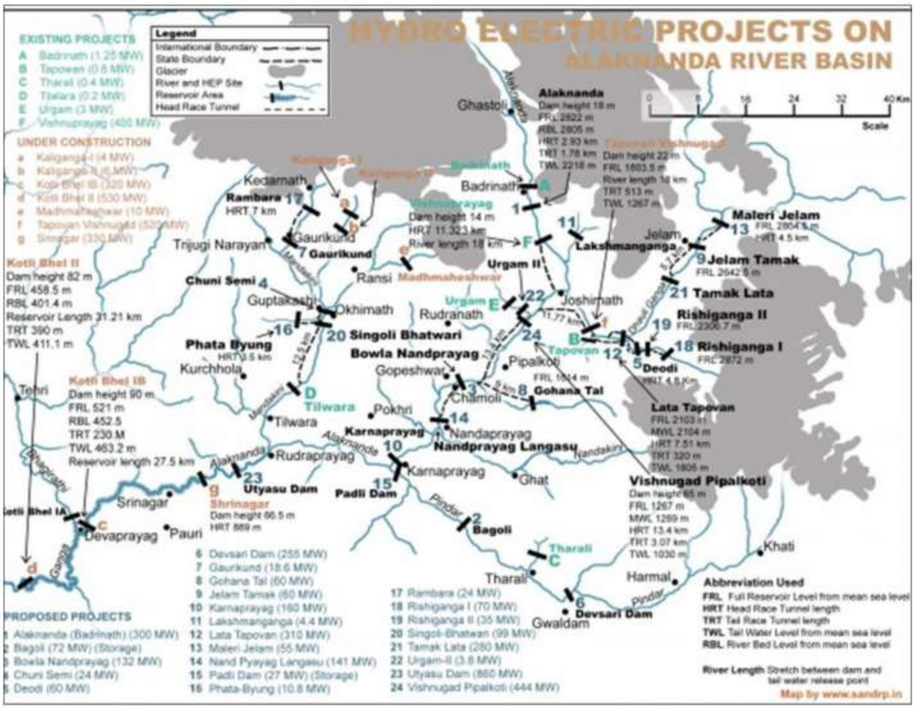

Fig 5: Hydro Electric Projects on River Alaknanda (Source: www.sandrp.in)

would have the proposed storage project Padli along the Pinder River on the one arm and the 160 MW Karnaprayag hydropower project on the other arm. The Nandprayag is likely to remain dry in non-monsoon months due to the proposed 141 MW Nandprayag Langasu Hydropower project, just upstream of the prayag. Vishnuprayag is already impacted due to the existing 400 MW Vishnuprayag project, but its fate would be worse if the proposed 520 MW Tapovan Vishnugad project on Dhauli Ganga River comes about.

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Table 2: Salient features of the proposed hydropower projects in Alaknanda catchment

Project name	Developer	Installed capacity(MW)	Location of Dam Lat & Long		Dam/ barrage height (m)	Submergence area (ha)
Malari–Jhelum	THDC	55	30°40′ 54.7″	79°53′4.5″	24.5	NA
Jhelum–Tamak	THDC	60	30°38′45″	79°49′57.5″	24.5	13.9
Tamak–Lata	UJVNL	280	30°36′00″	79°47′00″	12	NA
Lata–Tapovan	NTPC	171	25 km u/s of joshimath	NA	NA	NA
Tapovan–Vishnugad	NTPC	520	30°33′51″	79°33′46″	22	10
Vishnugad–Pipalkoti	THDC	444	30°30′50″	79°29′30″	65	24.5
Vishnuprayag	JPVL	400	30°40′10″	79°30′35″	NA	NA
Alaknanda	GMR Energy Ltd	300	30°43′09″	79°29′49″	36	3.74
Bowala–Nandprayag	UJVNL	300	Near Birahi village	NA	5	NA
Nandprayag–Langasu	UJVNL	141	30°19′30″	79°18′20″	15	NA
Srinagar (Supana)	Alaknanda Hydro Power Company Ltd	330	30°23′47″	78°22′20″	66 (concrete gravity dam)	NA

Source: Feasibility reports of the hydropower projects. NA stands for not available

Fig 5: Site of Tapovan Vishnugad dam under construction

Table 3: Likely Primary Adverse Environmental and Social Impacts of the Tapovan–Vishnugad HEP

Issue/Feature	Impact	Extend	Duration
Hydrology	Reduced river flows between barrage and tailrace outlet Decline in river water quality	Along an 18 km stretch of river	Permanent
Aquatic ecosystems	Altered river ecosystem Prevention of upstream fish Movement	11 km Dhauliganga, 7 km Alaknanda pondage inundation are Up to 90 km of the Dhauliganga plus tributaries	Permanent
Land resources	Loss of agricultural and forest land	144.6 ha total land conversion	Permanent
Social	Resettlement of households	57 households, predominantly self-relocated	Permanent

Source: WAPCOS. 2004. EIA Study for Tapovan–Vishnugad Hydroelectric Project. Gurgaon

The Alaknanda River is becoming a highly regulated water resource that is likely to have several HEPs installed over the next 10 years (fig. 5). The two HEPs that are most likely to increase or mitigate the impacts created by the Tapovan–Vishnugad HEP are the operating Vishnuprayag HEP and the proposed Vishnugad–Pipalkoti HEP, both on the Alaknanda River. The 400 MW Vishnuprayag HEP has a 14 m high barrage about 16 km upstream of the Dhauliganga confluence, with a tailrace outlet 1–2 km below the confluence. This project is dewatering the intermediate 18 km section of the Alaknanda River in the dry season. The proposed Vishnugad–Pipalkoti HEP dam, 2.5 km downstream of the Project's tailrace outlet, will inundate the Alaknanda to within 1 km of the project tailrace outlet.

Table 4: Environmental and Social Impacts of the Alaknanda HEP (Joshimath)

Issue/Feature	Impact	Extend	Duration
Hydrology	Reduced river flows between barrage and tailrace outlet Decline in river water quality	5.8 km downstream of the barrage site would become dry during the lean season	Permanent
Aquatic ecosystems	Altered river ecosystem Prevention of upstream fish movement	Will not harm exotic species of fishes	Permanent
Land resources	Loss of agricultural and forest land **(**Submergence of land)	7.53 ha of total agriculture land came under this project and 2.27 ha forested area will submerged	Permanent
Social	Resettlement of households	12 families affected(227 family members)	Permanent

Source: CISMHE, Environmental Impact and Management Programme of Alaknanda Hydro Electric Project, Uttrakhand.

Impact Assessment and Evaluation of Alaknanda Hydro Electric Project (HEP)

The environmental impacts of the proposed Alaknanda H.E. project are being forecast in light of the activities that would be undertaken during the construction of barrage, coffer dam, drilling and blasting during tunneling for head race tunnel, roads, construction of permanent and temporary housing and labour colonies, quarrying for construction material and dumping of muck generated from various

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project works and other working areas. The likely impacts are:

Impact on Terrestrial Ecosystems: Habitat disturbance, degradation, fragmentation and destruction due to construction activities would lead to disruption of flora and fauna. The proposed area to be submerged by the proposed project is about 2.27 ha, which is mainly under forest. The vegetation in the vicinity of the proposed project area is scattered composed of Temperate mixed coniferous and scrub forest. On the right bank, there are trees of Betula alnoides, Ilex excelsa, Rhododendron arboreum, Taxus baccata and Viburnum grandiflorum and shrubs like Berberis umbellata, Cotoneaster rotundifolius, Rhododendron campanulatum, Rosa macrophylla, Sorbus tomentosa, Viburnum cotinifolium, etc. Herbaceous flora is comprised of Anaphalis busua, Arabisamplexicaulis, Cardamine impatiens, Cerastium glomeratum, Corydalis cornuta, Epilobium palustre, Geranium wallichianum, Imperata cylindrica, Potentilla cuneata, Sedumewersii, etc. The reservoir would hamper the movement of wildlife. The creation of a barrage across the river and formation of a reservoir would result in the change of habitat and would lead to fragmentation of habitat. This reservoir will function as a physical barrier, which comes in the way of animal migration and dispersal. The proposed project activities like drilling, blasting, etc. would lead to increased noise levels in the area, which may cause disturbance to the wildlife in the area. The construction of the project facilities would involve deforestation. Thus the danger of erosion and disturbance to hill slopes is high.

Impact on Aquatic Ecosystems: The most obvious impact of hydro-electric projects is the upstream inundation of terrestrial ecosystems and, in the river channel. They also alter the downstream flow regime. Reservoirs reduce flow velocity and so enhance sedimentation. The rate at which sedimentation occurs within a reservoir depends on the physiographic features and land-use practices of the catchment, as well as the way the barrage is operated. It is estimated that between 0.5% and 1% of the storage volume of the world's reservoirs is lost annually due to sediment deposition. Downstream of the barrage, reduction in sediment load in the river can result in increased erosion of river-banks and beds and loss of floodplains. Reservoir flushing (i.e. the selective release of highly turbid waters) is a technique sometimes used to reduce in-reservoir sedimentation. The proposed project would result in submergence of 2.27 ha and it may lead to adverse changes in the river ecosystem. However, for mitigating the downstream impacts, it is mandatory to maintain at least 10% of the lean season flow in the river. The river stretch of about 5.8 km downstream of the barrage site would become dry during the lean season, therefore, the project authorities have been advised to maintain sufficient amount of discharge during the lean period to maintain and sustain the aquatic ecosystem functions in this stretch. The likely impacts on the water quality arise from inappropriate disposal of muck, effluents from crushers and other sources and sewage from labour camps and colonies. The muck will essentially come from the road-building activity, tunneling and other excavation works. The unsorted waste going into the river channel will greatly contribute to the turbidity of water continuously for long time periods. Therefore, in order to avoid any deterioration in water quality and subsequent changes in the aquatic biota, project authorities propose to have a proper sewage disposal system in and around various labour colonies to check the discharge of waste and refuse into the river. And this will not only deterioration water quality but will lead to subsequent changes in the aquatic biota. The degradation in water quality will mainly arises from discharge of waste and refuse into the river channel by the labour colonies and other temporary human habitations.

Geo-physical Impacts:_The area lies in the seismically active Zone-V of the seismic zoning map of India and has witnessed micro-seismic activity. As it is evident that the project area is very close to seismically active zone in the vicinity of MCT. Therefore, it is essential to adopt suitable seismic coefficient in the design_for various appurtenant structures of the project. Geological disturbance due to blasting, excavation, Soil erosion as cutting operation disturbs the natural slope & lead to land slides, Interruption of drainage pattern, Disturbance of water resources with blasting and discriminate disposal of fuel and lubricants from road construction machinery, Siltation of water channels/ reservoirs from excavated debris, Effect on flora and fauna, Air pollution due to dust from debris, road construction machinery, etc. Therefore, most of the muck is proposed to be dumped in an environmentally sound manner at pre-identified locations.

Impact on Human Ecosystem: the quantum of human population migrating from other areas is greater than the local human population in the area it would result in demographic changes and other repercussions that follow. Since the migrant workforce is generally from the different regions, diverse ethnic and cultural backgrounds and value systems, they are bound to affect the local socio-cultural and value systems. In addition, these migrants might be the probable carriers of various diseases not known so far in the region resulting in health risk for the local population. The threat of habitat disturbance, degradation and fragmentation may not only come from the constructional activities, but from the large labour population that is generally employed in such developmental projects. The presence of human population in large numbers in such areas is known to exert tremendous pressure on the natural ecosystems around the project activity sites.

Some positive impacts like availability of jobs, electricity in rural areas, increase in road connectivity and eco-tourism are anticipated on the socio-economic environment of the local people of villages of project area during the project construction and operation phases.

Kotlibhel HE Project (Stage 1A)

Kotlibhel HE Project (Stage 1A) has run of river type dam with Installed capacity of 195 MW (3×65).The height of Dam is 82.5m.This project is developed by National Hydro Power Corporation Ltd. The development of this project has submerged 217.629 ha of area and 92 percent of the total land acquired for the project is the forest-land. Environment Impact Assessment (EIA) of the Kotlibhel HEP Stage1A, project is done Hemwati Nandan Bahugana Garhwal University, Srinagar (Garhwal), Uttakahnd. EIA has serious methodological flaws; the EIA lacks a scale and valuation of the significance of the environmental impacts. The baseline

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information is incomplete with regards to the areas directly and indirectly affected by the project. The baseline information does not provide the quantitative information about the population density of wildlife species that would be affected present directly or indirectly by the project.

Kotli Bhel Hydroelectric Project (Stage 1B)

Kotlibhel HE Project (Stage 1B) has concrete gravity type dam with Installed capacity of 320 MW (4×80).The height of Dam is 70.5m.This project is developed by National Hydro Power Corporation Ltd. The development of this project has submerged 550.619 ha Out of which 496.619 ha is reserve forestland. That means 90 percent of the area required for the project is the forestland. The Environment Clearance was granted by Ministry of Environment and Forest by its order dated 14/08/07 for this project. EIA of this project analyses that the very origin of Ganga, at Devprayag would be permanently under about 10 m high water column. The area is rich in biodiversity –both floral and faunal. 90% of the area required for the project is the forestland. Butterflies of Nymphalidae and Papilionidae families are more likely to be affected by the proposed project. The impact is serious as these butterflies are host specific and the disappearance of host can lead to the extinction of these creatures. Along with this the life cycle of other life forms may be disturbed and can lead to various unexpected changes. There is also a greater chance of change in local climate: high humidity and increase in temperature which will breed vectors like mosquito's which are a threat to humans as well as a danger to fauna (Second Report on EIA Response Center (ERC), 2008). As per reports of Otter expert S.A Hussain of the Wildlife Institute of India, The entire Alaknanda Valley is suitable for Smooth Coated Otter habitation: "Along the entire Alaknanda, fallen rocks and boulders, deep crevices and caves provide suitable den sites for otters". The IUCN Species Survival Commission, Otter Action Plan, 2000s have opined that "Otters are not getting adequate attention while conducting EIAs. Trout and species of Mahseer are the two fish species threatened by the project. It is therefore important that along with biodiversity, the ecological significance of the fish species and aquatic biodiversity is also assessed, which unfortunately has not been done in the EIA Report. Thus The Supreme Court has agreed to the suggestions of the Central Empowered committee and the project has been sent back to the Forest Advisory Committee for reconsideration of forest clearance issued under the Forest Conservation Act, 1980.

Suggestive Measures Should Be Taken For Sustainable Development of Dams

1. **Small size:** Dams should be small sized; it will fulfill the irrigation requirement of the region and also electricity of the local areas. Benefits of small size dams is that it will lead to less submergence of nearby area, less forest cover of agriculture land will destroyed, negligible impact on environment, less or negligible reduction in flow and velocity, less people will be displaced, less load of water retained in the reservoir because of small size, thus will not influence the seismicity of the region.
2. Conservation and preservation of natural ecosystems and areas which may hold potentially important species from the conservation and/or economic significance.
3. Preservation of natural habitats in the catchment.
4. Special efforts for in situ or ex situ conservation of critical/ important plant/ animal species.
5. To improve habitat conditions by taking up afforestation and soil conservation measures
6. To create awareness regarding conservation and ensure people's participation in the conservation efforts.
7. Reduce and mitigate of noise so as to cause as little disturbance to the animals by using well maintained/new equipment that produce lesser noise than old and worn out one at the work sites. The combustion engines are required; they will be fitted with silencers. The traffic (trucks, etc.) used by the project works will be managed to produce a smooth flow instead of a noise producing stop and start flow. While clearing the land of vegetation for any project work, the project authorities will ensure that the work area has sufficient layers of tree cover around it. It will act as an effective noise absorber. It will be better not to have bigger trees lopped or cut around the periphery of the site. The tree layer will act as buffer zone and these are known to cut off noise by about 3-12 dB at a site depending upon the density of vegetation. These measures will be planned in advance and well before starting operation at any site.
8. Rehabilitation of degraded slopes and landslide prone areas.
9. Fisheries management by the construction of small check dams across the river. In order to the maintenance of pools small check dams are needed in the rivers. At least 4 dams would require in the 12 km stretch of the river. The check dams would be supplied through regular water supply from the mandatory release of water (10%) from the dam and other small tributaries.
10. Sufficient precautions should be taken for developing proper system for the sewage treatment from the colonies of labours and workers, solid waste disposal and cleaning of the colony area. For these septic tanks and soak pits shall be provided for individual dwellings. There should be proper water facilities to these workers for drinking and other purposes. The project authority should also take care to keep the local villages clean and provide various facilities related to water and sanitation.
11. **Disaster & Hazard Management Plan:** The Himalayan valleys are subject to the occurrence of apparently sudden calamitous events. These events, in fact, represent the climax of the interaction of numerous independent or unrelated natural phenomena, whose final action is synchronized to produce a sudden and major catastrophic effect. For example, an earthquake represents the culmination of a sequence of tectonic events which trigger seismic action. The seismic waves may lead to the occurrence of significant geo-morphological changes and create conditions for massive landslides and trigger snow or debris avalanches. These events could set the stage for a temporary lake formation in a river valley. Such a lake will have potential of creating a catastrophic flood downstream in eventuality of overtopping. Similar effect could be generated by a cloud burst in any of the sub-watersheds. Some of the potential phenomena and sites, where catastrophic conditions are foreseen in Alaknanda valley, are glacial lakes, cloud bursts – flash floods and avalanche hazard mitigation. The methods like structural control or afforestation arrests the creep and glide

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motion of snow on slopes, and thus avalanches too, artificial triggering helps to bring down the avalanches before they reach stupendous proportions. The latter method is relatively cheap. The passive methods include: a) Awareness, b) Forecasting and c) Safety and Rescue.

12. **Measures taken by government:** on July 16, 2010 The Union environment and forests ministry's Forest Advisory Committee (FAC) has decided not to give forest clearance to any of the proposed projects until the National Ganga River Basin Authority conducts a cumulative impact assessment study of all proposed dams. Uttarakhand has planned to build 300 small and large dams on the various tributaries of the Ganga to tap the hydel potential of the state. The FAC has decided not to allow even one dam to proceed unless the total impact of all proposed dams is studied.

Conclusion
Construction of large dams on river Alaknanda are not sustainable because Alaknanda flows in the Himalayan region which is geo-tectonically very active and prone to seismic activites which causes landslide, earthquack and flash floods in this area occasionally. Development of dams in Alaknanda basin will negatively affect the flora and fauna, climate, human ecosystems and it will also influence the geo-physical setting of this region. Thus for sustainable development of dams some measures should to be taken. And the most important one is that dams that are being built should be small in size, that will met the power requirements and irrigation requirements with negligible adverse impact on flora and fauna, climate, human ecosystems and geo-physical setting of this region.

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THE RESO RESEARCH SOCIOLOGY REVIEW JOURNAL

Addressing the Environmental Crisis in Uttarakhand: A Sociological and Ecological Analysis

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Abstract

Uttarakhand, a Himalayan state in India, is experiencing an escalating environmental crisis driven by climate change, deforestation, hydropower projects, unregulated tourism, and rapid urbanization. This research examines these crises through a sociological and ecological lens, analyzing their impact on marginalized communities, biodiversity, and sustainable development. Applying theories from environmental sociology, political ecology, and disaster studies, the study explores how structural inequalities exacerbate environmental vulnerability. Through qualitative and empirical analysis, including case studies of the Kedarnath disaster (2013), the Joshimath land subsidence (2023), and hydroelectric projects in the Alaknanda and Bhagirathi basins, this paper highlights governance failures and community resilience. Finally, it proposes policy recommendations to integrate environmental sustainability with social justice.

Keywords

Environmental crisis, Uttarakhand, climate change, hydropower, political ecology, disaster vulnerability, environmental justice, sustainability

1. Introduction

1.1 Contextualizing the Environmental Crisis in Uttarakhand

Uttarakhand, often called "Devbhumi" (Land of Gods), is an ecologically sensitive state in the Indian Himalayas. Its unique geography—characterized by glaciers, rivers, forests, and mountainous terrains—makes it vulnerable to climate-induced disasters. However, environmental degradation in the region is not solely a result of natural factors; rather, it is deeply rooted in developmental policies, economic expansion, and governance failures. Despite being one of the most ecologically fragile regions in India, Uttarakhand has witnessed rapid infrastructural development. The construction of hydroelectric projects, deforestation for urban expansion, and unregulated tourism have accelerated ecological damage. Over the past two decades, the frequency and intensity of disasters have increased, leading to mass displacement, loss of livelihoods, and the destruction of biodiversity.

1.2 Statement of the Problem

The environmental crisis in Uttarakhand is a multidimensional issue requiring both ecological and sociological analysis. The key problems identified include:

1. Climate Change and Glacier Retreat: The melting of Himalayan glaciers, including the Gangotri and Pindari glaciers, is accelerating, affecting water availability and increasing disaster risks (IPCC, 2021).

2. Hydropower Development and River Disruptions: Large-scale dam projects, such as the Tehri Dam, have altered river ecosystems, displaced

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local populations, and increased seismic vulnerability (Kumar, 2025).

3. Unregulated Tourism and Infrastructure Expansion: The surge in pilgrimage tourism, especially in areas like Kedarnath and Badrinath, has led to haphazard construction, overextraction of resources, and pollution (Negi & Joshi, 2022).

4. Urbanization and Land Subsidence: Cities such as Joshimath have experienced land sinking due to poor urban planning, faulty infrastructure, and the over-extraction of groundwater (Mishra, 2023).

1.3 Research Objectives

This study aims to:

Analyze the sociological and ecological dimensions of Uttarakhand's environmental crisis.

Assess the impact of developmental policies, such as hydroelectric projects and tourism, on local communities.

Evaluate the socio-economic consequences of climate-induced disasters.

Recommend sustainable policy interventions that balance ecological preservation and economic development.

1.4 Research Questions

1. What are the major environmental challenges in Uttarakhand, and what are their sociological and ecological implications?

2. How do developmental projects, such as hydroelectric dams and unregulated tourism, contribute to environmental degradation?

3. What are the socio-economic consequences of climate-induced disasters on marginalized communities?[1]

[1] Ghosh, A. (2018). "Himalayan Dams: A Threat to Ecology and Society" highlights the socio-environmental consequences of large-scale dam projects in the fragile Himalayan ecosystem.

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4. How can policy interventions integrate ecological sustainability with social justice?

2. Literature Review

2.1 Understanding the Environmental Crisis: A Global and Regional Perspective

The environmental crisis in Uttarakhand is part of a broader global pattern of ecological degradation and socio-environmental injustice. Studies in environmental sociology argue that industrialization and unregulated economic expansion have led to an increase in environmental risks (Beck, 1992). Similarly, political ecologists emphasize the role of capitalist structures in intensifying environmental exploitation (Robbins, 2012).

In the Indian context, Himalayan ecology has been a subject of concern since the 1970s, when the Chipko Movement pioneered grassroots environmental activism against deforestation (Guha, 1989). Contemporary studies show that despite environmental laws, weak governance and political lobbying have allowed unsustainable development in the region (Sharma & Joshi, 2021).2.2 The Role of Hydropower Projects in Environmental Degradation

Hydropower projects are often promoted as a solution to India's energy needs. However, several scholars have criticized their impact on fragile ecosystems: Dams alter river flow, disrupt fish populations, and increase sedimentation (Ghosh, 2018). The displacement of local communities leads to socio-economic distress and loss of cultural heritage (Singh, 2019). The construction of large reservoirs increases seismic activity in tectonically active zones (Kumar, 2025).

Case studies, such as the impact of the Tehri Dam on the Bhagirathi River, highlight the long-term consequences of large-scale hydroelectric projects on local ecology and communities.

2.3 Climate Change and Disaster Vulnerability in Uttarakhand

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The Intergovernmental Panel on Climate Change (IPCC, 2021) reports that the Himalayan region is witnessing higher-than-average temperature rises, leading to: Glacier Retreat: The Gangotri Glacier, a major source of the Ganga River, has receded by nearly 1.7 km since 1935 (Raina, 2009). Increased Flood Risks: Flash floods, such as the 2013 Kedarnath disaster, have become more frequent due to excessive glacier melting and erratic monsoons (Mishra, 2014). Land Subsidence: Urban expansion into ecologically fragile zones, like in Joshimath, has resulted in land sinking, affecting infrastructure and human settlements (Mishra, 2023).

2.4 Theoretical Framework: Sociological and Ecological Perspectives

This research applies multiple theoretical perspectives to analyze the Uttarakhand crisis: 1. Ulrich Beck's "Risk Society" (1992): Modernization has led to increased ecological risks, particularly in disaster-prone regions. 2. Bruno Latour's Political Ecology (2004): Environmental degradation is not just a natural phenomenon but is deeply influenced by power dynamics and governance failures. 3. Karl Marx's Metabolic Rift (Foster, 2000): The capitalist mode of production disrupts the natural relationship between humans and the environment, leading to ecological imbalances. 4. Amartya Sen's Capability Approach (1999): Environmental degradation disproportionately affects marginalized communities, limiting their access to resources and opportunities.

4. Findings and Discussion

4.1 Environmental Challenges in Uttarakhand

4.1.1 Climate Change and Glacier Retreat

The Himalayan region is warming at twice the global average, causing glacial retreat, unpredictable rainfall, and extreme we[2]ather events. The Gangotri Glacier, one of the largest in the region, is retreating at an

[2] Kumar, S. (2025). Impact of Hydroelectric Projects on Uttarakhand's Ecosystem presents a comprehensive analysis of environmental degradation caused by hydropower projects in the region.

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alarming rate of 22 meters per year (IPCC, 2021).

Impacts of glacier retreat include:

Water shortages: Melting glaciers initially increase water flow, but in the long term, they reduce water availability for agriculture and drinking water supplies. Glacial Lake Outburst Floods (GLOFs): Rising temperatures lead to the formation of unstable glacial lakes. Over 40 glacial lakes in Uttarakhand are classified as “potentially dangerous” (Wadia Institute of Himalayan Geology, 2022). Biodiversity loss: The shifting climate threatens alpine plant species, Himalayan brown bears, snow leopards, and other endemic species. The theoretical lens of Environmental Determinism suggests that climatic and geographical factors directly impact human civilization. In this case, climate change is forcing communities to adapt, migrate, or face socio-economic hardships.

4.1.2 Hydropower and Ecological Disruptions

Uttarakhand’s energy policy heavily favors hydropower projects (HEPs), with over 100 operational and planned projects. While these dams provide electricity, they disrupt river ecosystems, aquatic life, and local livelihoods.

Case Study: Tehri Dam – The Cost of Development

The Tehri Dam, one of India’s largest hydroelectric projects, displaced over 100,000 people, submerging entire villages, temples, and agricultural lands. The forced displacement of communities has led to economic hardship and the loss of indigenous knowledge related to river conservation. Studies indicate that Tehri town and surrounding areas have experienced increased seismic activity, raising concerns about dam safety (CSE, 2022). Downstream areas are experiencing reduced water flow and sediment transport, affecting agriculture and fisheries. Case Study: Chamoli Disaster (2021) – Hydropower and Landslides In February 2021, a glacial outburst in the Rishiganga Valley triggered a landslide, killing over 200 people and destroying two hydropower plants. Scientists linked this disaster to unregulated hydropower development and the weakening of mountain

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slopes due to excessive tunneling. From a Political Ecology perspective, this reflects the unequal distribution of environmental risks—while corporations and government agencies benefit from energy production, local communities bear the ecological and social consequences. 4.1.3 Urbanization, Land Subsidence, and Infrastructure Failure

Joshimath: A Sinking Town

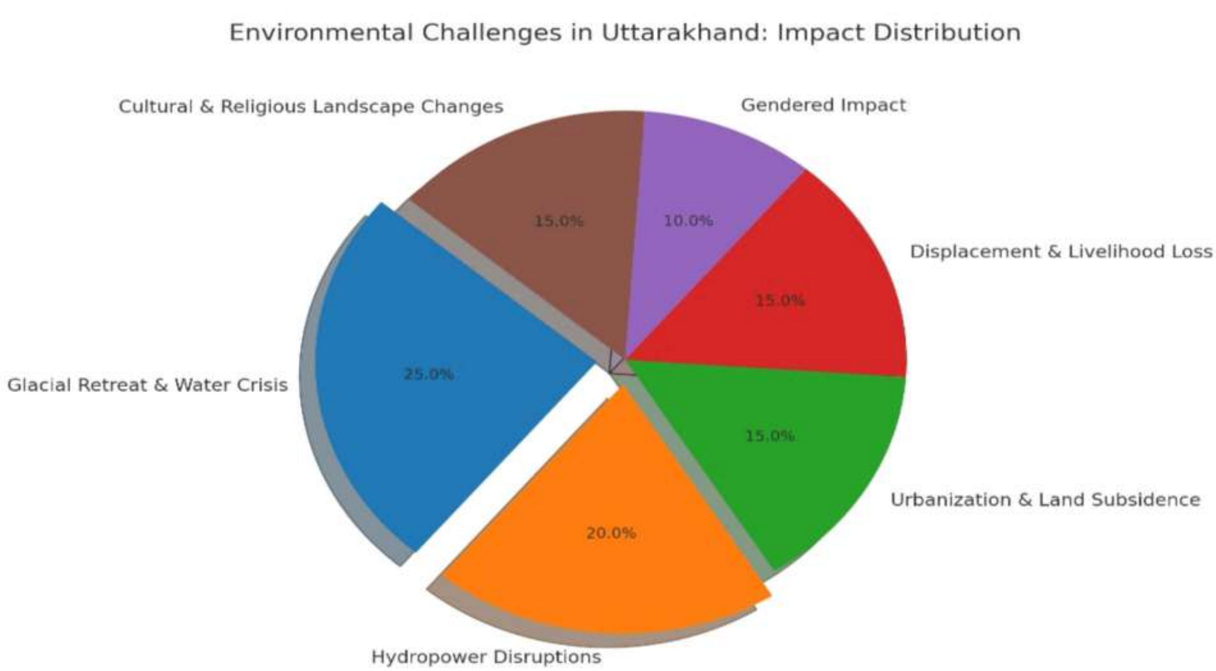
Joshimath, a crucial transit town for religious pilgrims and tourists, is experiencing land subsidence at a rate of 5 cm per month (Wadia Institute, 2023). Key factors contributing to Joshimath's crisis:

1. Unplanned Infrastructure Development:

The Char Dham Road Project and hotel construction boom have weakened the natural drainage system. The town sits on a fragile glacial deposit, making it highly susceptible to sinking.

2. Groundwater Depletion:

The excessive extraction of groundwater for tourism and domestic use is destabilizing the subsurface layers.



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3. Seismic Vulnerability:

Uttarakhand lies in Seismic Zone IV and V, meaning it is highly prone to earthquakes. This aligns with Ulrich Beck’s "Risk Society" theory, which argues that modern development projects create new forms of environmental risks that disproportionately affect marginalized communities.

The pie chart represents the distribution of key environmental challenges affecting Uttarakhand, based on their severity and impact. Below is a breakdown of each segment:

1. Glacial Retreat & Water Crisis (25%)

The largest segment (25%) highlights the accelerated retreat of glaciers like Gangotri, leading to water scarcity, increased flooding, and long-term ecological instability. The threat of Glacial Lake Outburst Floods (GLOFs) is rising, putting local communities at constant risk of disasters. This issue has severe implications for agriculture, drinking water supply, and river ecosystems.

2. Hydropower Disruptions (20%)

Uttarakhand’s reliance on large-scale hydropower projects is causing ecological damage, displacement, and increased vulnerability to landslides and earthquakes. The Tehri Dam and Chamoli disaster (2021) are key examples of how unregulated hydroelectric expansion contributes to environmental degradation. Reduced sediment flow in rivers affects downstream agriculture and aquatic life, altering the natural ecosystem balance. 3. Urbanization & Land Subsidence (15%)

Unplanned construction, deforestation, and over-extraction of groundwater are causing land subsidence in towns like Joshimath. Tourism-driven expansion has led to illegal constructions in ecologically fragile zones, increasing disaster risks. The Char Dham Road Project has weakened the Himalayan slopes, triggering landslides and infrastructure failures.

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4. Displacement & Livelihood Loss (15%)

Due to hydropower projects, floods, and land subsidence, over 50,000 people have been displaced. Many are forced into slum settlements in urban centers, losing access to traditional agriculture and forest-based livelihoods. Compensation policies are inadequate, leading to economic instability and social distress.

5. Gendered Impact (10%)

Women in rural Uttarakhand bear the brunt of environmental degradation, as they are responsible for water collection, farming, and household management. Men are migrating to urban areas for work, increasing the burden on women left behind. Water shortages and crop failures are deepening gender inequalities.

6. Cultural & Religious Landscape Changes (15%)

The reduced flow of the Ganga River due to dam construction is affecting religious rituals, pilgrimage, and cultural practices. Many sacred forests and shrines have been submerged due to infrastructure projects. The loss of indigenous environmental knowledge is eroding traditional conservation practices.

Key Takeaways from the Pie Chart

✔ Glacial retreat and hydropower projects are the two largest environmental threats, together accounting for 45% of the crisis.

✔ Urbanization and unplanned infrastructure (15%) are accelerating disaster risks, as seen in Joshimath's sinking crisis.

✔ Displacement (15%) is leading to increased migration and economic instability in rural areas.

✔ Women (10%) and cultural heritage (15%) are also facing significant but often overlooked challenges due to environmental degradation.

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The environmental crisis in Uttarakhand is a multi-faceted issue that requires urgent interventions in sustainable development, disaster preparedness, and ecological conservation. The chart illustrates how climate change, human activities, and policy failures interact to create a fragile socio-ecological system. Addressing these issues requires a shift towards community-led conservation, stricter environmental regulations, and alternative renewable energy strategies.

4.2 Socio-Economic Implications

4.2.1 Displacement and Livelihood Loss

Over 50,000 people have been displaced in Uttarakhand due to hydropower projects and climate-induced disasters (MoEFCC, 2023). Many displaced families receive inadequate compensation, forcing them into poverty and urban slums. Loss of traditional farming practices due to unpredictable weather and soil erosion has increased rural unemployment.

4.2.2 Gendered Impact

Women bear the disproportionate burden of climate change, especially in rural areas where water sources are drying up. With men migrating to cities for work, women are left to manage both agricultural labor and household responsibilities.

[3]

4.2.3 Cultural and Religious Landscape Transformation

The reduction in Ganga's water flow due to dam construction is affecting religious rituals and pilgrimage traditions. Traditional forest-based knowledge systems of indigenous communities are being lost due to

[3] National Institute of Disaster Management (NIDM). (2023). Joshimath Land Subsidence: Causes, Impacts, and Remedial Measures provides crucial insights into the ongoing land subsidence crisis and its relation to unplanned infrastructure expansion.

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forced resettlement.

5. Policy Recommendations

5.1 Sustainable Development Planning

1. Eco-Sensitive Zoning (ESZs):

Restrict construction in high-risk areas like Joshimath, Kedarnath, and Chamoli. Enforce strict building codes that prioritize earthquake-resistant and eco-friendly designs.

2. Regulating Tourism Expansion:

Implement a carrying capacity model for pilgrimage and eco-tourism sites.

Promote homestays and small-scale eco-tourism over large hotels and resorts.

3. Agro-Ecology Promotion:

Support organic and climate-resilient farming as an alternative to migration -driven urbanization. Provide subsidies for sustainable irrigation techniques.

5.2 Hydropower and Energy Transition

1. Limit Large-Scale Hydropower Projects:

Conduct cumulative impact assessments before approving new projects.

Encourage run-of-the-river hydro projects that do not involve large dams.

2. Invest in Renewable Energy Alternatives:

Scale up solar and wind energy investments in Uttarakhand.

Promote community-owned microgrids to decentralize energy access.

5.3 Community-Led Conservation and Governance

1. Empower Gram Sabhas in Environmental Decision-Making:

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Implement Community Forest Rights (CFRs) to involve locals in conservation efforts.

2. Indigenous Knowledge Integration:

Recognize and support traditional water conservation systems (Naulas, Dhara).

3. Strengthen Disaster Preparedness:

Expand early warning systems for flash floods, GLOFs, and landslides.

Train local youth in disaster response and first aid.

5.4 Disaster Resilience and Climate Adaptation

1. Reforestation and Watershed Management:

Afforestation programs should prioritize native species over commercial plantations.

2. Climate-Resilient Infrastructure:

Construct green-roofed homes and flood-resistant housing.

3. Economic Diversification:

Promote rural employment schemes in climate-resilient industries like handicrafts and forest-based livelihoods.

Conclusion

The environmental crisis in Uttarakhand is a complex socio-ecological problem requiring urgent, multi-sectoral interventions. A sustainable future depends on shifting from exploitative development models to community-driven conservation efforts. Key takeaways: 1. Restrict unsustainable hydropower and infrastructure expansion. 2. Adopt policies that prioritize local livelihoods and ecological resilience. 3. Integrate indigenous knowledge and community governance into disaster planning. A holistic

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approach combining scientific, sociological, and ecological strategies is necessary to preserve Uttarakhand’s fragile environment while ensuring social justice for its communities.

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Floods in Indian Rivers: Are Dams and Embankments the Solution or the Problem?

EPW Engage

Abstract: While dams and embankments are often touted as interventions for better flood management, they have often been at the root of more severe flood disasters.

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Flash floods, suspected to have been precipitated by a glacial lake outburst, have wreaked widespread destruction in Uttarakhand's Chamoli district, starting on 7 February 2021. Over a 100 people were reported to be missing in the days after the glacial lake outburst flood, as two hydropower projects were severely damaged—the missing included labourers working at the project sites.

This is not the first flood disaster in the country to be linked to a river project or a dam. Do dams and hydroelectric projects on rivers damage the riverine ecology and exacerbate damage due to floods? We look for answers in the *EPW* archives, with this reading list.

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Floods—Natural or Man-made Disaster?

In the classification of disasters into natural and man-made, floods are often categorised under natural disasters. For instance, the National Institute of Disaster Management lists "floods" under the subhead of "natural disasters." Similarly, the World Health Organisation calls floods "the most frequent type of natural disaster."

Yet, such a characterisation masks the human causes of flood damage. Shekhar Pathak (2020) observed:

> Floods have been a part of the natural system of the earth from the earliest times, along with earthquakes, landslides, avalanches, hurricanes and tsunamis. However, since the introduction of agriculture and urbanisation, human activity has been directly contributing towards floods.
>
> … Man-made structures such as dams and barrages, hydropower projects, unsustainable mining, deforestation, catchment degradation and encroachments in the riverbeds and climate change have also contributed to the cause and nature of floods.

In the context of the annual flooding of the Brahmaputra River in Assam, an *EPW* editorial (2017) wrote:

> Although the recurrent floods are a natural phenomenon, they are also an outcome of anthropocentric interventions. It is natural that the high precipitation in the Himalayas–the catchment of most of the tributaries of the Ganga and Brahmaputra–coupled with the sudden fall in altitude results in a large volume of water gushing down river channels from the Eastern Himalayas into the floodplains. This water exceeds the carrying capacity of the river channels resulting in a spillover into adjoining areas. But with increased deforestation in the Eastern Himalayas, the surface run-off has increased at the cost of infiltration leading to tons of sediment being deposited on the riverbed as the river reaches the plains. This further reduces

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> the carrying capacity of the river and enhances the risk of flooding. The plan to build large dams in upstream areas, largely in Arunachal Pradesh, is likely to exacerbate this process.

Role of Dams

While dams are often touted as a method to control flooding of rivers, they are also at the root of many flood disasters.

Himanshu Thakkar (2018) explained:

> In theory, every dam can help moderate floods in the downstream areas, as long as it has space to store water, and depending on the amount of space available. In fact, every action that helps store, hold, recharge (to groundwater aquifers), or delay the flow of rainwater from the catchment to the river helps moderate its flow, and, in turn, moderates floods in the river. However, our catchments are fast losing this capacity, due to the continued destruction of natural forests, wetlands, local waterbodies, and also the soil's capacity to hold water.
>
> … In practice, the potential capacity of dams to help moderate floods can be realised only when they are operated with this objective in mind. When dams are not operated with such an objective, and are, instead, filled up as soon there is water available, there is no space left to store more water. The only alternative then is to release all the inflow into the downstream river. Due to this, in downstream areas, which are already facing floods due to local rainfall or other reasons, the dams end up increasing the magnitude of the flood disaster.

He supplemented his explanation with examples of floods in India that have been exacerbated by dams:

> There are numerous instances of this kind, including the floods in Uttarakhand (June 2013), Tehri (September 2010), Hirakud (2009, 2011, 2014), Damodar dams (multiple

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years), Krishna basin dams (2006, October 2009), Ukai (August 2006), Chennai floods (December 2015), Bansagar dam (August 2016), Kurichu dam in Bhutan (2004, 2016, others), and Ranganadi (2017) and Doyang (2018), among other dams, where flawed operation of the dams created or worsened flood disasters in the downstream areas.

Building on Thakkar's analysis, Pathak (2020) wrote:

> Floods caused by a dam are sudden, and given its intensity and the unpreparedness of people living in surrounding areas, its impact is more destructive to lives and property. The sudden nature of floods caused by dams, together with the reluctance of authorities to share information with people, makes communities vulnerable in a two-term monsoon region like Kerala. In an undammed river, the flood water rises over a period of time, which allows people to respond. Moreover, due to the dam the contours of the riverbed, the flow of the river downstream and even the floodplains change. Besides, dams tend to give a false sense of security because people tend to forget even the normal impact on rivers due to the monsoons.

Focusing on the phenomenon of floods in Kerala, Pathak analysed:

> A combination of heavy rains and breaching of the dams triggered the 1924 floods that killed more than a thousand people and damaged property, including houses, roads, bridges as well as livestock and standing crops. The 2018 floods have been called a "repetition of this tragedy," as they were also caused due to the combined strength of heavy rains and inefficient dam management.

Even though he identified separate causes behind the floods in Kerala and Uttarakhand based on the different ecological factors at play, the common thread remained dams. Speaking of the 2013 Uttarakhand floods, he wrote:

> Natural silt, which comes with rivers from glaciers, debris created by faulty road-building, construction debris and muck deposited by hydroelectric companies near

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> riverbanks accelerated the flood. The collapse of many hydroelectric power projects in different valleys increased the devastation. The course of rivers were blocked by the immense amount of debris that caused major overflow.
>
> The Ravi Chopra Committee (2014) stated that dams played a role in worsening the disaster in the Uttarakhand floods.

Provided further examples of "dam-induced" floods, Mirza Zulfiqar Rahman (2020) elucidated the problem of "infrastructuring floods":

> The downstream communities of Assam of the 405 megawatt (MW) Ranganadi hydroelectric project in Arunachal Pradesh, for instance, experience catastrophic dam-induced flash floods in the monsoon months, while for the rest of the year they see the river as a trickle. The communities talk of "theft of their river," of "run-away-with-the-river" while they were promised a "run-of-the-river" dam project, and had no experience of dam-induced flash floods before the dam was built in 2002 (Rahman 2014). This underlines the aspect of infrastructuring floods, and of creating new flood discourses.
>
> Such dam-induced flood hazards are spread across the Brahmaputra river basin, for instance, the Doyang and Kopili hydroelectric projects in Nagaland and Assam respectively, and the several dam projects being built in upstream Bhutan, China, and the multitude of proposed small, medium and mega dams in Arunachal Pradesh.

The problems of flood damage due to dams need to also be seen in light of the government's disaster management preparedness. In this regard, Pathak highlighted:

> Around 5,254 completed dams in India are an integral part of flood management, apart from storing water for irrigation and generating power. The Comptroller and Auditor General of India (CAG) report of 2017 submitted in Parliament said that there is an emergency action plan available for only 7% of these 5,254 dams (CAG

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2017). For the 61 dams in Kerala, there are no emergency plans.

Role of Embankments

Apart from dams, another oft-touted method of flood management is embankments. But these too have been known to be ineffective.

For instance, an *EPW* editorial (2020) observed:

> In both Bihar and Assam, the approach of the government policies to mitigate the impact of floods has been mainly focused on building embankments. However, the increasing intensity of floods had made these embankments largely ineffective. Moreover, no cost–benefit analysis has been done so far to determine the effectiveness of embankments.

Instead, embankments have been criticised for their counter-effective impact of exacerbating floods and causing flooding over a more expansive area. J Albert Rorabacher (2008) wrote about the expansion of flood-prone areas in Bihar after the large-scale construction of embankments post-independence:

> The British had attempted to "tame" the Damodar, beginning in 1854 but by 1869 they had abandoned the idea of embankments completely. Never again would the British attempt to control the flooding of Indian rivers using levees or embankments.
> In 1954, when the Bihar flood policy was first introduced, Bihar had approximately 160 kms of embankments. These embankments were referred to as zamindari and maharaji bandhs and were administered by the department of revenue. At this time, the flood-prone area in the state was estimated to be 2.5 million hectares. Upon the completion of the system of embankments, 3,465 kms of embankments had been constructed and were administered by the Water Resources Department (WRD) [Krishnakumar 1999]. However, the amount of flood-prone land increased to 6.89 million hectares [Karunakaran 2004:1-2]! All one needs to do is look at a topographic

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> map of Bihar, to see that the flood-prone area is now also the area the government says is already protected!

An *EPW* editorial (2017) described how embankments can be dangerous both in areas that they divert water away from and in areas that they divert water to:

> Embankments were constructed to create a "safe" area for habitation and they provide these in areas where the embankments are new. But in areas like North Bihar and Assam, where there has been a fairly long history of embankments, the situation is complicated. Large populations continue to stay inside the embankment, that is, outside the "safe" areas, at the mercy of the imminent flood. Unfortunately, people located in the "safe" area also live in constant fear of embankment breach. Their fear is not completely unfounded—the floods in Assam this year and the Kosi River flood of 2008 were outcomes of embankment breach. Furthermore, people living inside the embankment face the risk of flash floods and sailaab floods. The latter is due to a gradual increase in water level, while the former, as was seen in Uttarakhand in 2013, occurs when there is sudden high discharge from a reservoir into the river channel.

Rorabacher listed the main problems with the use of embankments in flood management in Bihar—the build-up of silt, sand, gravel and stone in the riverbeds, increased height of the mean water level of the rivers, and scouring of embankments leading to catastrophic breaches. He explained:

> Prior to the construction of the bandhs, when the rivers were in spate, they would gently sweep across the landscape, depositing their burden of silt. As the rivers were channelised, their velocity increased, thus allowing the waters to carry, in addition to silt, sand and gravel and rocks. Initially, this burden was deposited in the river channels, as defined by the levees ... the mean level of the rivers rose, as the original river bed was filled with debris. Soon, the mean levels of the rivers were higher than the original floodplains. In some areas, the river levels increased to heights of three to four metres above their floodplains, requiring that the levees be further strengthened

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> and elevated.
>
> ... Before the embankments, the sand, gravel and stone that the rivers carried was released soon after the rivers entered Bihar. Farther downstream, the waters carried only silt. Now, sand, gravel, stone and silt are carried much farther downstream. The sand, gravel and stone, in addition to filling the old river beds, scour the face of the embankments. In time, the scouring action eats away at the embankments and creates holes or breaches in the levees.

He further explained that floods caused by embankment breaches were more severe than the regular flooding of the rivers:

> The breaches, in and of themselves, would not be catastrophic but the increased height of the mean river levels causes them to become catastrophic. Instead of simply spreading out over the flood plain, the rivers now cascade/crash down onto the floodplains below. These cascades carry with them sand, gravel and stone. These are then deposited on the surrounding landscape. In many areas, the accumulation of sand and gravel has made cultivation impossible.
>
> ... Some villagers insist that they are prepared to deal with natural floods. "It was man-made floods that wreaked havoc on them [farmers] all these years" [Karunakaran 2004:3]. The floods that come through the unrepaired breaches rise slowly, not like bulldozers smashing everything in their path, as happened when the levees breach suddenly and without warning.

Another adverse effect of the embankments in Bihar is the loss of agricultural productivity of the soil in the region:

> Between waterlogging and lands lost to sand and gravel deposits, cultivators have lost well over 8,00,000 hectares of previously cultivable land. At every turn, the land base of the cultivators of Bihar is shrinking, all in the name of flood protection. The loss of land means a loss of agricultural production.

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Kumud Bhushan Ray (1954) warned against embankments as a flood management intervention, citing the example of the Mississippi river in the United States:

> It will thus be seen that the flood embankments along the Mississippi continued to be breached in spite of their heights having been raised, and it became necessary to carry out channel improvement works at a considerable cost annually... Thus even ordinary flood, not to speak of major floods, are likely to cause breaches in flood embankments in China or India in some year or other, as had happened in the Mississippi embankments before 1927. Moreover, the fact that embankments along the rivers in China have now been strengthened and that they are being well maintained will give inhabitants of river-side lands a sense of security, so that they will cease to be on the alert. Hence when flood embankments arc breached and lands are suddenly submerged, there is the danger of greater flood damage along the embanked reaches of the yellow, Huai, and Yangtze rivers in China and the Kosi and Brahmaputra in India.

Politics of Flood Management

Despite the availability of research and literature on the drawbacks of infrastructural approaches to regulating floods, why do dams and embankments continue to be constructed on rivers?

Rahman (2020) placed the blame of such policies on the technological fix mindset and extractive nature of the water bureaucracies or "hydrocracies":

> The abilities of the hydrocracies in promoting technological fixes, lock-ins and regimes through their technical expertise, material capabilities, discursive power, knowledge production, building of narratives, agenda-setting capabilities, securitisation and political support to influence and gain from river development projects make for a heady mix of power and hubris. (Molle et al 2009; Mirumachi 2015)

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In the context of floods in the Brahmaputra, he wrote about the interrelated motives of the state and private dam construction companies in contrast with the risks for riverine communities:

> The geological and hydro-climatic hazardscape of the Brahmaputra river basin, overlapping with the eastern Himalayas, is under a perpetual shadow of unequal risk, constructed by aggressive state-led hydropower development policies (Huber 2019). The deployment of the narrative of hydropower dams in the hands of public and private dam construction companies, with scant regard to cumulative environmental impact assessments or public consultations (Vagholikar and Das 2010) brings such extractive policies of the hydrocracies as a site of popular public resistance by riverine communities against the dispossession of their lives and livelihoods (Baruah 2012). The cumulative layers of jeopardy are materialised for communities living in the Brahmaputra river basin through such embankment-induced and dam-induced floods.

These contrasting political interests are embedded in the "development" projects in the region and are often tacked on with "national security" dimensions:

> The hubris of large river-engineering projects in a geologically fragile and high-seismic region such as the eastern Himalayas comes from strong political support, and an overarching national security frame, which supersedes any traditional community world views of the river. The strong political backing to the hydrocracies is seen in India (Piper 2017) as well as in China (Ball 2017). Large river-infrastructure projects, such as hydropower dams in Arunachal Pradesh, for instance, are pushed in the name of national security, the logic being if China is building dams upstream, so must India. This has led to a sense of democratic deficit among riverine communities in North East India in their abilities to participate in decision-making on environmental governance of rivers, ecologies that are sacred to their socio-cultural world views. (Rahman 2019)

While such technological interventions have become commonplace, they continue to have a real effect on increased flood damage in the region.

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> The art of infrastructuring floods is not something new, and history is replete with examples of flood control engineering projects causing massive floods, both within India (D'Souza 2006), and in neighbouring China, where the rural countryside were deliberately flooded to protect important cities, during the 1954 Yangtze floods (Courtney 2018). The catastrophic floods seen in the Brahmaputra river basin as well as in China's Yangtze river basin in 2020, are stark reminders of how the respective hydrocracies of India and China imitate each other in many ways, infrastructuring floods and inflicting annual suffering upon riverine communities in the longue durée.

Adding another dimension to the problem of politicisation of floods, Rorabacher (2008) argued that one reason why embankments continue to remain a part of the flood management strategy in Bihar is the vested interests of politicians and businesses:

> The cost of the embankments is not just an issue of upkeep or maintenance, which amounts to millions of rupees annually. The maintenance of the embankments is big business for engineers, contractors and politicians. Each group has a vested interest in keeping the levees in place. None wants to cut the throat of its own personal cash cow.

He went on to contend that flood disasters themselves could be beneficial to certain interests:

> Added to the annual maintenance costs are the relief costs. Again, contractors and politicians have no reluctance accepting the money or praise their relief efforts engender among those being assisted. Entire humanitarian aid organisations would lose their mandate without the annual floods in northern Bihar. They, too, have no reason to resolve the problems of the people they serve. If the reports are to be believed, government-sponsored relief reaches no more than 10 to 15 per cent of the affected people. Where do all the monies and supplies go?

Benefits from flood disasters could also be in terms of gaining political mileage. In the context of recurring floods in coastal regions of Odisha, Kishor C Samal (2011) highlighted:

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> Politicians belonging to the state's ruling party were seen openly indulging in the "politics of relief". Even as the state government was conducting relief operations, these leaders would visit the affected areas almost daily to distribute relief materials they had collected from the private sector. In the worst affected areas the scene resembled that of the pre-poll days. Luxury vehicles carrying these politicians flocked to these areas and they did not forget to ensure that the media followed them everywhere (The Hindu, 22 September). It has been alleged that almost all the ruling party politicians badgered the district administration to keep their constituencies in mind during relief distribution. Their concern was no doubt also due to the massive compensation funds that were to be distributed in the flood-affected areas and the equally huge sums that would be spent for reconstruction and rehabilitation works.

Even when vested political and financial interests are not imputed, bureaucratic inefficiencies of the state contribute to mismanagement of floods. On the floods in parts of West Bengal in 1998, Nileen Putatunda (2001) wrote:

> It was not so much the torrential rain in northern and western India that caused the devastating floods in Malda in 1998. The blame must lie with the state government and Farakka Barrage authorities who failed to take proper preventive measures. The real reasons for the flood were breaches in the 1.5 km embankment along Farraka Barrage, weakened by theft of mud from its walls; failure to erect spurs – long poles on the banks to control direction of flow – along the Ganga at Farakka and failure to dredge the Ganga. There might have been some respite for Malda had the 27th and 28th spurs at Manikchak, along the Ganga, been put up to deflect the water current; but the Farakka Barrage authorities, who were in charge of the Rs 80 crore project, delayed it for months. When they finally decided to issue tenders, it was a case of too little, too late. Floodwater had submerged towns, villages and highways and left thousands homeless.

Rethinking Development to Manage the Impact of Floods

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> The Fifth Assessment Report of the Inter Government Panel on Climate Change (IPCC) released in February-March 2015 suggests an increasing vulnerability to natural disasters like floods in the coming years.
> ... The National Flood Commission of India states that 40 million hectares of land in India is flood prone which makes India one of the highly flood prone nations of the world.

—noted Aprajita Singh (2015), emphasising the "urgent need for the government to rethink its flood management approach and practices."

The approach to floods needs to look beyond infrastructural interventions and adopt inclusive policies that take into account stakeholders from riverine communities. What needs to be understood is that flooding of rivers is a natural phenomenon that need not devolve into a disaster. Calling the river a "living reality that needs space," Putatunda (2001) wrote:

> Inundation is a natural phenomenon, but when it affects people and damages property, we hype it as 'the ravages caused by floods'. What we forget is that the entire area in which homes and cultivation fields have developed – the Bengal delta – is the creation of annual inundation over millions of years. It is only greed that has forced settlements right on the banks, reclaiming land prematurely, against the wishes of nature. Now, the river has been forced to rebel and hence the floods. The river is a living reality that needs space.

In this regard, Dinesh Kumar Mishra (2001) highlighted the futility of technological methods of "flood management:"

> Modern flood control technologies have neither been very successful nor are they people-friendly. This is because their focus is on trying to control the waters of rivers in spate and not of making use of the flood waters in the best possible way, while ensuring the least damage.

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Accordingly, an *EPW* editorial (2017) proposed:

> What is required is an important normative shift that sees floods as a natural phenomenon, and a change in the discourse from flood protection to flood governance. Flood protection necessarily starts and ends with structural intervention and provision of relief. Flood governance would require the innovative combination of initiatives undertaken at various levels. At one level, it is important to conduct "strategic environment assessment" of all development activities in the ecologically pristine locations of the Eastern Himalayas and aim for river basin management. This might include some structural interventions. At the institutional level, strengthening the moribund Brahmaputra Board in Assam, and staffing it with scientists from a broad range of disciplines is essential. But the most important shift would be to plan a comprehensive initiative to build resilience within the riverine population through an integrated set of interventions which should be based on three pillars: reducing vulnerability, enhancing access to developmental services that flood-prone populations are deprived of, and creating conditions that enable the optimal use of people's resources.

Pathak (2020) also argued:

> Our approach to conservation, equity and climactic changes and their impact on everyday life, and on calamities should be relooked at in order to evolve new ways of sustainability and eco-sensibility, which are needed in both the regions [the Himalayas and the Western Ghats]. Natural calamities will be there, but we will be able to minimise their fury and the loss of human lives if our approach takes into account the changing realities of climate change.

Flood management can also not be viewed in isolation and has to be integrated as part of a holistic environmental policy that rethinks "development" altogether. An *EPW* editorial (2020) wrote:

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Environmentalists have argued that an approach that integrates water management with land use planning, agriculture, and ecology is needed to manage floods. For a long-term sustainable solution, a "basin-wide approach" that would bring together all the basin-sharing countries and states has been advocated to address the problem at the source. Additionally, it needs to be recognised that the political and economic systems that prioritise overconsumption and growth have also led to the destruction of nature. This being the root cause of recurring natural disasters, there is an urgent need to pursue alternative models of development that also accord importance to nature and its conservation.

Read More

India's Relief and Rehabilitation Efforts Need to Be Revised for a More Inclusive Approach to Disaster Management | *EPW* Engage, 2019

Dams and Development | Anant Phadke, 2002

Floods in Uttarakhand: A New Deal Relief | Hui Chi Goh, Mehul Pandya and Mihir R Bhatt, 2013

Flood Disasters and Forest Villagers in Sub-Himalayan Bengal | Bidhan Kanti Das, 2009

Flood Prevention in the Rivers of Bihar, North Bengal and Assam | Kumud Bhushan Ray, 1954

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मैं गोवर्धन पुत्र श्री स्व० गोकुल देव ग्राम- चन्द्रापुरी जिला रुद्रप्रयाग का निवासी हूँ। 2013 की आपदा में एल० एण्ड० टी० के भटवाड़ी सिगोली जल विद्युत परियोजना के कारण मेरा मकान एवं जमीन पूर्ण रूप से बह गए थे। जिस कारण हमारे पास कोई भी रोजगार का साधन नहीं है। परिवार को पालना बहुत ही मुश्किल हो रखा है। मेरी आर्थिक स्थिति बहुत कमजोर है। मैं अनुसूचित जाति का हूँ। मेरी माता जी का स्वास्थ्य ठीक नहीं है जिस कारण से मेरे को उपचार हेतु अस्पताल बार-बार जाना पड़ता है।

आपदा के बाद हमारी स्थिति बहुत खराब हो गई है। बच्चों की पढ़ाई- लिखाई नहीं कर पा रहा हूँ। मैंने अपने रिश्तेदारों से पैसे कर्ज ले रखे हैं। जिसको चुकाने में भी असमर्थ हूँ। आपदा के बाद जीवन बहुत ही बुरे समय से चल रहा है।

प्रार्थी गोवर्धन
गोवर्धन पुत्र स्व० श्री गोकुल देव
ग्राम- चन्द्रापुरी
जनपद- रुद्रप्रयाग

//TRUE COPY//

मैं रजपाल लाल पुत्र स्वर्गीय श्री कुत्ता लाल ग्राम-चन्द्रापुरी तहसील - बसुकेदार जिला- रूद्रप्रयाग का निवासी हूँ मेरा मकान । गोशाला । खेती बाड़ी वर्ष 2013 । मंदाकिनी नदी में भटवाड़ी - सिंगोली परियोजना के मलबे बहकर आने के कारण भीषण बाढ़ । आपदा में बह गया था।

जिस कारण हमारे पास कोई भी रोजगार का साधन नहीं है। कभी कोई काम मिल जाता है तो कर लेता हूँ, वरना बच्चों को पालना बहुत ही मुश्किल हो गया है। आपदा के पश्चात रोजगार ना होने के कारण बच्चों की अच्छी शिक्षा - दीक्षा नहीं हो पा रही है। मुझ पर परिवार के सदस्यों को पालने का बोझ है। रोजगार ना होने के कारण मेरी आर्थिक स्थिति दयनीय हो गयी है।

रजपाललाल

प्रार्थी

(श्री रजपाल लाल)

ग्राम - चन्द्रापुरी

तहसील - बसुकेदार

जिला - रूद्रप्रयाग

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मैं सुनील कुमार पुत्र श्री अमर लाल ग्राम - चन्द्रापुरी जिला - रुद्रप्रयाग 2013 केदारनाथ आपदा प्रभावित हूँ 2013 की आपदा में एल० एंड टी० के भटवाड़ी सिंगोली जल विद्युत परियोजना के कारण हमारा मकान व जमीन पूर्ण रूप से बह चुके थे. जिस कारण हमारे पास कोई भी रोजगार का साधन नही है। कभी कोई काम मिल जाता है तो मजदूरी कर लेता हूँ. वरना बच्चों को पालना बहुत ही मुश्किल हो रखा है. आर्थिक अभाव के कारण स्वास्थ्य भी ठीक नही है. मैं अनु० जाति का सदस्य हूँ।

मुझ पर माता-पिता (बुर्जुग) की जिम्मेदारी भी है. जो कि अक्सर बिमार रहते हैं, तथा मैंने रिश्तेदारों से कुछ धनराशि कार्ज के रूप में ली थी जिसे चुकाने में भी असमर्थ हूँ। आपदा के बाद जीवन बहुत ही बुरे दौर से गुजर रहा है।

प्रार्थी [signature]

श्री सुनील कुमार S/o श्री अमरलाल
ग्राम + पो० ओ० - चन्द्रापुरी
जिला - रुद्रप्रयाग

[signature]

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मैं भागा देवी पत्नी स्वर्गीय श्री तौंगी लाल ग्राम- -चन्द्रापुरी तहसील - बसुकेदार जनपद - रुद्रप्रयाग की निवासी हूँ, मेरा मकान / गोशाला / खेती बाड़ी 2013 में मंदाकिनी नदी में भटवाड़ी - सिंगोली परियोजना का मलबा बहकर आने के कारण भीषण बाढ़ / आपदा से बह गया था।

मेरे पति हृदय रोग ग्रासित हो गये किन्तु उक्त आपदा के कारण घर - गृहस्थी, पशु एवं भूमि बह जाने के कारण आय के सभी स्त्रोत खत्म हो गये, जिस कारण समय पर उनका इलाज नहीं करा पाये परिणाम स्वरूप अब वो हमारे बीच नहीं रहे, मैं स्वंय भी गरीब, बुजुर्ग एवं बीमारी से ग्रस्त महिला हूँ, आय का कोई भी साधन ना होने के कारण मेरी पारिवारिक स्थिति बहुत खराब हो गयी है जीवन - यापन भी बहुत ही मुश्किल हो गया है।

प्रार्थिनी
(श्रीमती भागा देवी)
पत्नी श्री स्वर्गीय तौंगी लाल
ग्राम - चन्द्रापुरी
तहसील - बसुकेदार
जिला - रुद्रप्रयाग

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मैं नन्द लाल पुत्र स्वर्गीय श्री - काला लाल ग्राम - चन्द्रापुरी तहसील - बसुकेदार जनपद - रुद्रप्रयाग का निवासी हूँ। मेरा मकान / गोशाला / खेती - बाड़ी वर्ष 2013 संदाकिनी नदी में भटवाड़ी - सिंगोली परियोजना का मलबा बहकर आने के कारण आयी भीषण बाढ़ / आपदा में बह गया था।

मैं एक बेरोजगार एवं साइटिका रोग का मरीज हूँ। आपदा में घर - गृहस्थी, पशु बह जाने के कारण आमदनी के सभी स्त्रोत खत्म हो गये। यही कारण है कि मैं स्वंय का इलाज कराने सहित रोजी - रोटी कमाने में असमर्थ हूँ।

जिससे मेरी पारिवारिक स्थिति बहुत दयनीय बनी हुई है।

नन्दलाल

प्रार्थी
(श्री नन्द लाल)
पुत्र स्व० श्री काला लाल
ग्राम - चन्द्रापुरी
तहसील - बसुकेदार
जिला - रुद्रप्रयाग

मैं रमेश लाल पुत्र स्व० श्री कुन्दनलाल ग्राम-चन्द्रापुरी का आपदा पीड़ित परिवार हूँ, आपदा में हमारा मकान पूर्ण मन्दाकिनी नदी की भेंट चढ़ गया है जिससे प्रार्थी परिवार पालन के साथ-2 मकान का निर्माण किया गया है जो कि समुचित स्थिति में नहीं है प्रार्थी द्वारा उत्तराखण्ड बहुउद्देशीय वित्त एवं विकास निगम लिमिटेड से वर्कशॉप हेतु ऋण ले रखा है जिसकी भरपाई आज दिन तक नहीं हो पाई है आर्थिक स्थिति अच्छी नहीं है जिससे बच्चों की पढ़ाई-लिखाई पर भी प्रभाव पड़ रहा है अतः आप सरकार से प्रार्थना है कि मुझ गरीब अनुसूचित जाति के परिवार को अपने स्तर पर सहायता ऋण माफ कराई जाय आपकी महान कृपा होगी,

प्रार्थी

[signature]

संलग्न — ऋण पत्र

उत्तराखण्ड बहुउद्देशीय वित्त एवं विकास निगम लिमिटेड की प्रति सत्यापार्थ

(रमेश लाल S/o कुन्दनलाल
ग्राम व पोस्ट-चन्द्रापुरी
रुद्रप्रयाग, गढ़वाल,

[signature]

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मैं दर्शनी देवी पत्नी स्व० श्री छोटिया लाल ग्राम - चन्द्रापुरी, तहसील - बसुकेदार, जनपद - रुद्रप्रयाग की निवासी हूँ, मेरा मकान/ गोशाला/ खेती - बाड़ी वर्ष 2013 मंदाकिनी नदी में भटवाड़ी - सिंगोली परियोजना के मलबे के बहकर आने के कारण भीषण बाढ़/आपदा से बह गया था,

मेरे पति हृदय रोग से ग्रस्त हो गये किन्तु उक्त आपदा के कारण घर - गृहस्थी, पशु बह जाने से आय के सभी स्रोत खत्म हो गये, जिस कारण समय पर उनका इलाज नहीं करा पाये परिणाम स्वरूप अब वो हमारे बीच नहीं रहे, मैं स्वयं भी गरीब, बुजुर्ग एवं बीमारी से ग्रस्त महिला हूँ, आय का कोई भी साधन ना होने के कारण मेरी पारिवारिक स्थिति बहुत खराब है।

प्रार्थी
श्रीमती दर्शनी देवी पत्नी स्व०
श्री छोटिया लाल
ग्राम - चन्द्रापुरी, तहसील - बसुकेदार
जनपद - रुद्रप्रयाग

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मैं पत्नी दर्शनी देवी पत्नी स्व० श्री दर्शनलाल
ग्राम व पोस्ट-चन्द्रापुरी की आपदा पीड़ित परिवार
हूँ। जून 2013 की भीषण आपदा के परिणामस्वरूप
मकान व जमीन मन्दाकिनी नदी की भेंट चढ़ गयी
है जिससे हमारी आर्थिक स्थिति दयनीय हो गयी
है, मेरे दो बालक है जो बेरोजगार है, मेरी सरकार
से अपेक्षा होगी कि मुझे गरीब विधवा को
आर्थिक सहायता प्रदान करने की कृपा की जाय,
आपदा के उपरान्त मेरे पति श्री दर्शनलाल स्वर्गीय
हो चुके है जिससे कमाने का जरिया भी नहीं
रह गया है, अतः श्रीमान से विनम्र प्रार्थना है कि
इस आपदा पीड़ित परिवार की मदद करने की
कृपा की जाय आपकी महान कृपा होगी।

प्रार्थिनी

(दर्शनी देवी)

ग्राम व पोस्ट-चन्द्रापुरी
रुद्रप्रयाग गढ़वाल

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आपदा सम्बंधित प्रार्थना - पत्र

मैं सन्तोष चन्द्रवाल S/O श्री बुद्धिलाल चन्द्रापुरी
मैं आपदा पीड़ित चन्द्रापुरी का मूल निवासी हूँ।

आपदा में हमारा घर -मकान- खेत और पुरा सामान नदी मे
बह गया, जिससे हमारी स्थिति बहुत ही दयनीय हो गयी है,
मैं एक मजदूर हूँ जिसे सदैव मजदूरी नही मिलती है, जिससे
परिवार हमेशा परेशान रहता है, मेरे दो बच्चे है
जिनकी फीस भी समय पर देना मुसकिल हो जाता है।

अत: महोदय से निवेदन है कि हमारी आर्थिक स्थिति ठीक नही है,
टाइम पे ध्याड़ी मजदूरी भी नही मिलती है, बच्चों को
खाने - पीने में परेशानी होती है।

अत: महोदय से निवेदन है इस स्थिती को मद्दय नजर रखते
हुए कुछ सहायता देने की कृपा कीजिएगा।
हम आपके आभारी है।

प्रार्थी
सन्तोष चन्द्रवाल
पुत्र स्व० श्री बुद्धिलाल
ग्राम - व पोस्ट - चन्द्रापुरी
जनपद - रुद्रप्रयाग (उत्तराखण्ड)

सन्तोष चन्द्रवाल

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मैं कुँवरलाल पुत्र स्व० श्री माधोलाल ग्राम-चन्दौली का आपदा पीड़ित परिवार हूँ, आपदा के उपरान्त मैंने ग्राम नौली में जमीन लेकर मकान बनाया था, आपदा के उपरान्त दो साल तक किराये के मकान में रहे मकान बनने के उपरान्त एक माह तक हम ग्राम नौली में निर्मित मकान में सपरिवार रहे परन्तु एक माह के उपरान्त पत्नी की आकस्मिक मृत्यु के उपरान्त हमने नवनिर्मित मकान नौली में छोड़कर चन्दौली में अपनी माता जी के साथ रहने लगे जिससे उक्त मकान बनाने का कर्जा भी अभी तक देय है, मेरी सरकार से अपेक्षा है कि मेरे छोटे बच्चे अभी नाबालिग हैं जिससे हमारी आर्थिक स्थिति अत्यन्त दयनीय है, मैं सरकार से प्रार्थना करता हूँ कि मुझे आपदा से पीड़ित होने पर आर्थिक सहायता प्रदान करने की कृपा की जाय आपकी महान कृपा होगी,

प्रार्थी

कुँवर लाल

(कुँवर लाल पुत्र स्व० श्री माधो लाल

ग्राम व पोस्ट-चन्दौली

रुद्रप्रयाग गढ़वाल

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मैं गीता देवी पत्नी स्व० श्री इन्द्रलाल ग्राम चन्द्रापुरी जो कि जून 2013 की आपदा पीड़ित हूँ, इस आपदा के उपरान्त मेरी स्थिति मेरे पति की आकस्मिक मृत्यु के कारण मेरी आजीविका छिन गयी है साथ ही हमारे पास खेती नहीं है जिसके कारण परिवार का पालन-पोषण कठिन हो गया है, आपदा में घर-बार बह जाने से पति चिन्ताग्रस्त हो गया था जिससे वे हमें साथ छोड़ दिये तब रह न सके जिससे मैं गरीब विधवा सरकार से अपेक्षा करती हूँ कि मुझ गरीब परिवार पर अपनी कृपा दृष्टि बनाये रखे, आपकी महान कृपा होगी।

प्रार्थिनी
गीता
गीता देवी पत्नी
इन्द्र लाल चन्द्रापुरी

//TRUE COPY//

मैं सुरेन्द्र लाल पुत्र स्व० श्री रवी लाल ग्राम व पोस्ट चन्द्रापुरी जोकि जून 2013 की भीषण आपदा का पीड़ित परिवार हूँ इस आपदा की वजह से मेरा घर व जमीन मन्दाकिनी नदी की भेंट चढ़ गया है, गरीब अनुसूचित परिवार किसी प्रकार से अपनी गुजर-बसर कर रहा है, गाँव के अन्दर जमीन न होने के कारण ग्राम भटवाड़ी सुनार में दया के आधार पर कम मूल्य की मकान निर्माण हेतु भूमि खरीदी गयी है जो कि सीमित परिवार के लिए भी पर्याप्त नहीं है, पीड़ित परिवार की दशा अति दयनीय है जिससे आपदा पीड़ित होने पर मुझ गरीब परिवार पर रहम की भीख प्रदान करने की कृपा कीजिए आपकी महान कृपा होगी,

प्रार्थी
सुरेन्द्र लाल
(सुरेन्द्र लाल S/o स्व० श्री रवीलाल)
हाल ग्राम भटवाड़ी सुनार
चन्द्रापुरी रुद्रप्रयाग गढ़वाल

मैं हर्ष लाल पुत्र स्व० श्री छोटिया लाल ग्राम- चन्द्रापुरी तहसील- बसुकेदार जनपद -रुद्रप्रयाग का निवासी हूँ. मेरा मकान / गोशाला / खेती- बाड़ी वर्ष 2013 मंदाकिनी नदी में भरवाड़ी -सिंगोली परियोजना के मलवे के बहकर आने के कारण भीषण बाढ़ / आपदा से बह गया था,

मेरे पांच बच्चे है तथा एक लड़के को हृदय सम्बंधी समस्याये है. जिसके इलाज हेतु मुझे आर्थिकी का सामना करना पड़ रहा है. और अन्य बच्चों की पढ़ाई- लिखाई तथा भरण-पोषण मे भी कठिनाई आ रही है, और आय का साधन न होने के कारण पारिवारिक स्थिति बहुत ही खराब है,

प्रार्थी हर्षलाल
हर्ष लाल पुत्र स्व० श्री छोटिया लाल
ग्राम- चन्द्रापुरी तहसील - बसुकेदार
जनपद - रुद्रप्रयाग

//TRUE COPY//

मैं गुड्डी देवी स्वर्गीय श्री दिनेश लाल ग्राम चन्द्रापुरी तेहसील बसुकेदार जनपद - रुद्रप्रयाग की निवासी हूँ मेरा मकान, गोशाला, खेती - बाडी वर्ष २०13 में मंदाकिनी नदी फाटाद्दी - सिंगोली परियोजना का मलवा बहाकर आने के कारण आगी भीषण बाढ़ / आपदा में बह गया था,

मैं एक बेरोजगार महिला हूँ और २०13 के आपदा के बाद मेरे पति रोग से पीड़ित थे। आपदा में हार दुधारू पशु बह जाने के कारण आमदनी के सभी स्त्रोत खत्म हो गये थे जिस कारण हम उनका इलाज करने मे असमार्थ थे जिस कारण उनकी मृत्यु हो गयी।

अब हमारी दयानीय स्थिति बहुत खराब है जिस कारण अपने परिवार को पालन पोषण करने मे असमार्थ हूँ

प्रार्थी गुड्डी
श्रीमती - गुड्डी देवी
पति स्व॰ श्री दिनेश लाल
ग्राम - चन्द्रपुरी
तहसील - बसुकेदार
जिला - ~~रुद्रप्राग~~ रुद्रप्रयाग

I, Govardhan, s/o - Late Shri Gokul Dev, am a resident of Village Chandraprui, District - Rudraprayag. In the disaster of 2013, my house and land were completely destroyed due to L&T's Bhatwari Singoli Hydroelectric Project. Due to which we do not have any means of employment. It has become very difficult to maintain my family. My financial condition is very weak. I belong to the scheduled caste. My mother's health is not good due to which I have to regularly take her to hospital for treatment.

After the disaster, our condition has become very bad. I am not able to educate my children. I have taken loans from my relatives, which I am unable to repay. For a long time, life after the disaster has not been easier.

Applicant

Sd/-

Govardhan s/o - Shri Gokuldev

Village - Chandarpuri

District: Rudraprayag

//TRUE COPY//

I, Rajpal Lal, s/o - Late Shri Kutta Lal, am a resident of Village Chandrapuri, Tehsil - Basukedar, District – Rudraprayag. My house, cowshed, and agricultural land were washed away in the devastating 2013 flood caused by the debris flow from the Bhatwari-Singholi project into the Mandakini River.

Due to the disaster, I lost all means of livelihood. Sometimes I manage to find small jobs, otherwise it has become extremely difficult to provide for my children. Since the disaster, the lack of employment has hindered my children's proper education and upbringing. I bear the responsibility of supporting my family, and due to the absence of employment, my financial condition has become dire.

Sd/-

Applicant

(Shri Rajpal Lal)

Village – Chandrapuri

Tehsil – Basukedar

District – Rudraprayag

//TRUE COPY//

I, Sunil Kumar, son of Shri Amar Lal, resident of Village Chandrapuri, District - Rudraprayag, am a victim of the 2013 Kedarnath disaster. In the 2013 disaster, due to the L&T's Bhatwari - Singoli Hydroelectric Project, my house and land were completely washed away. As a result, I have no means of employment. Occasionally, when I get some work, I do labor jobs; otherwise, it has become extremely difficult to feed my children. Due to financial constraints, my health is also not in good condition. I belong to the Scheduled Caste community.

I am also responsible for my elderly mother and father, who remain mostly ill. Additionally, I had taken some money as loans from relatives, which I am unable to repay to them. Since the disaster, life has been going through a very difficult phase.

Applicant

Sd/-

Shri Sunil Kumar S/o Shri Umar Lal

Village & P.O. – Chandrapuri

District – Rudraprayag

//TRUE COPY//

I, Bhaga Devi, wife of the late Shri Taungi Lal, resident of Village Chandrapuri, Tehsil Basukedar, District Rudraprayag, state that my house, cowshed, and farmland were all washed away in the severe flood/disaster of 2013 due to the debris flow from the Bhatwari-Singholi project into the Mandakini River.

My husband developed a heart disease, but due to the disaster, our household, livestock, and land were all lost, leading to the end of all income sources. As a result, we could not get him treated in time, and ultimately, he passed away. I myself am a poor, elderly woman suffering from illness. Due to having no source of income, my family's condition has deteriorated severely. Managing day-to-day life has become extremely difficult.

(RTI)

Applicant

(Smt. Bhaga Devi)

W/o Late Shri Taungi Lal

Village – Chandrapuri

Tehsil — Basukedar

District – Rudraprayag

I, Nand Lal, s/o Late Shri Kala Lal, resident of Village Chandrapuri, Tehsil Byungakdar, District Rudraprayag, state that my house, cowshed, and farmland were all washed away in the severe flood/disaster of 2013 caused by the debris flow from the Bhatwari-Singholi project into the Mandakini River.

I am an unemployed person and a patient of Sciatica disease. Due to the disaster, my house, household possessions, livestock, and land were all lost, resulting in the loss of all sources of income. This is the reason I am unable to afford my own medical treatment or earn a living to support myself.

As a result, my family's condition has become extremely miserable.

Sd/-

Applicant

(Shri Nand Lal)

S/o 0 Late Shri Kala Lal

Village – Chandrapuri

Tehsil — Basukedar

District – Rudraprayag

//TRUE COPY//

I, Ramesh Lal, s/o Late Shri Kundan Lal, resident of Village Chandrapuri, am from a disaster-affected family. In the disaster, all my belongings were completely taken away by the Mandakini River. Due to the loss of the house, it is not possible for the family to survive. I have somehow tried to raise my family alonwith some additional construction in my house, which is not in complete condition. I had taken loan from Uttarakhand Bahuudeshiya Vitta Evam Vikas Nigam which I have not been able to repay till date. My economic condition is very bad, which is also affecting the education of my children. Therefore, I request the Government to provide me, who is poor and from Schedule Caste, economic assistance. I shall be highly obliged for this.

Applicant

Sd/-

(Ramesh Lal S/o Late Shri Kundan Lal)

Village and Post – Chandrapuri

Rudraprayag, Gadhwal

I, Darshani Devi, wife of Late Shri Chhotiya Lal, resident of Village Chandrapuri, Tehsil Basukedar, District Rudraprayag, state that my home, cowshed and farmland were all washed away in the severe flood/disaster of 2013 due to the debris flow from the Bhatwari-Singholi project into the Mandakini River.

My husband developed a heart disease, but due to the disaster, our household, livestock, and land were all lost, leading to the end of all income sources. As a result, we could not get him treated in time, and ultimately, he passed away. I myself am a poor, elderly woman suffering from illness. Due to having no source of income, my family's condition has deteriorated severely. Managing day-to-day life has become extremely difficult.

(RTI)

Applicant

Name – Darshani Devi

w/o Lt. Shri Chhotiya Lal

Village – Chandrapuri Tehsil Basukedar

District – Rudraprayag

//TRUE COPY//

I, Darshani Devi, wife of late Shri Darshan Lal, Village and Post Chandrapuri, am from a disaster-affected family. As a result of the drastic June 2013 disaster, my house and land got washed away by the Mandakini River, which has left our financial condition in a crisis. I have two sons who are unemployed. I request the government to help this poor widow by providing economic assistance. After the disaster, my husband Shri Darshan Lal passed away, which left no source of income for the family. Therefore, I humbly request you to help this disaster affected poor family. I shall be highly obliged for this.

Applicant

LTI and Sd/-

(Darshani Devi)

w/o Lt. Shri Darshan Lal

Village and Post Chandrapuri

Rudraprayag, Gadhwal

Disaster Related Application

I, Santosh Chandrawal, S/o Late Shri Buddhilal, Village Chandrapuri. I am a disaster-affected individual and a permanent resident of Chandrapuri.

In the disaster, our house, land, and all our belongings were swept away in the river, due to which our condition has become very dire.

I am a laborer and depend entirely on daily wage labor. Because of this, my family is always in distress. I have two children as well, and I am unable to pay their fees on time.

Therefore, I humbly submit that our financial situation is very poor. Currently, I am not getting any consistent labor work, and it has become very difficult to feed and take care of my children.

Hence, I request you to kindly consider this situation and provide us with some assistance. We will be grateful to you.

Applicant

Santosh Chandrawal

Sd/ - S/o Late Shri Buddhilal

Village & Post – Chandrapuri

District – Rudraprayag (Uttarakhand)

//TRUE COPY//

I, Kunwar Lal, s/o - Late Shri Madho Lal, Village Chandrapuri, am from a family affected by the disaster. After this disaster, I built a house in the village of Naili, after purchasing the land. For 2 years following the disaster, we lived in a rented house, and after the house in Naili village was constructed, we lived there with the entire family, for a period of one month. But after the first month, due to the sudden demise of my wife, we left the Naili house and came to stay at my mother's house in Chandrapuri village. Because of this, the loan taken to construct the house is still pending. Both my kids are unemployed due to which our financial condition is dire. I request the government to provide financial support to my family. I shall be obliged for the help.

Applicant

Sd/ -

Kunwar Lal S/o Late Shri Madho Lal

Village and Post – Chandrapuri

Rudraprayag, Gadhwal

I, Geeta Devi, w/o Late Shri Harendra Lal, Village Chandrapuri, am a victim of the disaster of June 2013. After this disaster, due to the sudden demise of my husband, our livelihood has been lost. We also do not have any agricultural land, and this has made the daily upkeep of the family very difficult. Due to the loss of home and belongings in the disaster, my husband remained very tensed and could not stay with us for long. Therefore, I, a poor widow, request the government, to bestow their blessings on my poor disaster-stricken family. I shall be highly obliged for this.

Applicant

Sd/-

Geeta Devi

w/o Late Shri Harendra Lal, Chandrapuri

//TRUE COPY//

I am Surendra Lal, s/o - Late Shri Ravi Lal, village and post Chandrapuri, from a disaster-affected family. As a result of the June 2013 disaster, my house and land got washed away by the Mandakini River, which has left our financial condition in a crisis. I am from a poor family from the Scheduled Caste, somehow making ends meet. Because of having no land inside the village, the land for construction of a house was purchased at a very low price, on the basis of mercy, in Village Bhatwari Sunar. The house is not sufficient for even a limited family. The situation of this disaster-affected family is dire, and therefore, I humbly request to help this disaster affected poor family. I shall be highly obliged for this.

Yours sincerely,

Sd/-

(Surendra Lal S/o Lt. Shri Ravi Lal)

Village – Bhatwari Sunar,

Chandrapuri, Rudraprayag, Gadhwal

//TRUE COPY//

I, Harsh Lal, s/o Shri Chhotiya Lal, resident of Village Chandrapuri, Tehsil - Basukedar, District - Rudraprayag. My house, cowshed, and farming land were washed away in the 2013 Mandakini River disaster due to the flood and landslide.

I have five children and one of my sons is suffering from heart disease for which I have to regularly take him to hospital for treatments. I am facing trouble raising my children and providing education for them. Due to extreme poverty, illness, and lack of any resources, my family's condition is very critical.

Applicant

Sd/-

Harsh Lal S/O Shri Chhotiya Lal,

Village - Chandrapuri, Tehsil: – Basukedar

District - Rudraprayag

I, Guddi Devi, w/o - Late Shri Dinesh Lal, am a resident of village Chandrapuri, Tehsil Basukedaar, District Rudraprayag. My house, cowshed, and farmlands were washed away in the disaster in the year 2013 due to the severe flood caused by the debris of the Mandakini River Bhatwari-Snigoli project.

I am an unemployed woman and my husband was suffering from a disease after the disaster of 2013. Due to the loss of household and livestock in the disaster and floods, all the sources of earning were lost and we were unable to treat him, due to which he died.

Now our financial situation is very poor due to which I am unable to feed my family.

Applicant

Sd/-

Smt. Guddi Devi

W/o Late Mr. Dinesh Lal

Village – Chandrapuri

Tehsil - Basukedar

District – Rudraprayag

Service of Affidavit to Produce Supporting Documents in Mandakini Badh Prabhavit Samiti v. L&T Uttaranchal Hydropower Ltd., MA No. 71/ 2025 in OA No. 485/2017 before NGT
1 message

Ankur Sood <ankursoodoffice@gmail.com> 3 July 2025 at 17:33
To: Ankur Prakash <ankurnagar.adv@gmail.com>, Agarwal Law Associates <mail@aglaw.in>, law@atulsharmaadvocate.com, infodesk@larsentoubro.com, cs-uttaranchal@nic.in, secy-moef@nic.in, uttaranchal@nic.in

Dear All -

Please find attached the Affidavit to Produce Supporting Documents being filed on behalf of the Applicant in the case of Mandakini Badh Prabhavit Samiti v. L&T Uttaranchal Hydropower Ltd. & Ors., MA No. 71/ 2025 in O.A. No. 485/2017 before Hon'ble NGT, New Delhi.

With regards
Ankur Sood
Advocate for the Applicant

--
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Affidavit to Produce Supporting Documents.pdf
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