Assessment of Environmental Degradation and Impact of Hydroelectric projects during the June 2013 Disaster in Uttarakhand

Part I-Main Report

Submitted to

The Ministry of Environment and Forests

Government of India

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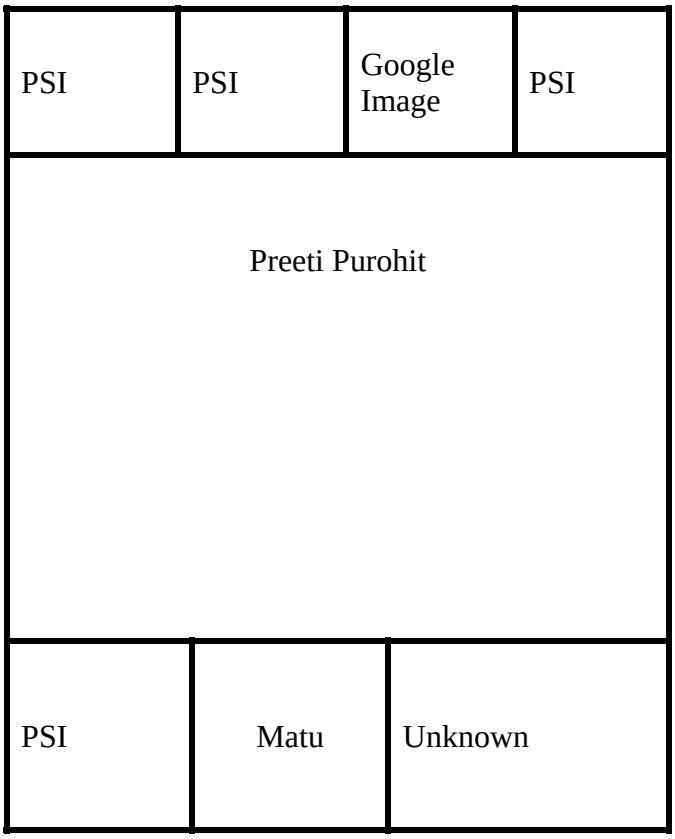

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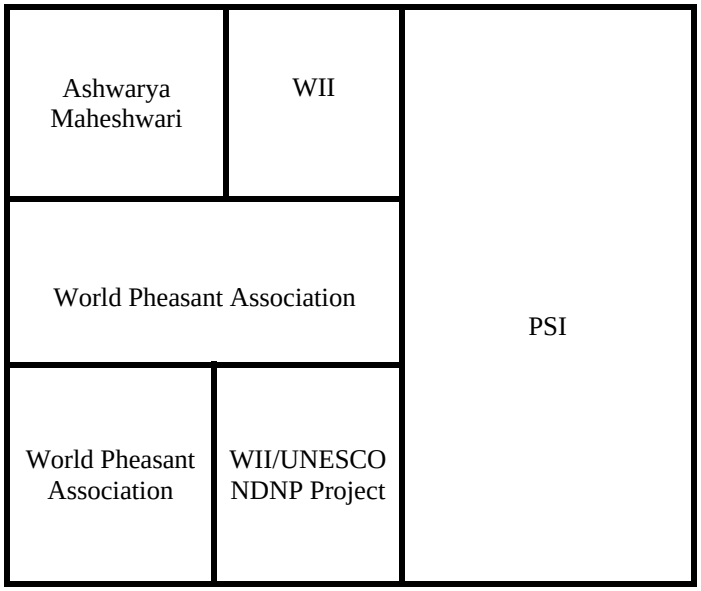

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Expert Body constituted on the directions issued by the Hon'ble Supreme Court vide judgment dated 13.08.2013 in the case of Alaknanda Hydro Power Co. Ltd. versus Anuj Joshi & others arising out of Civil Appeal no. 6736 of 2013 (SLP (C) no. 362) of 2012), with appeal no. 6746-6747 of 2013 arising out of SLP (C) no. 5849-5850 of 2012 and TC (C) no. 55-57 of 2013

Preface

"O sage Naarad ! Among the places on earth, the land of India is blessed, In India- the land of Himalaya is blessed and the region in Himalayas where Ganga is born is especially blessed because this is the place where she exists in confluence with God."

(Skandapuran-Kedarkhandam, Chapter 149, Shloka 39-40)

Majestic, massive, mighty, lofty, rugged, grand, – are some adjectives that come to mind when imagining the Himalayan peaks, iridescent in the morning sun. Only when we come up close we see the mighty peaks as the rumpled detritus of a collision that took place millions of years ago when the Indian plate rammed into the Eurasian landmass. As the Indian plate continued to grind under the Eurasian plate the detritus rose to lofty heights. Some of the detritus metamorphosed into rock with a ruggedly massive appearance. But much of it remained as soil and rubble, cloaked under verdant slopes. Remoteness hid its basic fragility. Its size displayed strength from afar.

Uttarakhand is gifted with abundant natural resources – scenic vistas, forests, rivers, wilderness, wildlife among many others. Over nine hundred glaciers feed its major rivers and many of their tributaries. Rain and spring-fed rivers nourish the mid-Himalayan region of the state, where most of the mountain population dwells.

Today a modernizing India sees the tremendous resources of Uttarakhand as the basis for a better life. Himalayan hydropower is a key component of the nation's energy basket. Assisted by the Union government, successive state governments have sought to harness Uttarakhand's flowing rivers to feed the nation's demand for hydropower. But it has come with a costly price tag.

A massive rain storm in June 2013 stripped some of the mountain slopes of their protective clothing, exposing their inherent fragility. Its fury took an unsuspecting population by surprise. As the battered state began to pick up the pieces, two Hon'ble Justices of the Supreme Court, concerned by the mushroom growth of hydroelectric projects in the state, directed the Union Ministry of Environment and Forests to set up a body of experts to study whether hydropower projects in Uttarakhand had contributed to environmental degradation and the June 2013 tragedy.

In preparing this report we have been conscious of the gravity of the task and the limited time available for its completion. We have also been mindful of the need for open, democratic functioning and for faithfully recording discordant notes. We have heard strong voices in favour of hydropower development in Uttarakhand and equally strong ones against it. Sometimes these concerns have slowed us down.

Within the limited time at our disposal we the undersigned have tried to fulfill the responsibility laid upon us by the Ministry of Environment and Forests to the best of our abilities. We submit this Report to the Ministry of Environment and Forests with humility and gratefulness for the opportunity to serve the nation and in particular the people of Uttarakhand.

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11.	Shri Y.K. Singh Chauhan, Member Secretary	Ministry of Environment & Forests, RO, Lucknow	

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First and foremost, we are very much thankful to the Hon'ble Supreme Court of India and the Union Ministry of Environment and Forests (MoEF) for giving us this important task. We thank the Uttarakhand Jal Vidhyut Nigam Limited (UJVNL), THDC for their unstinting help and assistance during the field visits and valuable information provided for analysis. We thank research institutions and departments that helped us with access to relevant information. Thanks to all the project developers and local communities to share their views and presentations which helped us to understand the different dimensions.

We gratefully acknowledge the support provided by the MoEF Regional Office in Lucknow in facilitating the work and the newly-established MoEF Regional Office at FRI, Dehra Doon for organizing local hospitality. We also place on record our appreciation of the services provided by the staff of People's Science Institute (PSI) in the final compilation and production of this Report.

Last but not the least, we owe our deep sense of gratitude and thank to each others, together with this journey, we remember the time spent with each other, discussions, interactions, hard exercise and work even during winters, harmonized us in a healthy spirit to work together.

Chairman, Co-Chairman, Member Secretary and Members,
Expert Body

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List of Abbreviations

AHEC	Alternate Hydro Energy Centre
BBM	building block method
BOD	Biological Oxygen Demand
BSI	Botanical Survey of India
CA	Compensatory Afforestation
CAG	Comptroller and Auditor General of India
CAMPA	Compensatory Afforestation Management and Planning Authority
CAT	Catchment Area Treatment
CEA	Central Electricity Authority
CEIA	Cumulative Environment Impact Assessment
CIMFR	Central Institute of Mining & Fuel Research
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CSE	Centre For Science and Environmental
CSR	Corporate Social Responsibility
cumecs	Cubic meter per second
CWC	Central Water Commission
d/s	down stream
dB	Decibels
DGMS	Directorate General of Mines Safety
DMP	Disaster Management Plans
DO	dissolved oxygen
DPRs	Detailed Project Reports
DST	Department of Science and Technology
EAC	Expert Appraisal Committee
EB	Expert Body
EC	Environmental Clearance
EF	Environmental flows
EIA	Environmental Impact Assessment
El	Elevation
EMP	Environmental Management Plan
ESZ	Eco-Sensitive Zone
FC	Fecal Coliform
FC	Forest Clearance
FCA	Forest Conservation Act
FD	Forest Department
FDC	Flow Duration Curve
FRL	Flood Reservoir Level
FSI	Forest Survey of India
GHG	Green House Gas
GLOF	Glacial Lake Outburst Flood
GoI	Government of India
GoU	Government of Uttarakhand

GSDP	Gross State Domestic Product
GSI	Geological Survey of India
ha	Hectare
HEP	Hydro Electric Project
HFL	High Flood Level
HLEG	High Level Expert Group
HLWG	High Level Working Group
HNB	HemwatiNandanBahuguna
HRT	Head Race Tunnel
ICFRE	Indian Council of Forestry Research and Education
IIT	Indian Institute of Technology
IITR	Indian Institute of Toxicology Research
IMD	Indian Meteorological Department
IMG	Inter Ministerial Group
ISRO	Indian Space Research Organisation
IUCN	International Union for conservation of Nature
IWMI	International Water Management Institute
IWPA	Indian Wildlife Protection Act
JEC	Joint Expert Committee
km	Kilometers
Km^2	Square Kilometer
kwh	Kilo Watt Hour
L&T	Larsen and Turbo
LCA	Life Cycle Assessment
m	Meter
m/y	meter per year
m^2	Square meter
MAF	Mean Annual Flow
MB	ManeriBhali
MBF	Main Boundary Fault
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MD	Muck Dumping
mm	Millimeter
Mm^3	Million cubic meter
MoEF	Ministry of Environment & Forests
MoWR	Ministry of Water Resources
MW	Mega Watt
NBWL	National Board for Wildlife
NDMA	National Disaster Management Authority
NEERI	National Environmental Engineering Institute
NGRBA	National Ganga River Basin Authority
NH	National Highway
NHPC	National Hydro Power Corporation
NIRM	National Institute of Rock Mechanics

NP	National Park
NTPC	National Thermal Power Corporation
NTU	Nephelometric Turbidity Unit
OUVs	Outstanding universal values
PF	Protected Forest
PH	Power House
ppm	Parts per Million
PPV	Peak Particle Velocity
PRL	Physical Research Laboratory
PSI	People's Science Institute
PSP	Pumped Storage Plant
PWD	Public Works Department
RBL	River Bed Level
RBM	River borne material
RCC	Reinforced concrete cement
RET	Rare Endangered and Threatened
RF	Reserved Forest
RO	Regional Officer
RoR	Run of River
S & I	Survey and Investigation
SC	Scheduled Caste
SEA	Strategic Environmental Assessment
spp.	Species
ST	Scheduled Tribe
STP	Sewage Treatment Plant
SWI	Shannon Weiner Diversity Index
TBM	Tunnel Boring Machine
THDC	Tehri Hydropower Development Corporation
THF	Trans Himadri Fault
TRT	Tail Race Tunnel
TWL	Top Water Level
UEEPCB	Uttarakhand Environment Protection & Pollution Control Board
UJVNL	UttarakhandJalVidyut Nigam Limited
UREDA	Uttarakhand Renewable Energy Development Agency
WCD	World Commission on Dams
WHS	World Heritage Site
WII	Wildlife Institute of India
WQI	Water quality index
WRDM	Water Resources Development and Management Department
WS	Wildlife Sanctuary
WWF	Worldwide Fund For Nature
ZSI	Zoological Survey of India

Executive Summary

Uttarakhand is India's newest Himalayan state. Since obtaining statehood successive state governments have pursued economic growth through industrialization without taking into account the fragility of the state's mountains. A massive rain storm in June 2013 exposed the inherently fragile character of the mountain region.

As a battered state began to rehabilitate itself the Supreme Court directed the Union Ministry of Environment and Forests (MoEF) to set up a body of experts to study whether hydropower projects in Uttarakhand had contributed to environmental degradation and the June 2013 tragedy.

Terms of Reference

An Expert Body was set up by MoEF in October 2013 with the following terms of reference (TOR):

2.1 Assess whether the existing and ongoing/under construction hydropower projects have contributed to the environmental degradation and, if so, to what extent and also whether they have contributed to the tragedy that occurred at Uttarakhand in the month of June, 2013. Also to make a detailed study and evaluate as to how far HEPs have contributed to the aggravation of damage caused by downstream floods.

2.2 Examine, as observed by Wildlife Institute of India (WII) in its report, as to whether the proposed 24 projects in Uttarakhand are causing significant impact on the Biodiversity of Alaknanda & Bhagirathi river basins.

The Expert Committee will devise its own, but follow established approaches and methodologies in collecting, collating and interpreting data/information for the purpose of preparing the report including but not limiting to the following:

3.1 Assess and review extent of progress made in respect of ongoing/under construction Hydroelectric power projects as on the date of occurrence of the tragedy vis-a-vis progress made in compliance of environmental conditions/safeguard measures.

3.1.A Study current state of Himalayan glaciers and impact of HEPs on glaciers, as well as the impact of receding glaciers on HEPs.

3.1.B To study cumulative effects of proposed and existing bumper to bumper & run of river schemes and on this basis review existing Cumulative Impact Assessment Reports.

3.2 Review compliance of existing protocols for construction activities in the basins of Alkananda and Bhagirathi.

3.3 Assess status of progress in respect of proposed 24 projects.

3.4 Assess projects where impacts cannot be mitigated to preserve biodiversity.

3.4.A Draft a Himalayan Policy for Uttarakhand keeping in mind the unique ecological, social and cultural characteristics of the state, and suggest environment friendly development activities

3.5 Suggest suitable environmental safeguard measures to mitigate the adverse environmental impacts in respect of ongoing projects for which ECs have been granted including tourism projects. Wherever felt necessary, the committee may also suggest necessary changes in project parameters.

3.6 Site visits, as part of the process, may be undertaken where it is considered necessary. Visits shall be undertaken with prior approval of MoEF to facilitate obtaining approval of competent authority for payment of TA/DA.

Activities

Over a period of just under six months the members of the Expert Body (EB) held seven formal meetings, field visits, listened to presentations by eminent experts, government officials, project developers and community representatives. It received and reviewed written representations from affected communities, project developers and their spokespersons among others. The EB accessed published scientific literature and commissioned laboratory analysis of sediment samples. It requested a prominent ecological scientist to undertake a review of WII's report. It also heard critiques of the latter by other scientists and representatives of industry.

Hydropower development is a contentious subject. This was reflected in the committees own meetings and discussions. But there was unanimity on many critical issues. The EB was mindful of the differences and decided to maintain an open democratic approach. By recording strong dissents in the report the members have been able to present an overall unanimous report. The broad unanimity achieved despite a paucity of time and in the face of enormous pressures from various stakeholders, is an achievement of sorts.

Hydropower Development in Uttarakhand

Uttarakhand has a variety of natural resources including scenic snow-capped mountain vistas, forests, rivers, wilderness and wildlife among many others. Its mountains are fragile and many of its rivers are pristine. The state, however, is disaster prone. It is highly vulnerable to strong earthquakes and on an annual basis to landslides, flash-floods and forest fires.

After Arunachal Pradesh, Uttarakhand has the highest hydropower potential among the Himalayan states. Melting of glaciers in the summer enables Uttarakhand to export power to other states when their shortages peak. The sale of hydropower, therefore, has been seen by Uttarakhand's leadership as an important source of revenue. Uttarakhand has set an ambitious programme to develop 450 hydroelectric projects (HEPs) to harness its potential of 27039 MW.

So far 92 projects with a total installed capacity of 3624 MW have been commissioned. Of these, 15 large and medium projects account for 95 per cent of the installed capacity. Another 38 projects with an installed capacity of 3292 MW are under construction. Here too 8 large and medium projects account for 97 per cent of the capacity.

Environmental Impacts

Reviews of available scientific studies, including official documents, and field visits have revealed several environmental impacts. Some impacts are inherent in the technologies themselves, while others are more the result of an inadequate regulatory framework. Among the significant impacts are:

River Flows: Minimal water releases downstream of hydroelectric projects leading to loss of the river's integrity in the non-monsoon months have been reported in the literature and by local communities. Scientific studies have shown that this has led to disruption of fish migration and loss of aquatic biota and diversity. The construction of a series of dams on a river has led to fragmentation of the river's length, again affecting riverine biota and diversity. For example, a series of dams on the Bhagirathi between Maneri in Uttarkashi district and Koteshwar in Tehri Garhwal district have disrupted free flow in a stretch of about 110 km, almost half the length of the Bhagirathi from its origin to Devprayag.

Water Quality: Loss of free flowing water has impacted the natural water quality. A comprehensive study by NEERI has highlighted the deleterious effect of the Tehri dam on the unique self-purifying ability of Gangajal in the Bhagirathi. A bio-monitoring study by scientists of the Central Pollution Control Board (CPCB) of 11 rivers in Uttarakhand including 5 HEPs sites stated that barrages 'have drastically changed the ecological sustainability of rivers in the state'. Another independent study shows the loss of self-cleansing and self-purifying capability of the Bhagirathi river and an additive effect of multiple dams on the river. There is a study, however, by WRDM at IIT-Roorkee which shows no significant impact on the conventional physico-chemical-bacteriological properties of river water at six HEPs.

Forests and Biodiversity: The most serious impact has been the submergence of riverine eco-system by the large reservoir at the Tehri dam. Other impacts that have been cited include the loss of forest area and critical wildlife habitats.

Geological Impacts: Several official committees have confirmed that slope instabilities leading to landslides and subsidence on the rim of the Tehri dam reservoir due to the raising and lowering of the water level have occurred. These reports have been discussed in Chapter 2.

The issues of slope instabilities and disruption of underground water resources due to tunneling, however, have been extremely contentious issues arising out of tunnels dug inside the mountains are Local communities have highlighted several problems of slope stabilities and drying of water springs (See Annexure 4.2). But scientific studies commissioned by the developers have cited other causes to explain the observations of the local communities. The rock mechanics expert on the EB has explained at length the near improbability of scientific

blasting methods to lead to landslides, underground fractures or fissures or the disruption of water flows. But technical journals do carry scientific reports of hazards during tunneling.

Mitigation Measures: There is evidence that conventional mitigation measures like provision of fish ladders and afforestation measures like CA and catchment area treatment have not led to satisfactory results. Far more effective measures include the release of adequate downstream environmental flows to ensure the maintenance of riverine integrity and eco-systems and the creation of protected river zones. The MoEF has taken important steps in this direction. The Expert Appraisal Committee (EAC) for the MoEF has now begun stipulating a minimum 30 % release in the monsoon months and 20-25% in the lean season.

The MoEF has also notified a decision of the National Ganga River Basin Authority (NGRBA) declaring a stretch of about 100 km in the Bhagirathi from its source to Uttarkashi as an Eco-Sensitive Zone (ESZ). The EB has recommended that legislation be enacted along the lines of the innovative concepts of (i) protecting small but significant rivers as done in Himachal Pradesh and also recommended by the IMG for Uttarakhand and (ii) designating Eco-Sensitive Zones for all rivers of Uttarakhand.

Given the massive scale of construction of HEPs in Uttarakhand it may be worthwhile to set up a formal institution or mechanism for investigating and redressing complaints about damages to social infrastructure. The functioning of such an institution can be funded by a small cess imposed on the developers. It is also suggested that to minimize complaints of bias, investigations should be carried out by joint committees of subject experts and the community. Local communities can get educated on the technical issues in the process and the experts may also begin to appreciate the loss and pain felt by the affected people.

The June 2013 Disaster and the Role of HEPs

Between June 15 and 17, 2013 there was wide spread and incessant heavy to very heavy rainfall all across Uttarakhand. Warm rain falling on wet snow led to over topping of a morainic dam and its collapse at Chorabari lake just upstream of the Kedarnath shrine. The sudden outburst of the lake, steep topographic conditions and continuing rain led to catastrophic floods in the Mandakini valley.

Large parts of the state received about 250 to 400 mm rainfall in this period. The upper most glacial region between Gangotri to the Nandadevi National Park received an estimated 350 to 400 mm in a period of about 48-72 hours. It caused devastating floods and landslides in many river valleys of Uttarakhand. The result was a tragedy with colossal loss of human and animal lives along with infrastructure.

Flood conveyance Through HEPs: The Central Water Commission (CWC) carried out hydrological analysis of the flood in Alaknanda and Bhagirathi (A-B) basins. Their data shows that the floods in the lower Ganga basin may have been the highest in this century. Flood routing analysis reported by CWC concluded that the Tehri dam had held back a flood peak of 7535 cumecs, releasing only about 350 to 400 cumecs, while the Alaknanda was disgorging its

enormous discharge into the river Ganga downstream of Devprayag. It concluded that if the Tehri dam had not existed a combined discharge of over 21,500 cumecs would have engulfed the towns of Rishikesh and Haridwar on the Ganga. Thus it was claimed by CWC, THDC (Tehri Hydro Development Corporation), State Officials and others that the Tehri dam had helped avert a major tragedy.

It cannot be denied that the Tehri dam attenuated a major flood in the downstream Ganga basin. But this was a fortuitous circumstance since the flood occurred in mid-June, a few days before the normal onset of the monsoon season, when the Tehri reservoir was perhaps at its lowest level. The Tehri dam is not designed to perform a flood control function. It does not have a mandated flood cushion. Hence it can hold back major floods only upto its mandated FRL. In September 2010, to retain flood inflows in the face of water levels rising beyond the permitted FRL the dam authorities had to seek the permission of the Supreme Court. It led to inundation of the upstream town of Chinyalisaur and later after draw down fresh landslide zones were created around the reservoir rim.

A review of the inundation analysis carried out by THDC on the basis of which it claimed to have saved Haridwar from drowning was not backed by a ground survey. It is therefore not clear how much of Haridwar would have been affected if the Tehri dam had not been there. The problem at Haridwar, as at other towns and habitations along river banks, is that there has been wide spread encroachment and construction inside the river's regime. Therefore it is imperative to set up river regulation zones where encroachments are forbidden.[1]

Assessing flood damages: The EB also did analysis of the impact of HEPs during the floods on June 15-17, 2013. The analysis highlighted the fact that floods are not just about water but water and sediments. The major damage was inflicted by the sediments and water rather than just the water. The role of HEPs in managing such water and sediments flows led to sharp divisions in the EB.

It was noted that the barrage at the under construction Phata-Byung (76 MW) HEP received a flood of 2000 cumecs against a design capacity of 1106 cumecs. Similarly the Vishnuprayag barrage was obstructed by a very high intensity debris flow brought by the Khiron Ganga, a tributary of the Alaknanda just upstream of the Vishnuprayag HEP, from the glacial moraines in its paraglacial valley. There is some doubt about whether the Vishnuprayag project authorities were able to properly manage the opening and closing of the gates. In any event the passage through the gates was blocked by the massive boulders and debris. It led to river out flanking the barrage on the left bank sweeping away the companies offices, helipad and the national highway on the left bank. Lateral migration immediately thereafter led to further downstream damage of the Lambagar market and Pandukeshwar upto Govind Ghat. The under construction Singoli-Bhatwari barrage too was out flanked on its right bank by about 30 m

[1] Unscientific sand mining on river beds adds to the problem.

leading to attack and scour of the banks slopes downstream of the barrage 10 m high flood wave entered into and silted adits under construction .

The role of the Srinagar HEP generated controversy in the EB. According to the Project authorities the dam held back massive sediments measuring about 26 Mm^3. Yet large parts of the lower areas of Srinagar town were swamped with sediments. The affected people in Srinagar believe that the improper disposal of muck generated by the HEP was largely responsible for raising the river bed and hence flooding the lower reaches of the town, e.g., Shakti Vihar and SSB campus. The rise in the river bed at a few locations below the dam site is accepted by the dam officials. They ascribe it, however, to the sediments transported from the upper catchment above the barrage. Hence they attribute the sedimentation of lower Srinagar to exogenic sources outside the domain of the Srinagar HEP.

The EB Co-Chair, using data provided by the project authorities has argued that the quantity of muck eroded from the banks of the Alaknanda downstream of the dam was a small fraction of the sediments that were brought down from the large catchment above the dam. Sediment data provided by project officials shows that the sediment concentration in the river water reduced from 38230 ppm at Supana bridge (downstream of the dam) to 24790 ppm at the power house, due to the river flowing through a relatively flat gradient.

Geo-chemical analysis of sediment samples taken from various locations along the river stretch in Srinagar, however, indicate that a significant contribution was made from much eroded from muck disposal sites nos. 6 and 9 located on the concave right bank and consequently experienced intense current of the order of 7m/sec. The geo-chemical analysis showed that the local muck contribution in the June 2013 flood varied from 47% near the barrage to about 23% much further downstream, below Kirtinagar.

This raises a question that if there was heavy to very heavy rainfall from the glacial reaches of the Alaknanda valley, leading to numerous landslides along the banks, then why was massive damage observed only downstream of the Vishnuprayag and Srinagar HEPs? A detailed investigation is warranted in order to arrive at a scientifically viable explanation.

For the Tehri dam to meet the objective of flood moderation, particularly during the later part of the monsoon, it requires the installation of a Real Time Flow Forecasting Network which would transmit hydrometeorological data to enable forecast of inflow into Tehri reservoir at least 12 to 18 hours in advance. Such a forecast is also required for advance information on the contribution of Alaknanda at Devprayag and of the basin below Devprayag to Haridwar. This is only possible by analysis of real time data which Tehri dam authorities must get. It will enable decisions on appropriate releases so as to prevent synchronisation of Bhagirathi (Tehri release) and Alaknanda floods. Until such time Tehri reservoir level should be around 825 m in the mid-September to be filled up judiciously from the receding monsoon flow.

Muck management is a crucial issue. Current practices need to be reviewed and technically sound and ecologically sustainable ways of muck management in Uttarakhand have to be proposed to protect the people and the terrain from a June 2013 type of situation.

The river bed profiles at Phata-Byung, Singoli-Bhatwari, Vishnuprayag and Srinagar HEPs have changed significantly. This requires a fresh analysis of the project hydrology and redesigning them if necessary.

Learning lessons from the 2013 calamity it is important to take note of the heavy bed load in the rivers during floods while designing the structures. It will be useful to carry out model studies of structures across the rivers to develop a prior understanding of river behavior after construction and particularly during massive floods.

Disaster preparedness is critical because all of Uttarakhand lies either in seismic Zone IV or V. These are the most vulnerable to strong earthquakes. The Disaster Management Plans of HEPs need to be carefully reviewed and approved by local communities in the probable zone of influence also.

Review of 24 HEPs cited by WII

The Hon'ble Supreme Court had directed the Expert Body to examine whether the 24 hydropower projects as observed by WII in its Report caused significant impacts on the biodiversity of Alaknanda and Bhagirathi basins.

The EB heard critiques of WII's report from an expert consultant of UJVNL (Uttarakhand Jal Vidyut Limited) and project developers affected by WII's review. It also heard presentations by scientists from WII. At the suggestion of the CWC Chairman, then member of the EB, the EB requested Dr. Brij Gopal an eminent ecological scientist to peer review WII's report.

In his review, Prof. Gopal mentioned that the methodology adopted by WII had certain limitations. But he agreed with WII's findings that the 24 proposed hydropower projects would impact the biodiversity of Alaknanda and Bhagirathi basins significantly. He added that WII could have gone further in its recommendations. Based on his own analysis, Prof Gopal recommended that several more projects could be dropped.

The issue was discussed and debated at several meetings of the EB. In its analysis the EB noted that the 24 projects were all located in sub-basins with high to very high biodiversity values. Construction of HEPs in these sub-basins have multiple impacts, not all of which can be resolved by ensuring high environmental flows, as suggested by some. For example, adequate environmental flows can minimize the impact on aquatic biodiversity. But an HEP can still act as a barrier to the migration of mammalian species besides other problems. The problem is of location in a high or very high biodiversity value area.

On the basis of its discussions and a review of the presentations the EB concluded that all the projects would have significant biodiversity impacts. It also accepted the argument that one

project, Kotli-Bhel 1A was in an already fragmented zone of the Bhagirathi river. It recommended that this project may be constructed with due modifications to its design and operations so that an adequate stretch of the river downstream of the Koteshwar dam just above KB-1A can be maintained in a free flowing state. It is however, considered desirable that the National Board for Wildlife, the apex body for wildlife clearance should examine these issues while taking a final decision on selection of the 23 projects.

Project Clearances and Compliances

Diversion of forest land for HEPs leads to loss of forests and is known to add to global warming. Forest Clearance (FC) require that the user will undertake CA(CA) over an equal non-forest land area (or double the area of degraded forest land in the case a GoI undertaking). For project cleared before Uttarakhand achieved statehood CAhas been done in the plains of Uttar Pradesh which fails to compensate for the environmental loss in Uttarakhand.

The FC requires that the non-forest land on which CA is done be mutated in favour of the Forest Department. It is observed that this is rarely done. As a result the long run fate of CA remains uncertain and to that extent mitigation of the diversion does not take place.

Catchment Area Treatment is required to be undertaken by users for preventing silting of reservoirs and also for mitigating the adverse environmental impacts. CAT plans also helps stabilize the mountains on the rim of storage reservoirs, reduce chances of landslides and thereby are of paramount importance for the safety of the people living in the area. It is found that the user agencies have deposited monies for CAT Plans with CAMPA. However, the monies have not been released in time with the result that the Forest Department has not been able to implement CAT Plans. The result is that reservoirs have been impounded while implementation of CAT Plans has not even started. This is a life-threatening situation.

The FCs require the Project Proponent (PP) to demarcate the forest land that is diverted with pillars. This has often not been complied with. As a result the Forest Department itself does not know the amount of land which has been actually diverted.

Many projects are located within 10 km of wildlife parks or protected areas. This requirement has been imposed because anthropogenic activities negatively impact wildlife. These projects are required to obtain clearance from the National Board of Wild Life. However, it is seen that many projects are located within 10 km of parks and protected areas but they have not approached the NBWL for clearance. Such clearance has often not been obtained even where the Environment Clearance explicitly requires the PP to obtain such clearance.

Environmental Impact Assessment (EIA) Reports are presently commissioned by the PPs. This leads to a bias in favour of the PP on part of the EIA agency. Many of the unintended environmental impacts have taken place because EIA agencies looked the other way. It is necessary to establish an independent authority which may commission the EIAs thereby insulating the EIA agency from the PP. Alternatively, the MoEF may establish a roster of institutions/organizations that are capable of undertaking the work and have a proven track

record of credible scientific work. In such a situation the PPs may deposit the EIA agency's fee with the Ministry so that the agency is paid by the Ministry rather than the PP.

Release of environmental flows has now been made mandatory for projects though earlier ECs do not have such a condition. However, there is no mechanism to ensure that these conditions are actually observed. The tendency of the PPs is to minimize e-flows as this directly impinges on the electricity generated and thus their profitability. As a result adequate e-flows are often not released, causing huge negative impacts on aquatic life and hardships to the local communities.

It is essential to maintain riverbed connectivity in order to enable upstream- and downstream migration of aquatic fauna such as the famed Golden Mahseer; and for the downstream flow of sediments which are capable of imparting special qualities to the river waters. Riverbed connectivity is also required for downstream flow of debris which provide food for aquatic life. Minimal flows invariably destroy this riverbed connectivity. Hence it is necessary to ensure adequate e flow releases or to redesign proposed projects to abstract water without completely obstructing the river flow.[2] across the riverbed so that riverbed connectivity can be maintained.

Bumper to Bumper

The increasing demand for power and the consequent exploitation of Himalayan rivers is a major concern today. This is particularly true of those rivers where multiple projects are proposed with very little distance of free flow between the tail race channel of one project and the reservoir/pond's tip of the next one downstream, i.e., bumper-to-bumper projects.

The cumulative impacts of multiple hydropower projects along the same river basin and the threat of a cascading chain of catastrophes in the case of structural failures or even from purely natural causes such as the Uttarakhand floods of June 2013, suggest that there is an urgent need for a region or entire basin based Strategic Environmental Assessment (SEA) rather than individual project oriented environmental impact assessments (EIA) that neglect the summation effect.

During the deliberations, most EB members agreed that the guiding principle(s) for determining the minimum distance between consecutive dams should include concerns for (i) maintenance of river ecology and its functions, (ii) conservation of biodiversity and wildlife habitats, (iii) ensuring adequate free stretches of the river for use by terrestrial wildlife as movement corridors, (iv) fulfilling the requirements of human societies for cultural, religious, domestic use and (v) preservation of natural beauty, aesthetic and wilderness values.

An alternate view was that the bumper-to-bumper schemes were not really so because no fragmentation of the river, thereby non-creation of a deprived reach occurred with 70%-80% of monsoon flow being let down and envisaging minimal hydrological modification. Low height

[2] Such a recommendation has been proposed in the interim report of the IIT's consortium on Ganga River Basin Management Plan

barrages generally 10 to 12 km apart as planned now along the river, with provision for fish passes is considered to enable the river to depict a lotic behavior significantly. Occurrence of dry stretches in the river unfavorable to the aquatic biota would not then happen. In the non-monsoon months the EB has already recommended 50% downstream releases.

The EB observed that in the Western Ghats context a High Level Working Group (HLWG) had recommended 3 km as the minimum distance between consecutive HEPs. The shorter distance was considered keeping the shorter river lengths in Western Ghats. The IMG recommended 3-5 km as a minimum distance between two HEPs while deliberating this issue with regard to HEPs in Alaknanda and Bhagirathi Basins. Both these recommendations are practical suggestions rather than science based decisions.

The EB therefore recommends that scientific studies by subject experts be conducted to establishing baseline data for deciding upon the minimum distance between two HEPs. Until such scientific studies are completed, no new HEPs (in S&I stage) should be cleared on the rivers of Uttarakhand within a distance that may later be revoked. Minimum distances for projects in the clearance stage should be revised upward from the current consideration of 1 km.

Irrreversible Impacts on Biodiversity

The impacts of HEPs in Uttarakhand on biodiversity and wildlife habitats have been presented in detail in the context of ToR 2.1a, 2.2, & 3.1B. It is well established that HEPs alter the natural flow of rivers due to submergence, drying up of rivers downstream of HEPs during the non-monsoon months due to diversion of river waters into tunnels for substantial distances and fragmentation of rivers due to cascading effects of multiple HEPs on a river.

The proposed 24 HEPs in the Alaknanda and Bhagirathi basins which are likely to cause irreversible impacts have been identified in the WII study. Comprehensive research studies of other basins in Uttarakhand are lacking at this stage. The loss of a riverine ecosystem, however, around the Tehri dam reservoir cannot be mitigated as discussed elsewhere (Chapter 3) in this report. Otters appear to be nearing extinction in the Ganga, Alaknanda sub-basins.

Impacts Glaciers on HEPs

Uttarkhand has 968 glaciers covering 2896 km^2 they act as natural reservoir storing water in a frozen state. They enhance stream flow during the warmest driest period of summer when all other sources of water release are at a minimum. Thus they impact the sustainability and profitability of hydropower projects located on rivers with a glacial origin.

The initial response of glaciers to climate change will be an increased melting rate while the glacier size is still substantial. Eventually it will lead to a decline in glacier runoff and eventual extinction. Current knowledge and inferences on the stability of glaciers in the phase of global warming remains uncertain.

A large area above 2500 m (asl) is occupied by glaciogenic sediments which are unconsolidated, fragile in nature and prone to remobilization under unusual weather events, as it happened in June 2013. This area is highly influenced by the monsoon and the snow/glaciers

melt processes as the winter snow line descends down an elevation between 2200 m and 2500 m in Uttarakhand. Streams emanating from glaciers and snow covered areas facilitate snow avalanches, debris flows and landslides. This is particularly true along the fast cascading juvenile streams. The direct consequences of such processes can be exaggerated by other synergistic changes in the mountain ecology. In such areas, particularly in fragile landscape and continuous deposition of sediments by glacier retreat, the construction of hydropower projects must not be encouraged.

There is an urgent need to review the present proposal to build hydropower projects in paraglacial regions, i.e., above 2200 m – 2500 m.

Draft Himalayan Policy

The Himalaya, known as the abode of snow, revered by millions, is home to a geological, geographical, biological and cultural diversity as in any developing society millennia of time are telescoped into the present, from hunting-gathering communities to pastoral-agrarian-trading societies to the economies of modern trade, industry and services sector. This mountain system has evolved a distinctive ecology that has become the basis for the existence of the natural as well as cultural systems of South Asia.

Today the Himalayan mountains, rivers and communities are in a crisis. The Himalaya are being rapidly encroached upon for their resources. The challenges of the global climatic change and the rampant 'developmental activities', pose a grave threat to the very existence of the mountain region and the people living there. It is a remarkable tragedy that repeated earthquakes, cloud bursts, landslides, floods, forest fires for the last few decades have failed to sensitize the policy makers, administrators and even the people.

The June 2013 disaster compels us to analyze the entire approach economic growth being followed in Uttarakhand and search for new answers. We believe that such a search cannot be limited to a handful of experts. For this a larger group of specialists from different disciplines, administrators, policy makers, legislators, drivers of the economy from farmers to captains of industry, men and women, i.e., representative stakeholders must take part. Here we can only enunciate the basic guiding principle which has been noted by earlier task forces and experts:

"The Himalayas are the Water Tower of Asia and that the water and food security for billions of people is dependent on these mountains and the rivers that originate from here. The ecological balance maintained by the Himalayas, the spiritual tradition and ambience they nurture, the socio-cultural significance of the Himalayas and the Himalayan Rivers is certainly far greater than any gain we can possibly receive through their exploitation."

Recommendations

The recommendations have been summarized in Chapter 10. They are also noted at the end of each chapter.

Final Report of

Expert Body constitution with the directions issued by the Hon'ble Supreme Court vide judgment dated 13.08.2013 in the case of Alakananda Hydro Power Co. Ltd. versus Anuj Joshi & others arising out of Civil Appeal no. 6736 of 2013 (SLP (C) no. 362) of 2012), with appeal no. 6746-6747 of 2013 arising out of SLP (C) no. 5849-5850 of 2012 and TC (C) no. 55-57 of 2013

भारत सरकार

Government of India

पर्यावरण एवं वन मंत्रालय

Ministry of Environment &Forests

New Delhi

April- 2014

Background

Over millennia the Himalaya – variously known as the abode of snow, *Dev Bhoomi*, *Dev Atma* – have been home to a geological, geographical, biological and cultural diversity. Today, the Uttarakhand Himalaya, its mountains, rivers and people are in a state of crisis – being rapidly encroached upon in many ways. Global climate change and the pressures on its resources for economic growth are challenges on a scale never seen before.

Uttarakhand's centuries old traditions of reverence for nature and caring for it have been rapidly overtaken by the encroachment of its mountains, rivers, forests, wilderness and people in the name of economic growth or development. The hidden fragility of its mountainous terrain has been laid bare. Nature seems to be hitting back with increasing regularity in recent years with cloudbursts, flash floods and landslides

But the June 2013 disaster brutally exposed the inability of the mountains, rivers and other natural resources to bear the pressures of a nation in a single-minded rush to modernize itself. The rain storm between June 15 and 17, 2013 spread across from the Baspa valley and Kinnaur in eastern Himachal Pradesh, engulfing Uttarakhand, to Western Nepal was perhaps unprecedented in its scale and duration. The last time such a massive and complex disaster occurred here was the great earthquake of 1803. The June 2013 disaster claimed the lives of many thousand pilgrims, tourists and local people providing them with hospitality services. It also destroyed the livelihoods of many more local mountain dwellers.

The scale of the tragedy shook the entire nation in the aftermath of those three days in June 2013 warning us of the possibility of future such disasters in the context of global warming. Many people, from common citizens to scientists, elected representatives, administrators, mediaperons and judges realized that this calamity could not be brushed aside as an 'Act of God'. In August 2013 two Hon'ble Justices of the Supreme Court, concerned by the mushroom growth of hydroelectric projects in the state, directed the Union Ministry of Environment and Forests (MoEF) to set up a body of experts to study whether hydropower projects in Uttarakhand had contributed to environmental degradation and the June 2013 tragedy.

In October 2013 the MoEF constituted an Expert Body (EB), as directed by the Supreme Court to assess whether the existing and under construction hydropower projects had contributed to environmental degradation and, if so, to what extent and also whether they had contributed to the tragedy that occurred at Uttarakhand in the month of June, 2013.

The list of the expert members as nominated by MoEF is given below.

S.No.	Name	Affiliation
1.	Prof. Ravi Chopra, Chairman	Member-NGRBA, Director, People Science Institute, Dehradun
2.	Shri Chandi Prasad Bhatt, Co-Chair	(Chipko Movement) Gopeshwar, Chamoli
3.	Prof. A.N. Purohit, Member	Ex-Director, G. B. Pant Institute for Himalayan Environment and Development, Almora
4.	Shri Hemant Dhyani, Member	Ganga Ahvaan
5.	Dr. B.P. Das, Member	Formerly Vice-Chairman, EAC River Valley & HEP
6.	Chief Engineer, Member	Central Electricity Authority, Sewa Bhawan, RK Puram, New Delhi
7.	Shri G. L. Bansal, Director (Hydrology), Member	Central Water Commission , Sewa Bhawan, RK Puram, New Delhi
8.	Chief Engineer, Member	Water Resource Department , Govt. of Uttarakhand
9.	Expert representative in blasting and tunneling, Member	National Institute for Rock Mechanics, Kolar Gold Mines, Karnataka
10.	Expert Representative, Member	National Disaster Management Authority, New Delhi
11.	Expert representative in biodiversity, Member	Indian Council of Forestry Research & Education, Dehradun
12.	Dr. D. P. Dobhal, Member	Wadia Institute of Himalayan Geology, Dehradun
13.	Dr. Navin Juyal, Member	Physical Research Laboratory, Ahmedabad
14.	Construction/Design expert Representative, Member	Central Public Works Department
15.	Dr. S. Sathyakumar, Member	Wildlife Institute of India, Dehradun
16.	Dr. Shekhar Pathak, Member	People Association For Himalaya Area Research (PAHAR)
17.	Mr. Y.K.S.Chauhan Chief Conservator of Forest, Member Secretary	Ministry of Environment & Forests, Regional Office, Lucknow

The terms of reference (TOR) given to the Expert Body are as follows:

2.1 Assess whether the existing and ongoing/under construction hydropower projects have contributed to the environmental degradation and, if so, to what extent and also whether they have contributed to the tragedy that occurred at Uttarakhand in the month of June, 2013. Also to make a detailed study and evaluate as to how far HEPs have contributed to the aggravation of damage caused by downstream floods.

2.2 Examine, as observed by Wildlife Institute of India (WII) in its report, as to whether the proposed 24 projects in Uttarakhand are causing significant impact on the Biodiversity of Alaknanda & Bhagirathi river basins.

3. The Expert Committee will devise its own, but follow established approaches and methodologies in collecting, collating and interpreting data/information for the purpose of preparing the report including but not limiting to the following.

3.1 Assess and review extent of progress made in respect of ongoing/under construction Hydropower projects as on the date of occurrence of the tragedy vis-à-vis progress made in compliance of environmental conditions/ safeguards measures.

3.1.A Study current state of Himalayan glaciers and impact of HEPs on glaciers, as well as the impact of receding glaciers on HEP

3.1.B To study cumulative effects of proposed and existing bumper to bunper &run of river schemes and on this basis review existing cumulative Impact Assessment Report.

3.2 Review compliance of existing protocols for construction activities in the basins of Alakananda and Bhagirathi.

3.3 Assess status of progress in respect of proposed 24 project.

3.4 Assess projects where impacts cannot be mitigated to preserve biodersity.

3.4A Draft a Himalayan policy for Uttrakhand keeping in mind the unique ecological, social and cultural characteristics of the state, and suggest environment friendly development activities.

3.5 Suggest suitable measures to environmental safeguard mitigate the adverse environmental Impacts in respect of ongoing projects for which ECs have been granted including tourism project parameter.

Departures/Withdrawals

After the constitution of the EB, Prof. A.N. Purohit and Shri Chandiprasad Bhatt informed MoEF of withdrawing from the EB due to personal reasons. The member from CPWD formally informed the Ministry by letter, that CPWD had no any significant role

in the given TORs and was therefore withdrawing from the EB. The NDMA representative wrote that it had would submit another report to the Supreme Court as directed by it and therefore would not participate. Later three new members were nominated by MoEF.

The MoEF also nominated Dr. B.P. Das, as Co-Chairman of the EB. Different members from CWC and CEA participated irregularly in a few meetings of the EB. But the two nominated members finally withdrew their participation in the 5th meeting of the Expert Body, citing differences over the ToR of the EB (related correspondences are attached in the appendix and annexure).

Activities Undertaken

1. During the tenure of committee, seven formal meetings (minutes annexed) along with the two field visits (field notes annexed) and some specific visits by EB members were made. They are listed below.

Meeting/ Filed tour No.	**Date**	**Venue**
1st meeting	15th Nov, 2013	MOEF, New Delhi
1st field visit of EB	05-09th Dec, 2013	Alakanada and Mankakini valleys
2nd meeting	7th Jan-2014	NCFRI, FRI campus, Dehradun
2nd field visit of EB	07-11th Jan-2014	Bhagirathi valley
3rd meeting	30-31st Jan-214	ICFRI, FRI campus, Dehradun
4th meeting	18-19th Feb-2014	ICFRI, FRI campus Dehradun
Other specific Visits		
Shri YK Singh Chauhan	07-10th Feb-2014	Alakanada and Mandakini Basin
Dr. Ravi Chopra	08-10th Feb-2014	Alakanada and Mandakini Basin
Dr. Naveen Juyal	24-27th Feb-2014	Alakanada and Mandakini Basin
5th meeting	04-05th Mar-2014	Van Vigyan, ICFRI, New Delhi
6th Meeting	20-22nd Mar-2014	ICFRI, FRI Campus, Dehradun
7th Meeting	03-06th Apr-2014	ICFRI, FRI Campus, Dehradun

1. During the tenure, members of the EB reviewed various research papers/reports, available literature, official documents and data provided by project developers, IMD and other institutions regarding ecological/geological/hydrological aspects,

flood discharges, rainfall, biodiversity, wildlife habitats and other aspects pertaining to the TORs provided by the MoEF.

2. All members of the EB were given specific responsibilities either individually or as a small group by the Chairman to conduct necessary research and consultations for one or more TORs. Different members were also given the responsibility to be lead authors of different sections or TORs. The list of members and their contributions are given at the end of this note.
3. The EB invited experts for presentations related to critical issues like e-flows and impacts on wildlife.
4. During the field visits, EB members heard project officials at the project sites to inquire about flood event, disaster-preparedness and other issues regarding impacts and damages in the vicinity of projects.
5. The EB also heard representations made by project-affected local communities during the field visits and meetings.
6. In the second meeting, it was decided to send the report of WII for peer review by an independent expert. Accordingly, WII's report was sent to Dr. Brij Gopal, an eminent scientist for peer review. It also studied and heard representations from project developers on this issue.
7. It received and reviewed written representations from affected communities, project developers and their spokespersons.
8. The EB invited the Chief Secretary, Government of Uttarakhand and other senior state officials to present the state perspective on the issue of hydro power development in Uttarakhand. It also discussed with them various aspects related to the disaster along with some other environmental concerns of the state.
9. Proper consideration of social aspects and scientific analysis/experiments have been carried out by the experts to draft the conclusions and recommendations.
10. After the continuous exercises mentioned above, drafts and presentations were prepared by the expert members according to the ToR. The tasks were divided as under:
    TOR 2.1- Chairman and Co-Chair, Dr. Navin Juyal, (PRL, SAC)
    TOR 2.2- Dr. S.Sathyakumar (WII)
    TOR 3.1, 3.2, 3.3- Shri Y K Singh Chauhan and Dr. Amit Gupta (MoEF)
    TOR 3.1-A- Dr. D.P. Dobhal (WIHG)
    TOR 3.1-B, 3.4- Dr. S.Sathyakumar (WII) and Dr. H. B. Vasistha (ICFRE)
    TOR 3.4-A- Dr. Shekhar Pathak (PAHAR) and Dr. Hemant Dhyani (Ganga Avhan)

These drafts were discussed and reviewed by the members. The issues involved were very contentious and so were the deliberations. Each ToR chapter and the recommendations were discussed at the last meeting and finalized.

Structure of the report

The Report is in two parts: (i) Part I, the main report and (ii) Part II, annexures. The main report begins with an introductory chapter about Uttarakhand's state profile, its development and ecological challenges with the current status of the hydropower sector in the state. Chapters 2 to 10 deal with specific terms of reference and the recommendations.

In preparing this report the members have been extremely conscious of the gravity of the task and the limited time available for its completion. We have been mindful of the need for open and democratic functioning. It was unanimously decided at the start that the views/observations on the different issues would be discussed thoroughly and if any member still had an alternate view it would be placed on record in the report. Such alternate views have been presented within the respective TORs or sections of the different chapters. It may be pertinent to record here that after the finalization of the report at the last meeting the representative of the state irrigation department under pressure from senior officials expressed a strong dissent. It has been recorded in the Appendix.

Many people affected by the June 2013 disaster and concerned with the state of Uttarakhand are in search of a sustainable and inclusive developmental path for the state. There are ways to design and shape the road ahead for this Himalayan state which does not need to compromise the fragile ecology that defines this terrain. In the TOR provided by MoEF the task of drafting a Himalayan Policy for Uttarakhand has given us an opportunity to identify possibilities that are in harmony with nature and complements with the culture of this *dev bhoomi.*

Chapter - 1

INTRODUCTION

Uttarakhand is India's newest Himalayan state. Here altitude is the principal determining factor for natural processes and human activities. Rapid changes in altitude across short distances, leading to tremendous variations in climate, have generated a profusion of geological, geographical, biological and cultural diversities in the state. Wilderness, its most special 'niche' resource, bestows natural beauty and tranquility. Little wonder then that Uttarakhand, is locally known as Dev Bhoomi, the land of important pilgrimage centres for Hindus, Muslims, Sikhs, Buddhists and Jains. India's national river Ganga, which holds special emotional, spiritual and cultural significance for Indians across the world, originates in Uttarakhand.

I.1 State Profile

Uttarakhand was carved out of the mountainous northwestern corner of Uttar Pradesh as a separate state on November 9, 2000. It stretches across an area of 53,483 sq km from the Tons river in the west to the Kali river in the east. Nine of the state's 13 districts accounting for 88 per cent of the total area are mountainous while the remaining four southern districts have substantial portions that are plains.

Uttarakhand is a part of the Western Himalaya physiographic division. Geographers divide the state into five transverse zones (see Figure 1.1).

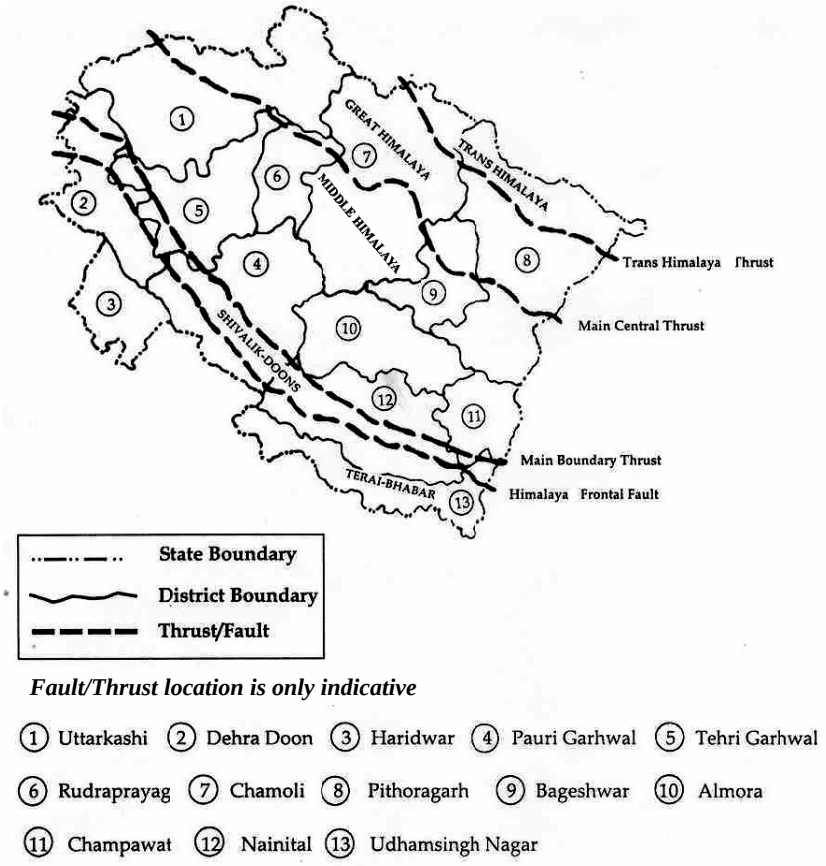

Fig.1.1: Geological divisions of Uttarakhand

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

(b) The Doons: Between the Main Boundary Fault and the Shivalik (Outer Himalayan) range with a ridge-line of about 2000-2500m.

(c) The Middle Himalaya: Between the Main Boundary Fault (MBF) and the Main Central Thrust. This is the most densely populated Himalayan zone.

(d) The Inner (or Great) Himalaya: The zone north of the Main Central Thrust including the permanently snow-clad peaks at heights ranging up to just under 8000 m.

(e) The Trans Himalaya to the north of the snow clad ridges line.

The Great Himalaya region is dominated by snow-clad ranges. It remains largely remote, sparsely populated and unspoiled. It is home to large, very high quality landscapes like the sub-alpine and temperate forests along with alpine meadows of Har-ki-doon, Gangotri National Park, Kedarnath Musk Deer Sanctuary, Nanda Devi Biosphere Reserve, the Valley of Flowers and the pristine Pindari, Gori Ganga, and Darma valleys. In recent years five prominent shrines – Yamunotri, Gangotri, Kedarnath, Badrinath and Hemkund Sahib – in this region are annually visited by over two million pilgrims and tourists. Other tourists visit this region for adventure, wilderness and scenic vistas.

The Middle Himalaya region lies between the MCT and the MBF with ridge heights ranging from 2,000 m to 3,000 m. It provides scenic vistas of the snow-covered Himalaya, terraced fields, oak and rhododendron forests and broad river valleys. South of the MBF the doons and terai region has a bird Conservaton Reserve at Asan Barrage, the Rajaji National Park in the Shivaliks, Jhilmil Tal Conservation Reserve, Sonanadi Wildlife Sanctuary and the Corbett National Park further east.

Table 1.1: A brief profile of Uttarakhand

Area (in sq. km)	53, 483
Population (in 2011)	10,116,752
Rural (%)	69.44%
Sex Ratio (F/1000M)	963
Density (per sq. km)	189
SC Population (%)	15.17
ST Population (%)	2.56
% Forest Area of Geographical Area	64.54
% Pasture Land of Geographical Area	3.51
% Net Sown Area	13.29
% Total Fallows	1.87
Rainfall (mm)	1550

Sources: Census of India 2011, State of Forest Report 2011, Uttarakhand State Perspective and Strategic Plan 2009-27

Key Features

Diversity: Uttarakhand is characterized by a tremendous variation in climate across the transverse zones. It varies from the sub-tropical humid climate of the *terai* region to the tundra-like climate of the Great Himalaya ridges. The climatic variation is even more dramatic along the slopes of the mountain ranges. For example, while the Doon valley has a sub-tropical humid climate, Mussoorie, which is just 1.3km higher, has a temperate climate.

Forests: Forests are the backbone of Uttarakhand's environment. They account for about 65 per cent of the state's geographical area. They are storehouses of biodiversity. Scores of plants in the forests are wild relatives of cultivated crops and represent an invaluable genetic resource. Many wild plants have medicinal properties. The state's forests also have an abundance of wild animals. The snow leopard, musk deer, Himalayan brown bear, Asiatic black bear, and pheasants like Western Tragopan, Himalayan Monal and cheer pheasant found in the Great Himalaya region are endangered species. Elephants and tigers abound in the Shivaliks and the *terai* regions.

The prominent tree species in the different latitudinal zones are: [1]

Sub-Himalaya: Sal (*Shorea robusta)*, khair *(Acacia catechu)*, sheesham *(Dalbergia sissoo).*

Lesser Himalaya: On the lower altitudes are chir pine *(Pinus roxburghii)*, on the dry slopes are oak (*Quercus leucotricophora)* and rhododendron *(Rhododendron arboreum)*, while alders *(Alnus nepalensis)* are found on moist slopes. At higher altitudes are cedars or deodars (*Cedrus deodara*), other oak varieties and blue pine or kail *(Pinus wallichiana)*. The oak species helps create good soil cover.

Great Himalaya: Firs *(Abies)*, bhojpatra or birch *(Betula utilis)*, stunted rhododendron *(Rhododendron companulatum)* and junipers *(Juniperus)* are the prominent species. At higher elevations the forests are replaced by *bugyals* or alpine meadows. The tree line is about 3000 m.

Forests are life-supporting ecosystems in the mountain region. They provide the local population with fuelwood, fodder and other livelihood

Once forests are cut down in the mountain areas, soil and water runoff increases. Fodder and year-round water availability decreases. As fodder becomes hard to get, mountain families tend to reduce their livestock, leading to reduction in farmyard manure, loss of soil fertility and reduced agricultural production. When a family's foodgrain production falls below sustenance levels, a typical response is the migration of an able-bodied male family member. The reduced availability of labour in the family increases the burden on the women. They react by further reducing the number of cattle, sending the family's agricultural production into a downward tailspin.

[1] K.S. Valdiya (1998): Dynamic Himalaya, Universities Press, Hyderabad, pp. 9-12.

resources. Easy access to forest resources reduces the drudgery of women in the mountain areas, since they are largely responsible for gathering the resources required for their families' daily sustenance. Good forests are essential for productive agriculture. They prevent soil erosion, reduce runoff, moderate stream flows and ensure perennial water supply in springs, streams and rivers.

A critical problem of the region is the loss of forest cover. In the last 130-150 years, there has been large-scale deforestation in the region due to the rapacious demand of the British for timber, and after Independence, due to the construction of physical infrastructure. Now forests and trees cover only about 47 per cent of the geographical area. With the loss of broad-leaved forests in the upper slopes a large number of natural sources of water, such as springs, have dried up.

Water: Uttarakhand is blessed with bountiful rainfall, averaging about 1550 mm. Between the Tons along its western boundary and the Kali at the eastern end, thousands of rivers and streams nourish Uttarakhand. It is also known as the land of a thousand Gangas. Here waters from the Kali Ganga, Madhu Ganga, Rishi Ganga, Khir Ganga, Dhauli Ganga, Garur Ganga, Patal Ganga -- to name a few -- merge with others to ultimately form the mighty Ganga. While rivers are important for agriculture and hydropower generation, thousands of springs sustain lives and livelihoods on the mountain slopes.

In the northern Inner Himalaya zone, the rivers are fed by glaciers and are fast flowing. Over nine hundred glaciers feed major rivers like the Yamuna, Ganga and Kali, and their tributaries like the Tons, Bhagirathi, Bhilangana, Mandakini, Alakananda, Nandakini, Pindar, Dhauliganga (East) and the Goriganga among others. The middle Himalayas -- the most populated belt -- are nourished by innumerable spring-fed rivers. The rivers originating further south in the Shivaliks are essentially monsoon torrents, with very little water flowing for the rest of the year.

People: Rajputs are the dominant caste in Uttarakhand. The SC and ST population in Uttarakhand is just under 18 per cent (see Table 1.1). The ST population is unevenly distributed in the state. More than 90 per cent of the population in the mountain districts lives in rural areas.

The villages generally have a high proportion of women to men as compared to plain areas. This is due to high levels of out-migration of men in search of jobs and cash incomes. The consequent drudgery of women's lives is highlighted by a study of 16 mountain villages in Uttarakhand and Himachal Pradesh.[2] It shows that typically a mother in a family works for 12 hours a day, of which 3.5 hours are spent on gathering

[2] R.Chopra, D. Ghosh: Work Patterns of Rural Women in Central Himalayas, Econ. & Pol. Weekly (EPW), Mumbai, December 30, 2000

fuel, fodder and water, another 3.5 hours are spent on livelihood related work and 4.75 hours on daily household tasks.

Economy: Agriculture is the main occupation of people in the mountain districts of Uttarakhand. According to the Census 2011 in the mountain districts 70 per cent of the working population is engaged in agriculture as cultivators or farm labour. But the cultivated area is 8.5 per cent of the geographical area.[3] The average land ownership is just about one acre. For SC/ST families, it is even less. About 92 per cent of Uttarakhand's farmers are marginal cultivators. The inability of mountain agriculture to provide adequate incomes and the non-availability of alternate employment opportunities in the mountain districts has led to heavy outmigration of men from the region.

Vulnerability to disasters: Finally, Uttarakhand is highly disaster-prone. The areas around the MCT and north of it fall in zone V, the most earthquake-prone zone in India. The rest of the state is in zone IV. Uttarakhand also witnesses landslides, flash-flooding and forest fires almost every year. Rain shadow regions are prone to droughts. Good forests can attenuate the probability and intensity of landslides, flash-floods and sheet erosion of the topsoil.

The Inner Himalaya area around the MCT and north of it is the most vulnerable region due to its extreme climate, high rainfall, steep slopes, availability of sediments left behind by receding glaciers and high seismicity. The high incidence of poverty in the northern parts of Uttarkashi, Tehri Garhwal, Rudraprayag, Chamoli, Bageshwar and Pithoragarh districts compounds the vulnerability due to the fragile mountains.[4]

I.2 Hydropower development in Uttarakhand

Uttarakhand's hydropower development programme is set within the context of the national power sector plans, policies and programmes. This section briefly profiles the national and state power sectors.

Energy Resources of India[5]

Along with capital, labour, natural resources and technology, energy is also regarded as a basic factor of production. It fuels all productivity. Industrialization is the engine of growth for India's economic development. Non-availability of energy can increase production costs, fuel inflation and lead to economic recession.

India is the fourth largest energy consumer in the world. But its per capita power consumption, seen as an indicator of development, at 869 kwh in 2011-12 is among the

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[3] Statistical Diary 2011-12 (2013): Directorate of Economic Statistics, GoU, Dehradun, pp 52-53. (Hindi)

[4] R. Chopra (2014): Uttarakhand: Development and Ecological Sustainability, Oxfam India, New Delhi, (under publication)

[5] Data from Energy Statistics 2013, CSO, Ministry of Statistics & Project Implementation, GoI, New Delhi, 2013

lowest in the world. India is the fifth largest power generating nation in the world. But over 500 million Indians do not have access to electricity. Large parts of India face crippling power shortages every day leading to hardships for the common consumers and production losses. At the end of the Eleventh Five Year Plan India's overall power shortage was estimated at 8.7 per cent, the peaking power shortages stood at 9 per cent. The source-wise power generation pattern in India is shown in Table 1.2 below.

Table 1.2: Source-wise power generation in India (30.09.2013)

Fuel	MW[1]	%
Total Thermal	155969	68.2
Hydropower	39,788	17.4
Nuclear	4,780	2.1
Renewable sources	28,184	12.3
Total	2,28,721	100.00

Source: http://www.powermin.nic.in/indian_electricity_scenario/introduction.htm
Notes: (1) Rounded off to the nearest integer. (2) Renewable Energy Sources (RES) include small hydro, biogas, biomass, urban & industrial waste power and wind energy

An increasing part of the demand for commercial energy is now being met by imports, largely due to oil and gas. India is now the fourth largest consumer of oil in the world. The production and use of fossil fuels poses severe risks for India's environment, energy security and ability to mitigate climate change impacts. Therefore there is a push away from its dependence on fossil fuels. Current efforts, however, rely largely on developing hydropower and nuclear power. Investments in alternate energy sources, like solar or wind, and other alternatives like demand management and co-generation are low. The expenditure for renewable (alternate) energy sources in the 11th Plan was just under 13 per cent of the total energy sector expenditure in the same period.[6]

Hydropower Development in India

Hydropower is seen as an indigenous renewable energy resource. The quick start-up time of a hydropower plant enables it to respond to peak load demands and provide grid stability. Though initial installation costs and times are high, operating costs are low. Once the costs of borrowing capital are paid off, revenues and profits increase significantly making hydropower a potentially attractive sector for investment.

India's ultimate hydropower potential has been assessed at an installed capacity of 148,700 MW from 25 MW or larger plants.[7] A total of 845 such hydropower projects have been identified all over the country which would be capable of annually delivering 600 billion units (kwh) of power. Another 98,000 MW installed potential has been identified from pumped storage sites and 6782 MW installed capacity in small, mini and

[6] Twelfth Plan proposals cited in http://www.downtoearth.org.in/content/12th-five-year-plan-spend-highest-ever-development

[7] MoP (2008): Hydro Power Policy 2008, Ministry of Power, GoI, New Delhi, p.1.

micro hydel stations (all less than 25 MW). The growth in India's installed hydro capacity from the 1st Five Year Plan to the start of the 12th Five Year Plan is shown in Fig. 1.2.

Almost 70 per cent of India's estimated hydropower potential is in the Himalayan states. With the shift from state-led development to market-led development in 1991-92 and the Government of India's decision to fast track power projects the role of the private sector has become significant in these states, many of which are cash strapped.

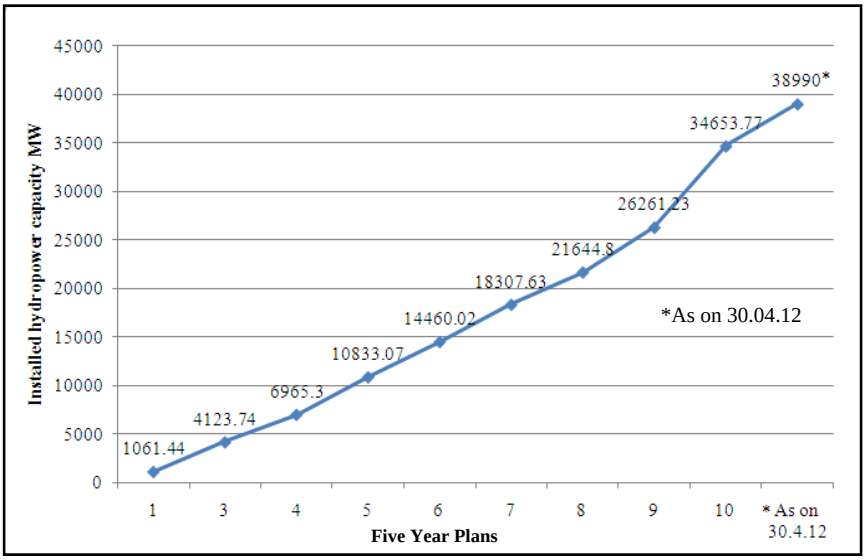


Fig. 1.2: Plan-wise growth in installed hydropower capacity

Hydropower Development in Uttarakhand

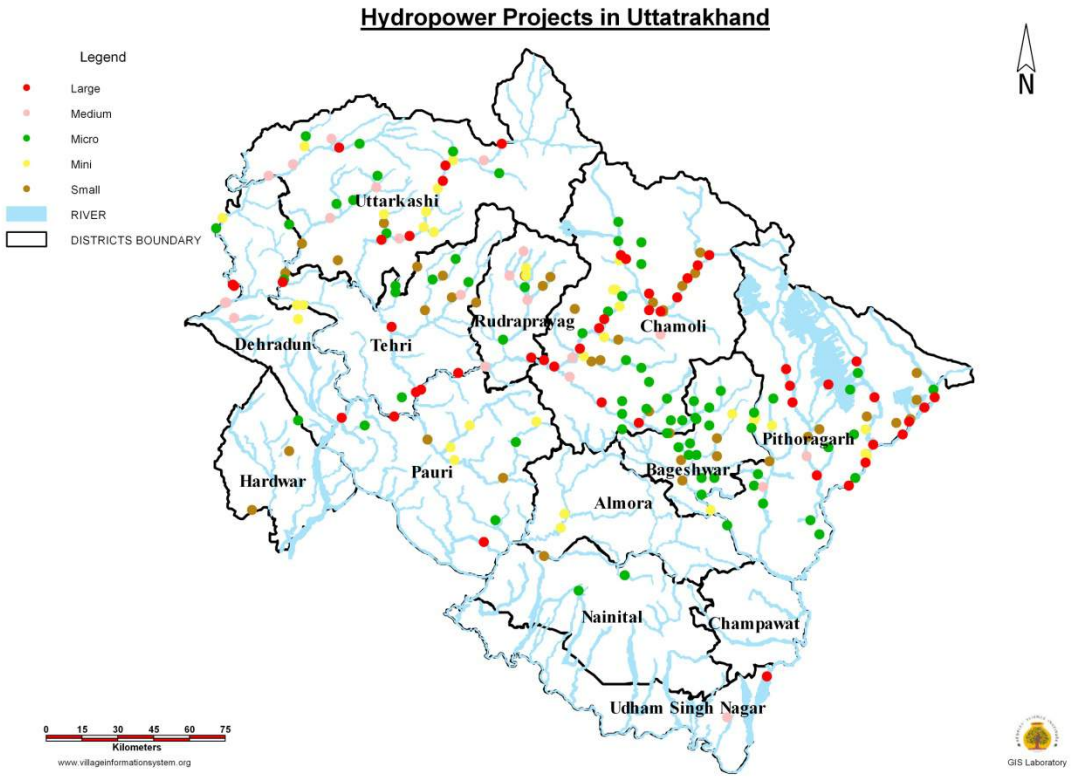
This section reviews Uttarakhand's hydropower development programme and analyzes the performance of its power sector.

After Arunachal Pradesh, Uttarakhand has the largest hydropower potential among the Himalayan states.[8] Hydropower was seen as an important potential contributor to the state revenues during the campaign for a separate state of Uttarakhand. After statehood it was also described as Urja Pradesh. State officials and political leaders consider the production and sale of hydropower as being essential for generating revenues, creating employment and the economic progress of the state.

Data provided by Uttarakhand Jal Vidyut Nigam Limited (UJVNL), a state government owned hydropower company, that also provides the state policy and planning support, shows that Uttarakhand has identified 450 potential HEPs. Uttarakhand's potential installed capacity and the present/ under construction installed capacities are shown in Tables 1.3a and 1.3b. They are categorized by size and their construction status.

[8] According to a 1987 hydropower reassessment survey by CEA, Himachal Pradesh has a slightly higher potential. The latest data for Uttarakhand provided by UJVNL, however, shows that Uttarakhand's potential has been revised substantially.

Fig.1.3 shows the locations of some HEPs in the state. Details for each project are given in Appendix 1.



Note: Some of the HEPs are on smaller rivers which are not shown in the map

Fig. 1.3: Locations of some HEPs in Uttarakhand

Table 1.3a shows that 92 projects have been commissioned so far and 38 are said to be under construction. Detailed Project Reports (DPRs) have been prepared for another 38 projects and they are awaiting clearances (Table 1.3b). The remaining 282 are still on the drawing board, undergoing surveys and investigation. A large fraction of the 450 HEPs are diversion projects that divert the river water through tunnels into power houses, while a small number (12) are storage projects.

Table 1.3a: Installed Capacities of Commissioned & Under Construction HEPs in Uttarakhand

S. No.	Project Status	Micro-Mini			Small	Medium	Large	Total
		≤ 1MW	>1MW ≤2	>2MW <5	≥5MW <25	≥25MW <100	≥ 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)**
Total		**14.74 (69)**	**10.65 (7)**	**51.7 (14)**	**198.1 (17)**	**421.15 (7)**	**6220 (16)**	**6916.34 (130)**

Source:UJVNL, December 2013 *Figures in () give the number of projects*

Table 1.3b: Potential Installed Capacities (MW)

S. No.	Project Status	Micro-Mini			Small	Medium	Large	Total MW
		≤ 1 MW	>1 MW ≤ 2	>2 MW <5	≥5 MW < 25	≥25 MW < 100	≥ 100 MW	
1	Awaiting Clearance	1 (1)	1.9 (1)	7 (2)	303.8 (22)	196 (3)	2808 (9)	**3317.70 (38)**
2	S & I Stage	21.28 (58)	32.85 (18)	101.25 (28)	1086.25 (84)	2233.8 (63)	13330 (31)	**16805.43 (282)**
Total		**37.02 (59)**	**45.4 (19)**	**159.95 (30)**	**1588.15 (106)**	**2850.95 (66)**	**22358 (40)**	**27039.47 (320)**

Source: UJVNL, December 2013: S & I= Survey and Investigation

Tables 1.3a and 1.3b also show that just 56 large dams (≥ 100 MW) will account for about 83% of the ultimate installed potential as estimated by UJVNL. Large (56) and medium (73) projects will account for over 93% of the estimated ultimate installed capacity. Finally 321 small (5≤ MW <25), mini and micro projects will provide just 7% of the total installed capacity.

The ultimate installed potential of 27039 MW assessed by UJVNL is almost 50% higher than the hitherto authoritative figure of 18175 MW determined by the 1987 reassessment survey of the Central Electricity Authority (CEA). The UJVNL figure includes the 6630 MW Pancheshwar dam whose construction requires joint action by the Nepal government. That appears unlikely in the foreseeable future. Also, in November 2010 the NGRBA took a decision to notify the 100 km stretch from Gangotri to Uttarkashi as an Eco-Sensitive Zone (ESZ). The GoI notified this decision in December 2012. It led to the cancellation of several dams within the ESZ with a total installed capacity of about 2040 MW. Hence a more realistic estimate of the ultimate state hydro potential would be about 18,379 MW.

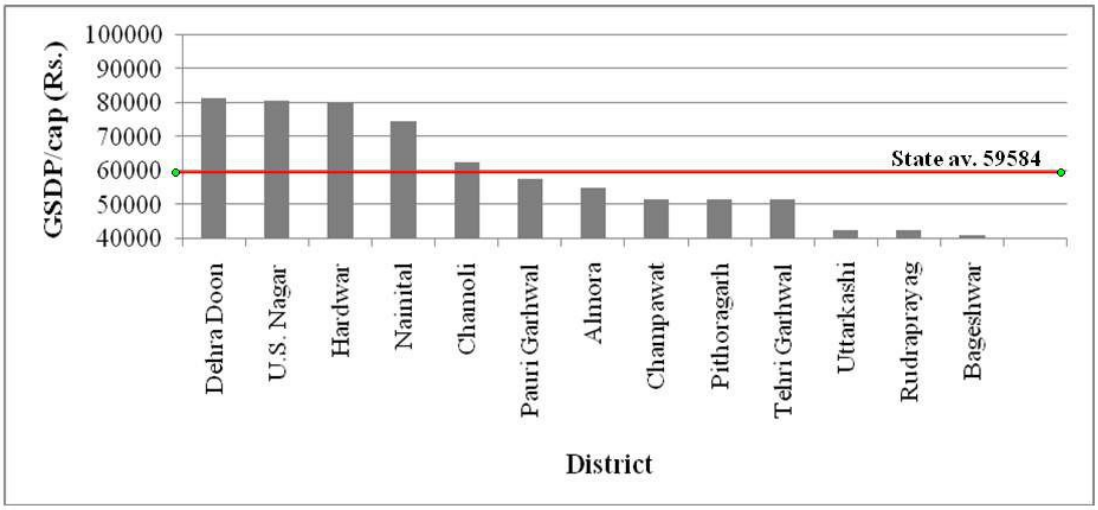
Tables 1.3a and 1.3b show that Uttarakhand has been able to commission about 13.4% of its potential installed capacity by 2013; another 12.2% is under construction and 12.3% are awaiting clearances. Once all these 168 projects are completed the installed potential created will be about 10234 MW. Analysis of the detailed project data in Appendix 1 shows that the existing and under construction – older projects – are mainly state sector projects; only 10 out of the 22 awaiting clearance and 80 out of 282 in the survey and investigation stage, however, are state sector projects. Hence the role of the private sector in developing Uttarakhand's hydropower is likely to grow.

Economic Development in Uttarakhand: Availability of power is an important driver of economic growth. Uttarakhand has a large hydropower potential. With the availability of surplus hydropower in the initial years after statehood, successive state governments have promoted the manufacturing sector for rapid economic growth. The Union

government also supported this approach by granting Uttarakhand a Special Category State status.

Out of the total power consumed in Uttarakhand, the share of the mountain districts is negligible. An industry document states that the mountain districts consumed barely 1.5% of the total power consumed in the state.[9] Daily power outages in the mountain districts are a common feature. Annual per capita consumption of less than 100 kwh in the mountain districts of Rudraprayag, Uttarkashi, Bageshwar and Almora was much below that of the southern Dehra Doon (936 kwh) and Haridwar (416 kwh) districts.[10]

The low level of electricity consumption in the mountain districts is because most manufacturing facilities and high value service sector enterprises are located in the four southern districts.[11] This has created more employment opportunities and better jobs in those four districts. Fig. 1.4 shows that the per capita Gross State Domestic Product of all



Source: Uttarakhand Statistical Diary 2011-12, Directorate of Economics & Statistics, Dept. of Planning, GoU, Dehra Doon, p.58

Fig. 1.4: District Wise Provisional Per Capita GSDP 2010-11

the mountain districts, except Chamoli, is below the state average. This has in turn led to heavy out-migration from the mountain districts as evident from Fig. 1.5. All the mountain districts have recorded slower population growth than the state average which has been boosted by rapid population growth in the four southern plains districts. For the first time perhaps in the history of this region, two districts – Pauri Garhwal and Almora - have recorded negative population growth.

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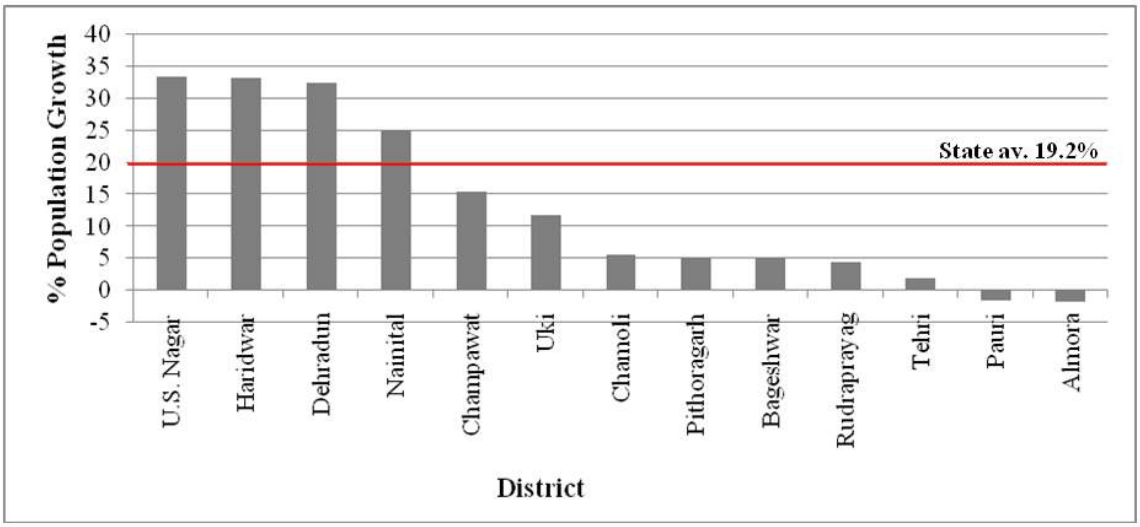
9 PHD Research Bureau (2013): Uttarakhand: The state profile, PHD Chamber of Commerce and Industry, New Delhi, June 2011, p.26

10 Based on a presentation made by the Uttarakhand Chief Minister to the Planning Commission to finalize the State Annual Plan for 2011-12, accessed at http://planningcommission.nic.in/plans/stateplan/present/Uttarakhand.pdf

11 R. Chopra (2014): *Op.cit.*



Source: Uttarakhand Statistical Diary 2011-12, Directorate of Economics & Statistics, Dept. of Planning, GoU, Dehra Doon.

Fig. 1.5: District wise decadal (2001-11) population growth rate

Since hydropower development in Uttarakhand is one of the important factors for its rapid economic growth, it can be concluded that hydropower has not been effectively used to benefit the northern mountain districts. The persistence of poverty in those districts, which are also more disaster prone, makes the people there more vulnerable to disasters.

I.3 Conclusions

Uttarakhand is a predominantly mountain state. Its mountain regions are fragile and vulnerable to regular disasters. With the availability of surplus hydropower in the initial years after statehood successive state governments encouraged development of the manufacturing sector in the four southern plains districts for rapid economic growth. It is the same model of development that is followed elsewhere in India. Thus it ignores the mountain character of Uttarakhand. In the process, the people of the nine mountain districts have not received significant benefits of hydropower. They remain poor and vulnerable.

Chapter – 2

ToR 2.1a

ToR 2.1a: Assess whether the existing and ongoing/under construction hydropower projects have contributed to the environmental degradation and, if so, to what extent.

The benefits of hydroelectric projects (HEPs) are well-known. As any other source of electricity hydropower provides (i) lighting for domestic and commercial purposes and (ii) motive power for industrial and agricultural production. Hydroelectric power generation can be a part of multi-purpose dams which may be designed to supply water for domestic use and agriculture besides generating power and controlling floods. Storage based HEPs can also be designed to absorb peak flood inflows and be used for tourism and recreation. In times of droughts storage reservoirs may be used to overcome water shortages. In general, per unit of power generated HEPs emit less greenhouse gases than fossil fuels based thermal power stations.

On the other hand HEPs also have serious environmental and social costs across their life-cycles as shown in Table 2.1 below.

Table 2.1: Life-cycle environmental and social impacts of HEPs

ACTIVITY	IMPACT
I. Pre-Project Construction	
1. Construction of approach roads	• Land acquisition (displacement, loss of lands, homes, and livelihoods) • Deforestation (loss of tree cover, access to CPRs, soil erosion and landslides, loss of flora and fauna, changes in micro-climate) • Disposal of debris and earth (loss of trees, river water pollution)
2. Construction of housing for staff and labour	• Deforestation • Pollution due to sewage releases
3. Quarrying	• Noise pollution, slopes destabilization, disruption of underground seepages and damage to houses
II. Project Construction	
4. Tunneling	• Air and noise pollution, destabilization of slopes, damage to houses, disturbing wildlife, drying of springs, disposal of muck into the river, psychological trauma to people and animals due to the repeated blasts
5. Dam Construction	• Disruption of river flows (biotic changes, disruption of natural functions, e.g., sediments disposal, land shaping, nutrient cycling), river pollution, loss of aesthetic, cultural, economic and recreational values.
III.Project Operation	
6. Testing of Tunnels	• Slope destabilization (loss of tree cover, land, livelihoods, water sources and access to CPRs)

7. Water Storage and Release	• Sedimentation (effect on river water quality) • Disruption of river flow • Secondary effects (release of greenhouse gases, warming of valleys, increased earthquake risks, floods, downstream urban and industrial development
8. Laying of Power Lines	• Deforestation (loss of wild life habitat), soil erosion

All HEPs -- big or small -- have environmental and social impacts. The negative impacts of small projects can be less intense and therefore mitigated more easily. Large projects often lead to massive impacts that are hard to mitigate and may result in permanent scarring of nature and society. Many of them are not even seen or felt immediately. They emerge over time. In the recent past as environmental and social concerns have been strongly expressed by affected communities, attempts have been made to design and implement mitigation measures.

The major impacts are on the (i) river eco-system, (ii) forests and terrestrial biodiversity, (iii) geological environment and (iv) social infrastructure. They are elaborated in the following sections with respect to commissioned and under-construction HEPs in Uttarakhand. The impacts cited are based on published research papers, official documents, observations of the Experts Body (EB) members during their field tours and in a few cases representations made to the EB.

2.1 Impacts on River Ecosystems

Disrupting River Flows

Context

Rain and snow feed thousands of streams and rivers that course through Uttarakhand. Twelve important glacier-fed rivers span the entire state (west to east): the Tons, Yamuna, Bhagirathi, Bhilangana, Mandakini, Alaknanda, Dhauliganga (W), Nandakini, Pindar, Ramganga (E), Gori Ganga, Dhauliganga (E) and the Mahakali. Hundreds of smaller glaciers and springs fed streams meet these rivers along their length.

Natural functions inherent to rivers depend on sustaining the integrity (continuity and spread) and variability of their natural flows. They include transporting water and sediments from their catchments to the sea; shaping the landscape and their own channels; supporting aquatic and terrestrial biota; water, nutrients and energy cycling and digesting pollutants or self-cleansing. Uttarakhand's rivers support an estimated 125 fish species.[1]

Uttarakhand's rivers also have enormous cultural and religious significance. Ganga, designated as India's National River in 2008, is worshipped by hundreds of

[1] WII (2012): Assesment of Cumulative Impacts of Hydroelectric Projects On Aquatic And Terrestrial Bio-Diversity In Alaknanda and Bhagirathi Basins, Wildlife Institute of India (WII), Dehra Doon, p.3.

million Indians throughout the world. It is undeniably India's most sacred river. Its devotees believe that bathing in the river washes away all sins. Several festivals are held on its banks throughout the year.

Four major shrines, located near the origins of the Alaknanda, Mandakini, Bhagirathi and Yamuna rivers, attract over a million worshippers and services providers each year. The last rites of deceased persons are performed by the banks of almost all the rivers in Uttarakhand. Several fairs and festivals are also organized along their banks. As elsewhere, Uttarakhand's rivers provide livelihoods to local communities. Water is extracted from rivers for irrigation and domestic use. Livelihoods are also derived from adventure sports and tourism related to their cultural, recreational and aesthetic values.

Glacier and snow melts provide good flows in the summer. This makes hydro-based Uttarakhand generally power surplus in summer when power generation from rain-fed rivers is minimal elsewhere. Power in excess of the state's own needs is traded or banked with other states so that Uttarakhand can buy power in the winter, when its own hydro generation is reduced due to the absence of glacier and snow melts.

But hydropower projects alter the natural flow patterns of rivers. Most of Uttarakhand's HEPs are diversion projects which divert water upstream of a dam into a tunnel and drop it several kilometers downstream in order to obtain a large head. The stretch of the river between the dam and the powerhouse, often 10 to 20 km, goes dry during the non-monsoon months when only a nominal flow is allowed to flow into the river or is added by small streams in between (See Fig. 2.1).

Fig. 2.1: R. Alaknanda downstream of the Vishnuprayag dam in Chamoli district

Series of dams are proposed for the major rivers of Uttarakhand. They will have a dam every 20 to 25 km of their length, in some cases after even shorter stretches. They will be converted into a series of ponds (reservoirs behind the dams) connected by pipes (tunnels). Large fragments of these rivers could be left with minimal flow as almost all the river water is extracted for producing hydroelectricity, as per current practice.[2] This can lead to synergistic cumulative impacts, especially when the zone of influence of one dam overlaps with that of the neighbouring dams.

[2] Mandatory downstream releases are now being enhanced. But until now compliance with mandated rules has lax due to inadequate monitoring (see section on ToRs 3.1, 3.2, 3.3).

Storage projects generally reduce the annual discharge, the seasonal flow variability and the daily flow pattern downstream of dams. The magnitude of change and impacts depends on the design of the project and its operation.

A river's ecosystem develops in response to its water flow pattern. Once a river bed dries up or remains dry for significant periods, its ecosystem changes. Species that need to remain under water all the time decrease and are replaced by hardier ones. This change in the species populations and diversity can affect the entire aquatic food chain. Riverine vegetation, including that of the flood plains, changes as water and nutrients are withdrawn. Dams hold back sediments, gravels, cobbles and other debris leading to greater erosion of river beds and banks downstream and the loss of spawning or feeding habitats for various aquatic organisms including fish. Dams and barrages also block the movement of migratory fish species.

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. The accompanying reduction in moisture can diminish the valley's biodiversity and productivities. In the long run it may also speed up the melting of nearby glaciers.

River managers in many parts of the world value rivers as freshwater ecosystems. Rivers require varying amounts of water during the year to sustain their ecosystemic and anthropocentric functions. Hence in recent decades river managers have begun to implement the concept of environmental flows (EF), defined as an 'acceptable flow regime designed to maintain a river in a predetermined state', i.e., a pattern of flows that mimics the natural flow variations.[3] The critical aspect is to maintain the variability of the flow and not just the amount of flow. In 2000 the Report of the World Commission on Dams noted that 29 countries were releasing environmental flows to meet predetermined ecosystemic objectives. [4] In a country like India the environmental flows released downstream from dams must be adequate to meet social, cultural, livelihoods and other anthropocentric needs.

In India dam engineers try to utilize the maximum amount of water. Their basic approach is to maintain a 'minimum flow'. But there is no agreed definition of minimum flow in India. A commonly accepted thumb rule in many states, as in Uttarakhand, is 10 per cent of the lean season flow or the base flow. In neighbouring Himachal Pradesh it is 15 per cent of the inflow. A report prepared by the Central Water Commission in 2007 recommended that for Himalayan rivers 2.5 per cent of the annual average flow at 75 per

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[3] V. Smakhtin & M. Anputhas (2006): An Assessment of Environmental Flow Requirements of Indian River Basins, Research Report 107, International Water Management Institute, Colombo, p.6.

[4] WCD (2000): Dams and Development: A New Framework for Decision-Making, The Report of the World Commission on Dams, reissued by South Asia Network on Dams, Rivers & People, New Delhi, May 2012 p 81.

cent dependability should be provided as a minimum flow.[5] These approaches estimate the total volume of water to be released annually. They ignore flow variations. Such thumb rules are arbitrary, with little scientific basis.

Impacts

Post facto studies of the impacts of HEPs on Indian rivers and in particular their flow patterns are rare. The few that have been conducted by reputed investigators highlight four critical impacts as explained below.

(i) Dry river beds: A perusal of the EIA reports of several existing HEPs in Uttarakhand reveals that scientific assessments of EF requirements have not been done. Provisions are only made for minimum downstream releases. Many reports simply state that while several kilometers of the river will go dry, there will be no significant impact, except on benthic invertebrates and fish. Dry stretches are therefore routinely visible below the Vishnuprayag HEP (Fig 2.1), the Maneri Bhali-I dam (Figs. 2.2a), the Maneri Bhali-II barrage (Fig. 2.2b), and Ichari dam among others, particularly in the non-monsoon months. A water quality study of the Bhagirathi river conducted by National Environmental Engineering Institute (NEERI), Nagpur noted that "a stretch of the river is completely dried in between Maneri and Uttarkashi due to diversion of water, required for Maneri Bhali project."[6] A CAG study team also found dry river beds downstream of the sites it visited. In several locations it noted that the local people were deprived of

Fig. 2.2a: R. Bhagirathi downstream of the Maneri-Bhali I dam

Fig. 2.2b: R. Bhagirathi downstream of the Maneri-Bhali II barrage

[5] CWC (2007): Report of Working Group to Advice WQAA on the Minimum Flows in the Rivers, Central Water Commission, Ministry of Water Resources (GoI), New Delhi, p.43

[6] NEERI (2011): Water Quality of Bhagirathi/Ganga River in Himalayan Region, a study report submitted to THDC.

drinking water and irrigation resources.[7]

A review of the multipurpose Ramganga project commissioned by the Central Water Commission (CWC) reported that 10 per cent of the lean season flows (av. 5 cumecs) were supposed to be released for ecological conservation. But such releases are not made says the review.[8] Consequently pollution levels due to urban areas and industries on the banks of the Ramganga are very high.

(ii) Fragmentation of river length: When a number of dams are built in a series on a river, each dam fragments the river due to minimal flows between the dam and the power house. In these stretches the rivers lose their continuity and spread. As a result they are unable to perform their natural functions. The loss of natural flows also affects anthropocentric values of rivers, i.e., social, economic, cultural, aesthetic and recreational values. No EIA report discusses the cumulative impact of minimal flows due to multiple projects in its valley.

The ratio of the river length diverted to its total length is a good indicator of the cumulative impact of multiple dams. This is shown for a few rivers in Table 2.2 below. The affected river length was first determined by AHEC. IMG recommended that some of the rivers be maintained in a pristine state which would mean the cancellation of a few projects and hence changes in the river length affected.

Table 2.2: Likely cumulative fragmentation by proposed, under construction and existing projects

S. No.	River	Total River Stretch (km)	Percentage of river length affected			Remarks
			AHEC	WII	IMG#	
Bhagirathi Basin						
1	Bhagirathi	217	*81*	*70.7*	*53*	
2	Asi Ganga	20.5	*59*	*53.4*	*0*	IMG recommended that this river be kept in a pristine status.
3	Bal Ganga	37	*35*	*39.8*	*5*	IMG recommended that this river be kept in a pristine status.
4	Bhilangana	109	*41*	*36.1*	*8*	
5	Small Tributaries	73	*28*	*22.5*	*39*	
	Total	456.5	*58.5*	*51.5*	*33.8*	
Alaknanda Basin						
6	Alaknanda	224	*65*	*48*	*25*	
7	Dhauliganga (W)	92	*99**	*93.6**	*48*	Upper reach to be kept pristine.

[7] CAG (2010): Performance Audit of Hydropower Development Through Private Sector Participation, Report of the Comptroller and Auditor General of India, Dehra Doon, p.28-29

[8] AFC (2012): Report on Environmental Evaluation Study of Ramganga Major Irrigation Project, Agriculture Finance Corporation, Hyderabad.

8	Rishi Ganga	38.5	*32*	*28.6*	*3*	IMG recommended that this river be kept in a pristine status.
9	Birahi Ganga	29.5	*36*	*74.3*	*5*	IMG recommended that this river be kept in a pristine status.
10	Nandakini	44.5	*24*	*34.9*	*24*	
11	Mandakini	81	*51*	*43.7*	*41*	
12	Pindar	114	*39*	*30.7*	*23*	
13	Small Tributaries	83	*30*	*22.6*	*26*	
	Total	664.5	*51.3*	*43.9*	*26*	

Note: *AHEC and WII have only considered the 50 km stretch of the river from the first project. Upper reaches of the river (42 km) were not counted.IMG has considered the total river length of about 92 km.
#Has recommended cancellation of new projects on Asiganga, Balganga, Rishi Ganga and Birahi Ganga.

(iii) Disruption of fish migration: Lack of connectivity limits the territory of species that migrate extensively along the length of the river. The isolated and localized populations become more vulnerable with increasing fragmentation. A study to assess cumulative impacts of HEPs in the Alaknanda basin states that earlier the popular game fish mahseer was reported as far upstream as Karnaprayag.[9] But the Chilla HEP downstream of Rishikesh has reduced access to its main spawning ground on the Nayar river – a tributary of the Ganga – upstream of Rishikesh. As a result fewer mahseer fish reach Srinagar. With the construction of the large AHPC HEP at Srinagar it is doubtful if the mahseer species will now be seen upstream of the project.

Wildlife Institute of India (WII) has estimated that 87 per cent of the 76 fish species found in the Alaknanda and Bhagirathi basins could be potentially affected if all the HEPs planned in these basins are eventually constructed.[10]

(iv) Impacting aquatic biota and diversity: Altering the flow pattern of a river affects its aquatic biota and diversity. The loss of micro-organisms like planktons and macro-invertebrates is significant because they are the food for larger organisms, including fish.

As part of an all-India project, the Central Pollution Control Board (CPCB) analyzed the impact of HEPs on benthic macro invertebrates at 11 HEP sites in Uttarakhand.[11] Bio-monitoring was done at five sampling locations for each HEP – a reference station, the inlet to the reservoir, reservoir, downstream of the dam/barrage gates and at the powerhouse (tailrace tunnel outlet). The populations of the sensitive species in the reservoir and downstream of the dam/barrage declined 50 per cent to 90 per cent compared to the reference stations, whereas the tolerant species' populations increased. It was argued that changes in the stream flows led to changes in the substrata which reduced the species.

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9 Anon (2009): Consultancy Report, pers. comm.

10 WII (2012): *Op.Cit.*, p.107.

11 CPCB (2007): Annual Report 2006-2007, Central Pollution Control Board, New Delhi.

The HNB Garhwal University, Srinagar conducted a post impoundment faunal survey of the Tehri reservoir and its surroundings for the Tehri dam authorities.[12] The survey revealed that while the annual mean density of zooplankton had increased after the filling of the reservoir, there was a sharp decline in the annual mean density of macro invertebrates. More sensitive species like Ephemeroptera, Trichoptera, Coleoptera, Hemiptera, Plecoptera either declined significantly (~ 80 %) or disappeared while the density of hardier species like Mollusca and Odonata increased. This data indicates moderate levels of pollutions in the reservoir.

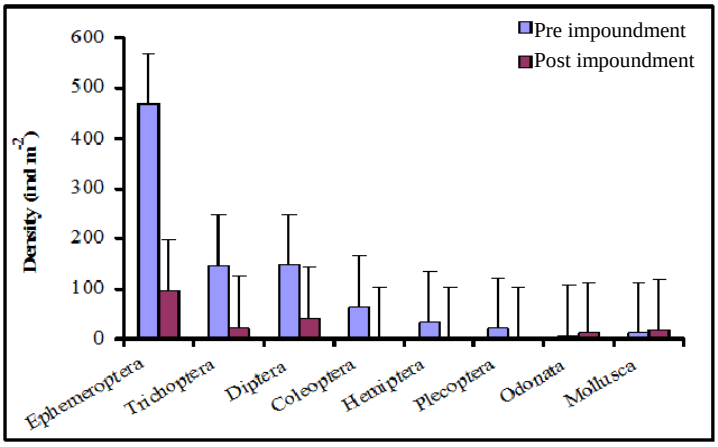

Fig. 2.3 Depression in the annual mean density (inds/m^2) of macro invertebrates caused by impoundment

A High Level Expert Group (HLEG) constituted in 2008 by the Ministry of Power, GoI, to examine technical aspects for ensuring perennial EF in all stretches of river Bhagirathi commissioned a bio-monitoring study on the impact of HEPs on the aquatic ecosystem in the Bhagirathi between Gangotri and Uttarkashi.[13] This study reported 98 individuals/ft^2 benthic macro invertebrates – a basic component of the aquatic food chain -- at a reference point upstream of the then under construction Loharinag-Pala dam. But downstream of the Maneri-Bhali II barrage in Uttarkashi the investigators found a reduced benthos population of only 9 individuals/ft^2.

The above study also found that aquatic diversity had been severely affected downstream of the Maneri Bhali-I project due to drying of the stream (See Fig. 2.2a). It reported a low value of 0.40 for the Shannon Wiener diversity index in the Bhagirathi downstream of Maneri whereas it was 2.01 in the tributary Asiganga further downstream.

The passage of living organisms through long tunnels of diversion HEPs impacts their survival due to inadequate availability of oxygen. Fish can suffer injuries in the turbines or sliding down spillways. It appears, however, that no specific studies have been taken so far to determine such impacts in Uttarakhand.

HEPs can impair aquatic biodiversity values. In the Alaknanda-Bhagirathi basins the three lower sub-basins: (i) Bhagirathi IV – the stretch from the Tehri dam to

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12 -------- (2012): "Post Impoundment Faunal Survey and Analysis of Tehri Dam Environs", HNB Garhwal University, Srinagar

13 H.R. Singh, N. Kumar & N.K. Agrawal (2008): "Ecological Parameters of the Bhagirathi", Report submitted to the High Level Expert Group (HLEG), National Thermal Power Corporation, New Delhi.

Devprayag, (ii) Alaknanda I stretch from Karnaprayag to Devprayag and (iii) River Ganga from Devprayag to Rishikesh have very high aquatic diversity values.[14] Ten sub-basins in the Lesser Himalaya belt have high aquatic biodiversity values. Analyzing the comparable Bhagirathi III sub-basin and the Alaknanda I sub-basin, which lie in a similar altitude range, it can be surmised that the aquatic biodiversity value of the former has declined from very high to high due to the Maneri Bhali II and Tehri projects. No stretch of the Bhagirathi will have a very high aquatic biodiversity value once the Koteshwar and Kotli-Bhel IA projects become operational.

Mitigation

Conserving Fish Populations: Dams and barrages block fish passages to upstream spawning grounds and thereby deplete migratory fish populations. Two mitigation measures are commonly proposed: (i) fish passages and (ii) *ex-situ* stocking.

Fish passages include fish passes, ladders and locks or lifts. They provide an alternate route to migratory fish like trouts and mahseer in Uttarakhand's rivers by enabling them to climb over a dam or a barrage. High structures and downstream fish migration, however, are still problematic. According to the World Commission on Dams, the efficiency of fish passes is generally low and fish migration remains severely impacted.[15] WII's Cumulative Impact Assessment report (2012) adds, "Even where fish passes have been installed successfully, migration can be delayed by the absence of better navigational cues, such as strong currents…. …..However, the efficiency of fish pass in Himalayan rivers would be highly doubtful if the dam height is more than 16 meters."[16] Generally fish lifts or locks work better for fish species with low to moderate jumping capability.

An Alternate View

An examination of altered flows in a few HEPs in Uttarakhand, e.g., Maneri Bhali I & II and Srinagar shows that the flow released below the barrier in the monsoon season is of the order of 50-80%, considered adequate in the critical migration period, the early and late monsoon.

- ***B.P. Das, Co-Chair, EB***

The golden mahseer migrates upstream into the Ramganga from the Ganga. But the multipurpose dam at Kalagarh is a barrier to this migration.[17] The fish passage constructed here has rarely worked. An 82.5 km long irrigation feeder channel connecting the reservoir and the Ganga River serves as on alternative route for fish migration between Ganga River and the Ramganga Reservoir at Kalagarh.

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14 WII (2012): *Op.Cit.*

15 WCD (2000): *Op.Cit.*

16 WII (2012): *Op.Cit.*

17 AFC (2012): *Op.Cit.*

Ex-situ conservation is sometimes attempted by artificially stocking the affected fish species in hatcheries and releasing them into the reservoir periodically.

EFlows: Not only are fish passages generally inadequate, but they do not address the need to sustain aquatic biota other than fish. To comprehensively sustain aquatic biota it is necessary to ensure environmental flow (EF) releases. Since 2008 there has been a growing awareness in India of the need to release EF downstream of dams and barrages. Earlier EF assessments were limited to releasing water only to sustain aquatic biota. With time there has been a growing understanding for more comprehensive assessments so that the EF released is enough to enable the river to fulfill its natural functions and meet anthropogenic needs.

An Inter Ministerial Group of the Government of India reviewed various recommendations for environmental flows in the context of hydropower projects in the Alakanada and Bhagirathi basins. Its own recommendations are tentative, pending the completion of a more substantial study by a consortium of IITs preparing a Ganga River Basin Environmental Management Plan. The IMG-reviewed and some other EF recommendations for Indian rivers are summarized in Table 2.3.

Table 2.3: EF recommendations for Indian rivers

S.No	Agency	Recommendations
1.	International Water Management Institute (2007)	Rivers are classified into different Environment Management Classes, depending on their state. The latter is quantified using a scoring method for various flow, quality and diversity parameters. The natural flow variations of the river are plotted as a Flow Duration Curve (FDC). The EFs are determined by attenuating the FDC depending on the desired Management Class.
2.	Sub-committee, Union Ministry of Water Resources (2010)	Release 10% to 20% of MAF (Mean Annual Flows) distributed on the pattern of the natural river flow (FDC).
3.	Alternate Hydro Energy Centre (AHEC), Roorkee (2011)	It calculated EF for 31 locations in the Alaknanda Bhagirathi basins using practical but simple methods followed elsewhere in the world.[18] It recommended EF values for locations in the Bhagirathi basin generally ranging from 4 to 20% of the mean annual flow (MAF). In the Alaknanda basin they ranged from about 7.5% to 28% of the MAF. At religious places the recommended EF ranged from about 8 to 24%.
4.	Wildlife Institute of India (WII), Dehra Doon (2012)	For biodiversity conservation in the Alaknanda and Bhagirathi basins WII proposed minimum EF computed on the basis of Mean Seasonal Flows (MSF). It recommended EF releases of 30% for the High Flows Season (May-September), 20% of MSF for Low Flow Season (November-March) and 25% of MSF in April and October

[18] AHEC (2011): Study on Assessment of Cumulative Impact of Hydropower Projects in Alaknanda and Bhagirathi Basins upto Devprayag, Alernate Hydro Energy Centre, IIT, Roorkee.

5.	Worldwide Fund For Nature, India (WWF) (2013)	Using the more comprehensive building block method (BBM) it determined EF requirements at three locations in river Ganga between Devprayag and Kanpur. EF requirements in the upper reach up to Rishikesh were estimated at 72 % of the natural flow in normal years and 44 % in drought years.
6.	Inter Ministerial Group (IMG) (2013)	For hydro projects in the Alaknanda- Bhagirathi basin: May to September: Release 25% of the daily uninterrupted flows provided that the total inflow in the river was not less than 30% of the MSF. April, October & November: 25% of the daily uninterrupted river flow. December to March: 30% of the daily uninterrupted flows, rising to 50% of the inflow where the average monthly lean season flow is less than 10% of the average monthly high season flows.
7.	Centre For Science and Environmental (CSE) (2013) reported in the IMG Report	50% of the inflows during November to April and 30 per cent from May to October.
8.	IITs Consortium (2013)	Based on a detailed study at 7 specific locations on the Bhagirathi, Alaknanda and Ganga. EF ranged from 29.05% (u/s of Devprayag on the Alaknanda) of the average 20 5 dependable virgin flow to 39.45 % (d/s of Pashulok barrage at Rishikesh) during the monsoon season. From 27.98 % (u/s of Devprayag) to 53.09% (u/s of Rishikesh) in the non-monsoon months.

Commenting on the issue of EF releases the Central Water Commission (CWC) has stated that the required quantitative data to make reliable estimates is not available for Indian rivers at present.[19] It has therefore suggested 20% releases at present, pending the availability of detailed site/reach specific studies.

The IITs consortium study is the most detailed and comprehensive study. It also proposed that a special river passage be allowed through a barrage or a dam that is capable of transporting E-flows along with river sediments and allow migration of aquatic species under natural flow conditions.[20]

Ultimately the level of EF recommended depends on the objectives that are to be satisfied. But it is seen from the above table that there has been a rapid recognition of the complexities involved in determining quantitative values for EF releases. As the level of complexity considered increases, generally the recommended EF are higher.

[19] IMG (2013): Report of the Inter-Ministerial Group on Issues Relating to River Ganga, Vol-I, GoI, New Delhi, p.21-22

[20] IITs Consortium (2013): Ganga River Basin Management Plan Interim Report, IIT-Kanpur, Kanpur, pp. 26-36.

The cost of water allocations for EF can be less than generally expected and not necessarily proportional to the flow reductions. The loss in power generation due to EF releases can be reduced by making suitable changes in the operational schedule or in the equipment or dam design. [21]

Protected river zones: The upper reaches of most of Uttarakhand's rivers are essentially remote, pristine, wilderness stretches. IWMI's suggested river management perspective states that such stretches should be protected and no water projects be allowed in these protected zones. [22] Their aesthetic and recreational values are of a very high quality. Scientists value their biodiversity, land forming processes, energy flows and nutrient and water cycling as vital life-supporting systems.

In 1968 the USA enacted the Wild and Scenic Rivers Act to save such treasured rivers in their pristine state.[23] New South Wales and Queensland states in Australia have also adopted similar legislation.[24] Among other methods of protecting such rivers they propose banning highly damaging activities such as the construction of dams/ barrages and intensive agriculture. In India a beginning was made in Himachal Pradesh where the legislature passed a resolution in 2004 declaring the Tirthan river to be pristine and to be protected as such. The resolution bans the construction of dams on the Tirthan and its two tributaries, Jibbi and Hirrub Nala.

In November 2010, the National Ganga River Basin Authority (NGRBA) cancelled the approval for three HEPs – 600 MW Loharinag-Pala, 400 MW Pala-Maneri and the 1381 MW Bhairon Ghati HEPs – upstream of the Maneri Bhali I project on the Bhagirathi. In December 2012 on the direction of the NGRBA, India's Ministry of Environment and Forest created a protected river zone by notifying the watershed of about 100 km stretch of the Bhagirathi from its origin at Gaumukh to Uttarkashi as an Eco-Sensitive Zone (ESZ). To protect and regenerate the region's environmental resource base it prohibits certain types of development projects like HEPs above 2 MW or establishing polluting industries. It regulates activities like ground water extraction or clear-felling of trees. It calls upon the State Government to prepare a Zonal Master Plan for the watershed in consultation with the local people, particularly women.

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21 ANON (2008): A World Bank internal discussion document. See also, B.D. Richter & G.A. Thomas (2007): "Restoring Environmental Flows by Modifying Dam Operations", Ecol. & Soc., v 12(1) no. 12.

22 V. Smakhtin et. al. (2007): Developing Procedures for Assessment of Ecological Status of Indian River Basin in the Context of Environmental Water Requirements, Research Report 114, International Water Management Institute, Colombo.

23 A. McGrath (2009): "Beyond Banning Dams: Benefits of Wild and Scenic River Designation for Northwest and National River Systems", American Rivers.

24 ---------- (2009): Wild Rivers Act 2005, Office of the Queensland Parliamentary Counsel, Reprint No.2A.

Water Quality

Context

By obstructing the natural flow of a river, a dam can cause significant changes in the physical, chemical and biological properties of river water. Such changes occur across the life span of an HEP. They can affect a river's ability to perform its natural functions like supporting aquatic biota, nutrient cycling, removal and digestion of pollutants and self-cleansing.

HEPs transform a flowing water ecosystem characterized by high velocity, turbulence and mixing of water, suspended solids and bed load and high re-aeration into a stagnant water one with low velocity, low mixing and turbulence, limited aeration, sedimentation, thermal stratification and longer residence times. These physical changes affect the water quality.

Aquatic biota are sensitive to temperature changes. Storage of water behind dams or barrages or its passage through tunnels can raise its temperature. Large storage reservoirs can become sources for greenhouse gases emission, particularly if large amounts of vegetation are submerged.[25] Passage through turbines can crush benthic invertebrates, reducing their populations and affecting the food chain downstream.

Uttarakhand's rivers are generally fast flowing due to their steep gradients. As a result they are highly aerated. Their dissolved oxygen (DO) content is high and there are relatively few sources of point pollution in the mountain regions. The riverine life forms are thus adapted to the fast flows and clean water. The native species are highly pollution sensitive.

Gangajal, i.e., the water of river Ganga, is often preserved by devotees for long periods because its quality does not deteriorate. Its high self-purifying capacity is known to be unmatched by other rivers, including other Himalayan rivers in Uttarakhand.[26] Impoundment behind dams and barrages leads to retention of sediments, minerals and vegetative matter that influence the river's self-cleansing or purifying ability. It also reduces the DO content.

Reduced flows downstream of dams and barrages diminish the rivers' ability to dilute pollution loads. Nutrients-laden raw sewage from human settlements or fertilizers washed down from agricultural fields can turn oligotrophic (poor in nutrients) Himalayan rivers into eutrophic (rich in nutrients) water bodies when flows are reduced. This can

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[25] I.B.T. LIMA et.al. (2007): "Methane Emissions From Large Dams as Renewable Energy Resources: A Developing Nation Perspective", Mitigation and Adaptation Strategies For Global Change, published on-line, March 2007.

[26] D.S. Bhargava (1977): "Water Quality in Three Typical Rivers in U.P. – Ganga, Yamuna and Kali", Ph.D. Thesis submitted to IIT-Kanpur.

reduce aquatic bio-diversity with key Himalayan pollution sensitive species being replaced by more pollution-tolerant ones.[27]

Impacts

Construction Stage Impacts: During the pre-construction and construction phases large amounts of overburden from the side slopes, muck and debris are generated while building approach roads, quarrying for construction materials, tunneling and constructing the dam itself. These are to be disposed off at designated sites with retaining walls to prevent their entry in to the river. But poorly constructed or maintained retaining walls are sometimes washed away during floods (See also detailed discussion on muck dumping impacts in the next section, on ToR 2.1b). This increases the suspended solids load. It leads to increased turbidity, cutting off light at the deeper levels and affecting the abundance of the river's biota.

Drastic changes in the physico-chemical and biological profile of the Bhagirathi's aquatic ecosystem due to road building activities during the construction of the Tehri HEP were documented.[28] The severest was the destruction or degrading of the feeding, spawning and migration routes of the mahseer due to detrimental effects on transparency, current velocity, conductivity, substrate composition, dissolved oxygen and benthic communities.

H.R. Singh et.al.'s study mentioned earlier showed that construction activities at the Loharinag-Pala HEP site had severely reduced the abundance and diversity of benthic invertebrates from 98 individuals/ft^2 representing 10 taxonomic families at the reference station (Harsil) to only 22 individuals/ft^2 of seven families downstream of the dam construction site.[29]

Mountains of soil and debris dumped over denuded slopes, often with inadequate retaining walls, could be seen at the Srinagar HEP (330 MW) during the construction phase (Fig. 2.4a). Consequently the river water became muddy (Fig. 2.4b). Similar observations were made in the CAG report of 2009.[30] AHEC-IIT Roorkee reported a sharp increase in turbidity levels from 0.91 upstream of the dam to 6.52 NTU downstream.[31] The CAG report cited violations of muck dumping rules at all the three other project sites it visited.

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27 -------- (2009): *Op.Cit.*, p.4-19.

28 R.C. Sharma (2003): "Protection of an endangered fish Tor tor and Tor putitora population impacted by transportation network in the area of Tehri Dam Project, Garhwal Himalaya, India", in Proceedings of the 2003 International Conference on Ecology and Transportation, Eds. C.L. Irwin, P. Garrett and K.P. McDermott, North Carolina State University, Raleigh, NC, pp. 83-90.

29 H.R. Singh, N. Kumar & N.K. Agrawal (2008): *Op.Cit.*

30 CAG (2010): *Op.Cit.*, p.32.

31 AHEC-IIT R (2011): Assessment of cumulative impact of hydropower projects in Alaknanda and Bhagirathi basins, Roorkee, p.6-28.

Inadequate maintenance of muck dumping sites was witnessed by the EB teams during their field tours. Most of the muck dumping sites are along the river banks or on the banks of nearby smaller tributaries. The retaining walls were usually constructed with wire mesh crates of rounded rocks. At some locations there was little visible effort to re-vegetate the muck materials to protect the loose soil from eroding or to facilitate habitat development. Several muck dumping sites of the Phata-Byung and Singoli-Bhatwari sites were found in a damaged condition and much of the muck had been washed away. It was evident that the existing retaining walls were unable to survive the massive June 2013 floods.

Fig. 2.4a Overburden and muck dump along R. Alaknanda upstream of Srinagar (May 2008)

Fig. 2.4b Muck dump site downstream of Tehri dam along the left bank of Bhagirathi river

While driving down from the Tehri dam axis, a team of EB members saw two muck dumping sites. According to THDC officials, the older and relatively better stabilized muck disposal site corresponds to Phase-I (2004-2005). It is located before Chopra village along the left bank of the Bhagirathi River. The muck is being terraced and at one location there is a wire-fenced stone wall. However, no appreciable growth of vegetation cover was seen, almost a

decade after the commissioning of the project. At the Tehri Phase-II sites muck protection had just started at one location by no protection measures had started at another location with a steep slope of 60^0-70^0.

Large contingents of labourers and officers are employed at HEP construction sites. Temporary settlements for the workers and permanent staff quarters are constructed by the river side. The resulting sewage load can pollute the river unless adequate sewage treatment facilities are provided for all. At Srinagar the fecal coliform (FC) value rose from 43 MPN/100ml upstream of the dam to150MPN/100ml downstream. "This increase in FC may be due to the waste water coming from project colonies," explained the above-mentioned AHEC- IIT Roorkee report. (See also compliances monitoring section in Chapter 5)

Scientists of the Central Pollution Control Board (CPCB) carried out water quality field studies of Uttarakhand rivers in 2004-05.[32] They assigned a clean class A to the Alaknanda river upstream of the Vishnuprayag HEP, then under construction, but a moderately polluted class C to it downstream of the project.

Tehri Dam Impacts: A comprehensive study conducted by National Environmental Engineering Research Institute (NEERI) highlighted the deleterious effect of the Tehri dam on the unique self-purifying ability of Gangajal. It attributed the unique self-purifying capacity of Gangajal to the river sediments.[33] The study data indicates that the blocking of sediments behind the Tehri dam diminishes this unique property of Gangajal.

NEERI ascribes bactericidal properties to River Ganga's sediments and water. Its study attributes the self-purifying capacity of the Bhagirathi-Ganga to adsorption of coliphages and other microorganisms onto sediment surfaces, the proliferation of coliphages and their predation on coliforms in the Ganga water.

The NEERI study reveals that the Bhagirathi-Ganga sediments are radioactive. Due to the presence of radioactive uranium, thorium and potassium in these sediment samples they are more radioactive than those present in other river and freshwater lake sediment samples.

Water quality data analyses in the NEERI study showed a big increase in coliform counts downstream of the dam in the May 2008 and January 2009 samples. These results, however, were not reproduced in the May 2009 samples.

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[32] N. Semwal & P. Akolkar (2006): "Water Quality Assessment of Sacred Himalayan Rivers of Uttaranchal", Curr. Sci., v 91 n 4, pp. 486-496.

[33] The Tehri Hydro Development Corporation India Limited (THDC) engaged NEERI to investigate the impact of the Tehri dam, if any, on the water quality of the Bhagirathi river and the upper stretch of the Ganga River after the dam had been commissioned. NEERI did the water sampling between May 2008 – May 2009 and in October 2010.

The NEERI study also identified other negative impacts that could be attributed to the damming of the river. Ammonia at levels higher than 0.88mg/l is toxic to aquatic life, especially fish. High average values of ammonia were determined in the samples from Bhilangana river upstream of the dam, in the Tehri reservoir and downstream of Tehri dam. Tehri reservoir water samples also showed high levels of total nitrogen and phosphorus. Both these elements are nutrients for the growth of nuisance aquatic plants.

Water quality index (WQI) values were determined using the of National Sanitation Foundation (1970) protocol. They showed a clear, though small, negative impact of the Tehri dam. The WQI values of all the Tehri reservoir water samples were lower than those of the river water, showing the clear effects of impoundment. A similar effect was also reported for the Maneri-Bhali-I project.

Algal ecological balance, the proportion of algae in the ecosystem's biotic population, was found to decrease after the Tehri reservoir. Algae are the starting point of the aquatic food chain.The Shannon Weiner Diversity Index (SWI) for phytoplankton and zooplankton generally decreased downstream of the dam. SWI values for reservoir water were also lower than the values upstream of the reservoir.

Other Studies: Semwal and Akolkar reported results of bio-monitoring analysis done on 11 rivers of Uttarakhand in 2004 and 2005.[34] The sampling locations included sites of 3 operating HEPs on the Bhagirathi (MB-I) and Mahakali (Dhauliganga 280MW and Tanakpur HEP) and one dam each then under construction on rivers Alaknanda (Vishnuprayag HEP) and Bhagirathi (Tehri dam). They observed stagnant water bodies behind barrages and that 'these disturbances have drastically changed the ecological sustainability of rivers in the state'. They reported a total absence of any benthic macro invertebrates upstream and downstream of HEPs on the Bhagirathi, Dhauliganga and Ramganga.

To assess the impact of HEPs on the self-cleansing and bactericidal properties, People's Science Institute (PSI) collected water samples upstream of MB-I barrage near Gangnani, downstream of it, in the MB-II reservoir in Uttarkashi and downstream of the Tehri dam on the Bhagirathi river in the month of March 2009.[35] Samples were also collected upstream of the Ichari dam and downstream of the Khodri power house (located downstream of Ichari dam) on the Tons river. To one part of the samples a known amount of sludge was added and to the other part, raw sewage with known fecal coliform concentration was added.

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[34] N. Semwal & P. Akolkar (2006): *Op.Cit.*

[35] R. Chopra (2012): Hydropower Development in Uttarakhand, Research Report Submitted to WWF-India, New Delhi

The self-cleansing capabilities of the river samples were determined by measuring the sludge settling rates. The results (See Figs.: 2.5a and 2.5b) clearly show that the

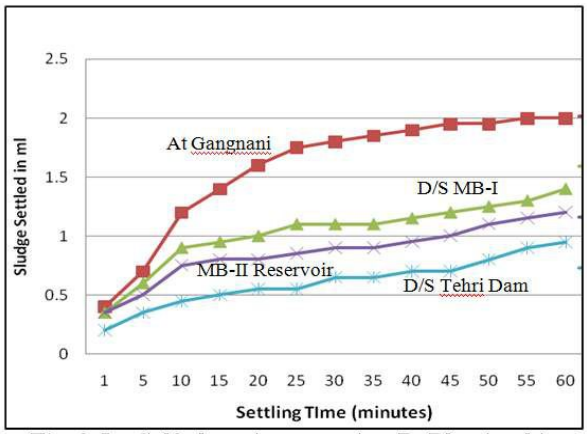

Fig. 2.5a: Self-cleansing capacity, R. Bhagirathi

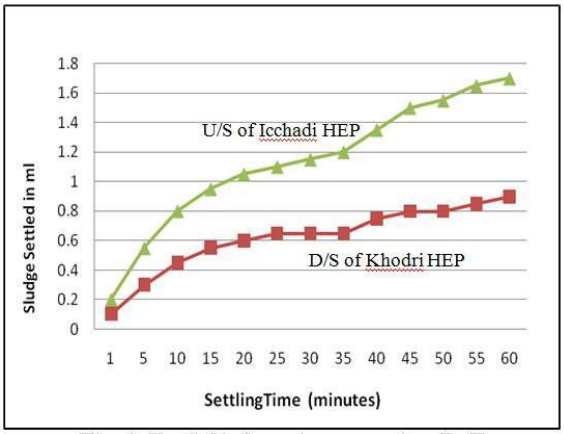

Fig. 2.5b: Self-cleansing capacity, R. Tons

sludge settling rates of samples collected downstream of the dams are significantly lower than those of the upstream samples. Similarly the fecal coliform removal rates of the downstream samples are lower than those of the upstream samples (See Figs. 2.6a and 2.6b). The cumulative affects of multiple dams can also be seen in Fig. 2.6a, where the bactericidal rate below the Tehri dam (last) is much less than that below the MB-I barrage (first dam after Gangnani), even though there is some recovery of the bactericidal property as seen from the graph of the sample collected from the reservoir of MB-II barrage (in between the other two dams) at Uttarkashi.

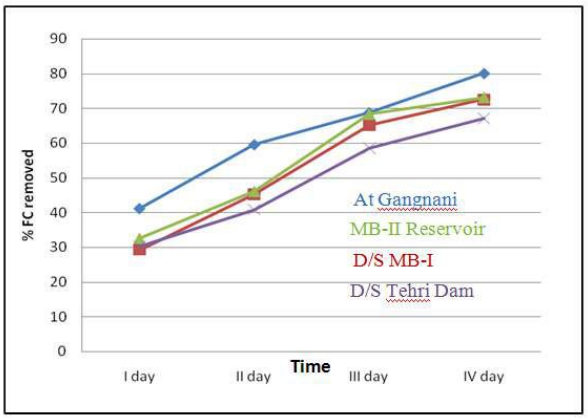

Fig. 2.6a: Impact of HEPs on collicidal strength of R. Bhagirathi

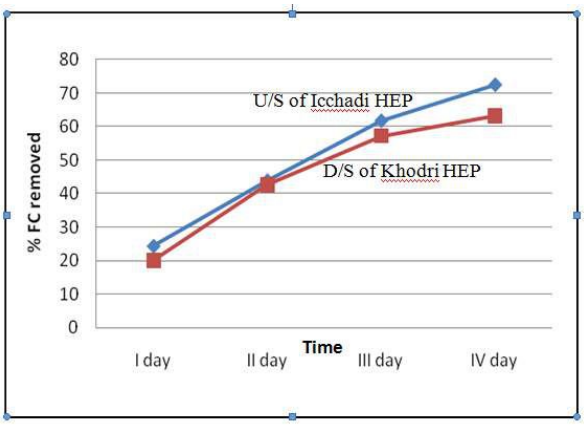

Fig. 2.6b: Impact of HEPs on collicidal strength of R. Tons

The WRDM unit at IIT-Roorkee reported results of a study on the impact of HEPs on conventional physico-chemical-bacteriological parameters of river water quality. The important parameters measured were turbidity, electrical conductivity, dissolved oxygen, BOD, COD, presence of trace elements, and fecal bacteria. It was commissioned by Uttarkhand Jal Vidyut Nigam Liprmited (UJVNL) and conducted in 2012-13. Water samples were taken at the inlet to the pond/reservoir and at the outlet of the tail race

channel at six HEPs: Chibro-Khodri (Tons river), Maneri-Bhali I (Bhagirathi), Vishnuprayag (Alaknanda), Vanala (Nandakini), Loharkhet (Sarju) and Dhauli (Dhauliganga East). The study concluded that there was no significant impact of the HEPs on the parameters measured. There was no comparison with similar previously published studies.

The WRDM study gives a one-time assessment of the impact of dams and barrages on the physico-chemical-bacteriological parameters of river water quality, or rather tunnel water quality since the downstream measurement was at the outlets of the tail race tunnel. The Central Pollution Control Board, however, has pointed out that bio-monitoring of river water is the most suitable method to assess the health of river ecosystems at dam sites.[36] Measurements of physico-chemical-bacteriological parameters give a onetime picture of water quality. Bio-monitoring reveals cumulative impacts over time. The WRDM study did not involve any bio-monitoring. It also did not measure the quality of the water in the river bed between the barrage and the power house. This stretch is generally the most affected since it remains dry during the non-monsoon months due to inadequate water releases.

Mitigation

In the context of mitigating the Tehri dam impact NEERI has reported that Alaknanda river sediments have identical antibacterial properties as that of Bhagirathi river. It is therefore argued that there are ample sediments from the catchment between Tehri dam and Devprayag, and also from Alaknanda River to maintain the self preservation capacity of the Ganga river water after the construction of the dam. This argument is, however, now nullified by the construction of several dams on the Alaknanda upstream of Devprayag and the Koteshwar and Kotli Bhel IA HEPs between Tehri and Devprayag.

Conclusions

River Flows: There is a growing realization among Indian scientists and water managers that the practice followed till very recently, of releasing minimum flows downstream of dams/barrages, is inadequate. It needs to be improved on the basis of sound scientific analysis. Minimum flow releases damage the integrity of flowing rivers in the non-monsoon months and over time severely impacts aquatic biota. Mitigation efforts like *in situ* or *ex situ* aquatic diversity conservation have had only limited success at best.

Hence in the last few years several expert committees and scientific organizations have begun to recommend significantly higher downstream releases in the form of environmental flows rather than minimum flows. Environmental flows aim to mimic the natural flow patterns of rivers so that they can perform their natural functions and optimally meet human needs. This trend needs to be encouraged. The Expert Appraisal

[36] CPCB (2007): Annual Report 2006-07, Central Pollution Control Board, New Delhi.

Committee (EAC) of the MoEF has now begun stipulating a minimum 30% release in the monsoon months and 20-25% in the lean season. These figures need upward revision, based on scientific analysis, to keep the river healthy and flowing particularly in the November-April period.

It is recommended that MoEF develop tentative guidelines for EF releases downstream of all HEPs, based on the recommendations contained in the Inter-Ministerial Group's Report submitted to the Government of India.[37] These should be revised later once the Ganga River Basin Management Plan has been submitted by the IITs' consortium.

The innovative concepts of (i) protecting small but significant rivers as done in Himachal Pradesh and also recommended by the IMG and (ii) designating specific protected rivers zones as Eco-Sensitive Zones also needs to be encouraged.

It is therefore suggested that the MoEF develops legislations for enactment along the lines of the above concepts.

River Water Quality: By obstructing the natural flow of a river a dam or a barrage can significantly alter the physical, chemical and biological qualities of river water. These changes occur across the life span of the structure and can affect the river's ability to perform its basic natural functions.

It is noted that conditions set for HEPs to sustain the river water quality are often not strictly followed during the construction stage. This indicates a lapse on the part of the project developers and the monitoring system of the MoEF.

The construction of reservoir-based projects on the National River Ganga and its major tributaries in Uttarakhand holds back sediments that are said to impart the rivers their unique self-purifying capability.

It is recommended that MoEF strengthens its personnel and procedures for post-sanction monitoring of environmental conditionalties. The MoEF should develop a programme for studies by reputed organization and reports of the impacts of river quality (and flows) on its Post-facto studies of impacts of HEPs on river quality (and flows) are limited.

2.2 Impacts on Forests & Terrestrial Biodiversity

Context

Forests: The recorded forest area of Uttarakhand is 34520 km^2, i.e., 64.54 per cent of the state's geographical area.[38] It is categorized as Reserved Forests (71.1%), Protected

[37] The IMG Report contains the one set of recommendations on EF releases by the Group and another made by one Group member

[38] Forest areas data provided by MoEF, regional office, Lucknow (See also ToR 3.1)

Forests (28.5%) and Unclassed Forests (0.4%). Most villages also have smaller forests within their boundaries that are managed by the villagers through Van Panchayats an institution unique to Uttarakhand. The total forest and tree cover is estimated as 47% of the state's geographical area.

There are four major forest types in the state:[39]

(i) Tropical Moist Deciduous Forest: Mainly found in the sub Himalaya *terai-bhabar* belt. The prominent species are Sal (*Shorea robusta),* khair *(Acacia catechu),* sheesham *(Dalbergia sissoo).* These trees are interspersed with rich assemblages of climbers, stands of bamboo and patches of grass.

(ii) Subtropical Pine Forests: The dominant species is chir pine *(Pinus roxburghii).* These forests are found at lower elevations of the lesser Himalayan belt.

(iii) Moist Himalayan Temperate Forests: They occur at elevations between 1600 and 2900m. At lower elevations oak (banj, *Quercus leucotricophora)* and rhododendron *(*burans, *Rhododendron arboreum)* dominate on the dry slopes while alders *(*utees, *Alnus nepalensis)* dominate moist slopes. At higher altitudes are cedars (deodars, *Cedrus deodara*), kharsu oak *(Quercus semecarpifolia),* tilonj *(Quercus floribunda)* and blue pine *(*kail, *Pinus wallichiana).* The leaf litter of oak and rhododendron trees helps create good protective soil cover.

(iv) Sub-Alpine and Alpine: Exist at altitudes of 2900 to 3500 m. The main species are Fir (*Abies spectabilis),* silver fir *(Abies pindrow),* junipers *(Juniperus squamata, Juniperus indica),* birch *(*bhojpatra, *Betula utilis)* and stunted rhododendron *(Rhododendron companulatum).* At higher elevations the forests are replaced by *bugyals* or alpine meadows. The present tree line is about 3200m.

Temperate and tropical grasslands exist inside forest areas. *Chaurs* or grasslands found in the Corbett and Rajaji National Parks and Sonanadi Wild Life Sanctuary an ideal habitat for predatory species like tigers and herbivores like elephants.

Forests prevent erosion, reduce runoff and moderate stream flows by increasing base flows and ensuring perennial water in springs, streams and rivers. They are also life-supporting ecosystems in the mountain region. They provide local communities with food, fruits, fuelwood, fodder, and livelihood resources like fibers. The presence of good forests is essential for productive agriculture. Easy access to forest resources reduces the drudgery of rural mountain women who gather the resources required for the family's daily sustenance.

Forest expanses north of the MCT and in the upper reaches of river valleys in the Middle Himalaya are still largely undisturbed. The middle and lower slopes in the major river valleys of the Middle Himalaya suffered during the British period due to heavy

[39] WII (2012): *Op. Cit.*

felling of low density trees which could be floated down the rivers. Large scale felling continued after border roads brought truck traffic to the region in the early 1960s. But the tremendous awareness created by the Chipko movement in the 1970s and 80s, a ban on clear felling at altitudes above 1000m and a number of afforestation and watershed development programmes in the last three decades halted the decline to some extent.

Biodiversity: Uttarakhand's forest areas are storehouses of biodiversity. A range of climatic regions in the state has resulted in storing an astonishing diversity of 4500 plant species, of which 116 are endemic, in its forests.[40] The massive heights of the Himalayan ranges enable them to capture pollen from different parts of the world, adding to this diversity. Scores of plants in the forests are wild relatives of cultivated crops and represent an invaluable genetic resource. Many wild plants have medicinal properties. Visually appealing and sometimes threatened flower species like orchids, primula primroses, brahma kamal, fen kamal, and rhododendrons dominate different parts of river valleys.

The State forests have an abundance of wild animals. Almost a fifth (75 species) of all the mammalian species of India are found in Uttarakhand and about 650 bird species have been identified here. The region also abounds in amphibians and reptiles (60 species).

Among the faunal species, the snow leopard, musk deer, Asiatic black bear and the cheer pheasant are listed as endangered or vulnerable in IUCN's Red List while almost half of the mammalian species are in the threatened category. Other prized animals whose habitats are threatened are elephants and tigers. Recognizing the need to protect the rich biodiversity of the state a number of protected areas (six National Parks, six Wildlife Sanctuaries, one Biosphere Reserve and two Conservation Reserves) have been demarcated. Uttarakhand's protected area network covers about 13.7 per cent of its geographical area, compared to the national average of 4.8 per cent. UNESCO has included the Nanda Devi and Valley of Flowers National Parks as World Heritage Sites.

Landscapes: Local folklore refers to Uttarakhand as 'dev bhoomi' or the land of the gods. This was largely due to its remoteness till recently and its pristine environment.

Broadly speaking, the Great Himalaya region north of the Main Central Thrust (MCT) still remains largely remote, sparsely populated, unspoiled and dominated by snow-clad ranges. It is home to large expanses of very high quality landscapes like the alpine meadows of Govind Pashu Vihar, Gangotri National Park, Kedarnath Musk Deer Sanctuary, Nanda Devi National Park & Biosphere Reserve, the Valley of Flowers, Askot Wildlife Sanctuary and the pristine Pindari, Gori Ganga, and Darma valleys. Non-pilgrim

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[40] S.K. Srivastava and D.K. Singh (2005): Glimpse of the plant wealth of Uttaranchal, Bishen Singh and Mahendra Pal Singh, Dehra Doon, p.35

tourists visit these highlands for adventure, their wilderness, biodiversity, scenic vistas and to experience peace, quietude and oneness with nature.

The Middle Himalaya region lying between the MCT and the Main Boundary Fault (MBF) with crest lines ranging from 2,000m to 3,000m has high landscape values. The region is full of sites that provide scenic vistas of the snow-clad Himalaya, terraced fields, oak and rhododendron forests and broad river valleys. The Doons and terai region south of the MBF, with a bird sanctuary at Asan Barrage, the Rajaji National Park in the Shivaliks, and the Corbett National Park further east, has medium to high landscape qualities.

Impacts

HEPs have life cycle impacts on forests and terrestrial biodiversity as evident from Table 2.2. In the preconstruction 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. Quarrying leaves scars on mountain faces that take long to heal.

Reserved forests and village forests are both affected. Thousands of trees are cut, often far beyond the officially sanctioned limit, during road construction and to meet the fuelwood needs of the labourers. More trees are damaged or destroyed when large boulders and debris roll down the mountain slopes during road construction. Shrubs and undergrowth are also affected when the overburden and muck is disposed.

Submergence reservoirs affect riverine and terrestrial habitats. The extent of the impact depends on the extent of the topography and the habitats. Terrestrial animals in the submergence zone are lost or scattered. Animals and plant species that are dependent on riverine forests or ecosystems may disappear since they lose their natural habitats. Wild carnivores begin preying in surrounding villages, leading to increased human-animal conflicts.

By acting as barriers to downstream flows, dams can have significant impacts on downstream riverine plant communities. Changes in the variability of water discharges affect the diversity and abundance of aquatic biota, birds and mammals that live downstream of dams. Drying of river beds degrades riparian vegetation and the dependent flora and fauna. Besides, it reduces or eliminates animals' access to drinking water.

(i) Loss of Forest Area & Critical Wildlife Habitats: According to information provided by the Ministry of Environment & Forests, Regional Office, 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 has been in Uttarkashi, Rudraprayag, Chamoli and Pithoragarh districts, the ones most affected by the June 2013 disaster. This is while a vast majority of the

planned hydropower projects are still to get off the ground. Additional forest land is lost for transmission lines.

Conversion of forests to non-forest use leads to loss of wildlife habitats. In the Alaknanda-Bhagirathi basins WII has identified the Mandakini, Dhauliganga (W) and Bhyundar Ganga sub-basins as having very high terrestrial diversity values. All the other sub-basins have high terrestrial biodiversity values. Many sub-basins of the Tons, Yamuna, Bhagirathi, Mandakini, Alaknanda, Dhauliganga (W), Gori Ganga, Pindar and Kali rivers and their tributaries similarly would have high or very high terrestrial biodiversity values. Many RET wildlife species will be threatened in the near future by the multiple projects scheduled for construction in these sub-basins.

(ii) Irreversible loss of riverine ecosystems: During its field visits members of the Experts' Body noticed a complete disappearance of riverine ecosystems due to submergence at existing and under construction large hydropower projects such as Tehri Stage I and Koteshwar HEP in the Bhagarathi basin and the Srinagar HEP in the Alaknanda basin.

Riverine or riparian systems once submerged cannot be compensated for elsewhere because they can only exist along the banks of specific water bodies. This is an irreversible loss because it is not the loss of a few plant or animal species, but the loss of a complete ecosystem.

Riverine ecosystems are sensitive habitats which occur as 'edge' habitats between aquatic and upland ecosystems. They ensure continuous interaction between aquatic and terrestrial habitats through exchange of energy and nutrients. They are critical corridors for migration of several faunal and floral species. The scrub vegetation around the Tehri reservoir formed a typical habitat for partridges.[41] It is now lost.

Riverine ecosystems facilitate river courses and help prevent soil erosion. In mountain regions they help stabilize slopes along the river banks. Riparian vegetation is capable of removing toxic heavy metals.[42] Such elements are found in the Himalayan sediments as reported in the previous section. Riverine vegetation helps to maintain the water quality of flowing rivers and also serve as a nutrient filtering zone to retard

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[41] B.S. Adhikari, S.K. Uniyal, G.S. Rawat, and A. Rajvanshi (2009): "Vegetation structure and community patterns of Tehri Dam Submergence Zone, Uttarakhand, India", EurAsian Journal of Biosciences, Issue 3, p40

[42] N.K. Srivastava and R.S. Ambasht (1990): "Impact of industrial effluents in the limnology of Pant Sagar and Rihand river", in Environmental Degradation of Obra-Renukoot-Singrauli Area and its Impact on Natural and Derived Ecosystems, J.S. Singh, K.P. Singh and M .Agarwal (eds), Final MAB Tech Report, Banaras Hindu University, pp 265-284.

eutrophication processes.[43] It provides nutrients and habitats for macro-invertabrates and fish.

The riverine forests along the Bhagirathi and Alaknanda stream courses support a large number of rare, endangered and threatened (RET) floral and faunal species. Some of the threatened taxa of flora include *Datisca cannabina, Itea nutans, Eriocaulon pumilio, Eria occidentalis, Flickingeria hesperis, Nervlia mackinnonii and Cautleya petiolaris*, besides several species of medicinal and aromatic plants.[44]

So far the riverine ecosystem in a 68 km continuous stretch of the Bhagirathi river from Chinyalisaur (upstream of Tehri stage I) up to the Koteshwar HEP has been lost since the zones of influence of the two projects overlap. Once the Kotli Bhel IA project is constructed another 19 km stretch downstream of Koteshwar will be submerged. Thus there will be a complete loss of riparian/riverine ecosystems in an 87 km stretch from Chinaylisaur almost up to Devprayag along the river Bhagirathi. It is therefore recommended that the design and operation of Kotli Bhel 1A are changed to ensure the creation of a significant lotic environment downstream of the Koteshwar project. A similar disappearance of a 24 km stretch of a riparian ecosystem along the Bhilangana river, an associate river of Tehri Stage I, has also occurred.

In the same manner the under construction Srinagar and Vishnugad-Pipalkoti HEPs will together submerge stretches of almost 50 km in the Alaknanda river. If approved in the future, construction of the Kotli Bhel IB and Kotli Bhel II HEPs on the Alaknanda and Ganga rivers respectively will add to these irreversible losses.

(iii) Threatened Protected Areas: HEPs can fragment and destroy wildlife habitats. Poaching of wild animals for consumption and trading through smugglers is a heightened risk, especially where the projects are near protected areas. Noise and traffic disturb the wildlife in such areas. 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 bio-mass productivity. Such impacts can impair the terrestrial biodiversity value of river basins.

The maximum impacts may be felt in the Dhauliganga (W) valley in Chamoli district. Five major (>100MW) projects are to be built here in a 50 km stretch of the river. The last four of them are located in the buffer zone of the Nanda Devi Biosphere Reserve. The area has a large number of endemic plant species. Several animal species in the IUCN Red List are found here, including the snow leopard, musk deer, Asiatic black bear, cheer pheasant and the blue sheep. The loss of plants will disrupt the food chain for

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43 R. Kumar, M. Shankar and R.S. Ambasht (1990): "Water, soil and nutrient movement from riparian and artificial slopes", in Environmental Degradation of Obra-Renukoot-Singrauli Area and its Impact on Natural and Derived Ecosystems, J.S. Singh, K.P. Singh and M. Agarwal (eds), Final MAB Tech Report, Banaras Hindu University.

44 WII (2012): *Op.Cit.*

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. Cumulatively, construction activity at all the sites will disturb the animals.

Many HEPs have been sanctioned inside protected areas. Two small projects are proposed on the Rishiganga inside the core zone of the Nanda Devi National Park. As a result habitats of musk deer and snow leopard, which are endangered animals on IUCN's Red List, are imperiled. Two projects have been sanctioned on the Mandakini river inside the Kedarnath Musk Deer Sanctuary and another is located just at its boundary. Earlier four projects on the Gori Ganga – Gori I (65MW), Gori II (120MW), Gori IIIA (120MW) and the Khostoli – Lumti Malla (55MW) – all to be developed by NHPC, were inside the Askot Musk Deer Sanctuary. Another six large projects – Cris King, Bokang Baling, Chunger-Chal, Urthing-Sobala, Garbadhar-Tawaghat and the Kalika-Dantu, on the Dhauliganga (E) and Kali rivers were also within the Askot Sanctuary. Efforts made by the developers to have large parts of the Sanctuary denotified finally succeeded with the Supreme Court ordering a fresh demarcation of the Sanctuary. Now most of the above projects are outside the Sanctuary. Projects on the Gori Ganga will also affect the yak winter habitat. Winter habitats are more important for their successful herding because the snow makes them less mobile and vulnerable to poor nutrition and predation.

The Govind Pashu Vihar (Wildlife Sanctuary) in the western corner of Uttarakhand is drained by the Tons river and its tributaries, the Supin and Rupin among others. The area is pristine and sparsely populated. A number of small projects are proposed inside the sanctuary.

Other impacts on terrestrial biodiversity: Several of the early HEPs constructed in Uttarakhand, before the mid-1980s, were in the ecologically sensitive forested areas of the Tons, Yamuna and Bhagirathi valleys. Among the existing projects the Chila HEP, inside the Rajaji National Park, is known to have affected the movements of elephants in the Park.[45] The massive Tehri dam led to deforestation affecting 462 plant species under 99 families.[46]

During the field visit to Pratapnagar block on the northern rim of the Tehri reservoir, villagers told the Committee members of increased human-animal conflicts in the area in recent years. These are most likely the result of a combination of factors like habitat loss, habitat degradation, changes in vegetation, habitat use, reduced prey and movement patterns of animals.

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[45] A.J.T. Johnsingh, S.N. Prasad, & S.P. Goyal (1990): Conservation status of the Chilla–Motichur corridor for Elephant movement in Rajaji–Corbett national parks area, India. Biological Conservation, 51, 125–138.

[46] V. Govardhan (1993): Environmental Impact Assessment of Tehri Dam, Ashish Publishing House, New Delhi, pp.348-373.

(iv) Landscape impacts: Scarred landscapes are visible where HEPs have been constructed or are under construction. Visitors to Gangotri are shocked by the dry river beds downstream of the Maneri Bhali I and II HEPs in the upper Bhagirathi valley. Road construction, the appearance of engineered structures and urban style infrastructure have damaged the very high quality, tranquil, forested landscapes at the now cancelled 600MW Loharinag-Pala project in the upper Bhagirathi Valley. Those going to Badrinath are equally shocked by sight of the dry river bed in the non-monsoon season downstream of the 400 MW Vishnuprayag project at Lambagad -- in a pristine stretch of the upper Alaknanda valley.

The present decade will see rapid destruction of very high and high quality landscapes with the projected completion of bumper-to-bumper HEPs – one almost every 20 to 25 km -- planned in many pristine river valley stretches north of the MCT. Many very high quality landscapes may face permanent damage due to the cumulative effects of road construction, deforestation, landslides, despoliation of rivers, air pollution, disturbance of the tranquility, loss of wilderness, massive increase in population during the construction phase and the appearance of urban style infrastructure, when multiple projects are built on a single river.[47]

If all the 450 HEPs are completed about 252 projects will each have an installed capacity of 5MW or more. The vast majority of them will divert rivers through tunnels to power houses downstream. Their combined impact will affect all the landscapes of Uttarakhand. The Environment Management Plans of individual projects do not address the cumulative impacts of multiple projects in a river valley.

Mitigation

(i) **Compensatory Afforestation & Catchment Area Treatment:** Almost 65 per cent of Uttarakhand's geographical area is designated forest land. Hence HEPs in Uttarakhand often require forest land for quarrying, building access roads, staff and labour colonies and tunneling. According to the guidelines of India's Forest (Conservation) Act, 1980 and the Forest (Conservation) Rules, 2003 private project developers and state agencies (like UJVNL) have to transfer an area of non-forest land equivalent to the forest land diverted for the project to the Forest Depart for Compensatory Afforestation (CA). Once transferred the area has to be re-designated as forest land. Government of India undertakings like NTPC, NHPC or THDC have to transfer degraded forest land equivalent to twice the area diverted. The plantation is done by/under the aegis of the state Forest Department (FD). Developers also have to pay a sum equivalent to the Net Present Value (NPV) of the forest lands acquired by them.

For HEPs with installed capacities above 10 MW, the Government of India has made Catchment Area Treatment (CAT) mandatory to reduce soil erosion, moderate

[47] Anon (2009): *Op.Cit.*

water runoff peaks and thereby sustain steady power generation. Up to 2002 payments for CA were deposited with the state government. Thereafter the money for CA, NPV and CAT is all deposited with the Compensatory Afforestation Management and Planning Authority (CAMPA) of MoEF and released by the latter to the state forest departments.

CA has not been successful so far (See also CAG[48]). For projects approved before Uttarakhand became a separate state CA was done in Hardoi, Jhansi and Lalitpur districts of Uttar Pradesh. It has obviously not benefitted Uttarakhand. Between 2002 and 2010 no money was released by CAMPA due to administrative disputes between MoEF and state governments.

The track record of FDs for planting trees and sustaining them is not encouraging either. The experience of three decades in Uttarakhand – the home of the Chipko movement – shows that survival in departmental afforestation projects without people's involvement is only about 20-50 per cent. By comparison, the community-led Chipko movement's afforestation projects achieved survival rates of 70-90 per cent.[49]

A study done by a senior forest official in Uttarakhand highlighted the crucial role of the nature of the FD's intervention in CAT programmes.[50] It noted that one innovative CAT plan (for the Vishnuprayag 400 MW HEP) was successfully implemented with community participation but could not be sustained due to an absence of planned withdrawal by the FD. But the CAT programmes of six other projects failed due to weak mentoring of the planning process by the state FD. The plans were prepared by Divisional Forest Officers and implemented without significant community involvement.

As part of Corporate Social Responsibility (CSR) activities, the Singoli-Bhatwari, Phata-Byung and Tapovan-Vishnugad HEP authorities have all undertaken plantation activities. But the survival rates are poor.[51]

THDC made a presentation to the EB about its efforts to conserve flora and fauna based on evaluation reports submitted by official agencies like BSI, ZSI, ICFRE. They indicated that useful and important activities had been satisfactorily carried out by the Tehri dam authorities. Unfortunately since the designated land is in Jhansi and Lalitpur districts of U.P. it will not have any beneficial impact in the vicinity of the dam or even the state of Uttarakhand. A mahseer hatchery has been developed near Koteshwar dam. The fingerlings will be used to restock the Tehri reservoir. Fish diversity has shown marginal to no improvement. Sensitive macro-invertebrates have reduced in the post impoundment environment.

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48 CAG (2010): *Op. Cit.*, p. 34.

49 R. Pahari (1997): Dasholi Gram Swarajya Mandal, DGSM, Gopeshwar, p.20

50 J. Sitling (2013): "Participatory CAT Plan implementation under payment for ecological services: Evaluation of applied innovation", PGPPM Policy Folio, Indian Institute of Management, Bangalore, pp. 23.

51 AHEC (2011): *Op. Cit.*, p. 10-58.

Conclusions

The submergence of riverine ecosystems by large storages, e.g., Tehri dam, Koteshwar HEP, Srinagar HEP and the proposed Vishnugad-Pipalkoti project, is an irreparable loss since these ecosystems cannot be replaced elsewhere.

A few small projects are located inside wildlife sanctuaries or national parks while several large ones lie in the buffer zones. RET species in several basins or sub-basins with high or very high bio-diversity values are thereby endangered by existing or under construction projects.

As a rule mitigation programmes for forests and biodiversity conservation have not succeeded so far. Recommendations made in the CAT programme monitoring study cited above have to be systemically implemented for ensuring sustenance of the plantations. This requires training of forest officials to work with the communities through their Van Panchayats.

2.3 Impacts on Geological Environment

Slope Stability

Context

The collision of the Indian plate with the Eurasian landmass gave birth to the Himalayan ranges. Geologically they are the youngest yet highest mountains in the world. The continued northward movement of the Indian plate squeezed, uplifted and moved mammoth blocks of rock masses along regionally extensive faults. These faults divide the Himalaya into four litho-tectonic and physiographically distinct zones. From south to north these are the Himalayan Frontal Fault (HFF) which demarcates the Indo-Gangetic plain from the 900–1500 m high Shivalik Hills. The Shivalik Hills are separated from the 500–2500 m high matured Lesser Himalayan ranges by the Main Boundary Thrust (MBT). To the north, the Main Central Thrust (MCT) demarcates the Lesser Himalaya from the extremely rugged and youthful 2000–7000 m high Great Himalaya. Further

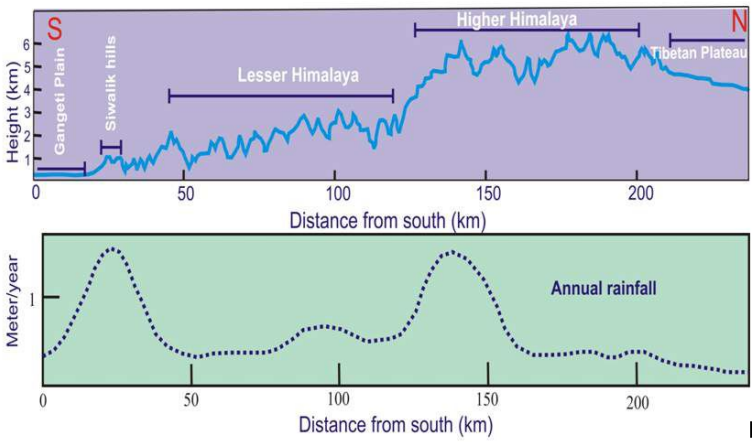

Fig. 2.7: Orographic profile of Himalaya based on SRTM data. Rainfall variability across the Himalaya (after Bookhagen et al., 2005).

north, the Trans-Himadri Fault (THF) separates the Great Himalaya from the extensively glaciated Trans Himalaya (Tethyan Himalaya).[52]

The topographic gradient described above controls the south-north rainfall gradient in the Himalayan region. Two major zones of focused high rainfall are located in the foothills (Shivaliks) along the Main Boundary Thrust (MBT) and the transitional zone between the Greater and Lesser Himalaya (around MCT).[53]

The extreme altitudinal variability (100 m to >7000 m) has created microclimatic niches which govern the eco-system variability and biodiversity. In Uttrakhand, below the permanent snow line (~5000 m) lie debris-covered valley glaciers. Depending upon their orientation and slopes the snouts of these glaciers can be found between 4500 m to 3900 m.[54] This is followed by the climate-sensitive periglacial zone (3500 to 3000 m) representing an area which was once occupied by the glaciers (sediment surplus areas). The periglacial zones are strongly controlled by external climatic forces and are sensitive to landscape disturbances and land surface instability that accompany climatic change.[55] Below this lies the paraglacial zone (~2000 m) an area in which the landforms were produced during deglaciation. The dominant paraglacial processes are mass movements and fluvial erosion which redistribute sediments from the glaciated terrain to the non-glaciated terrain.[56] This is followed by the fluvial regime which is responsible for the evolution of the major landscape in the Himalayan region.

Mass-wasting, i.e., the large scale movement of earth matter under gravity, either in the form of a slow soil creep or a rapid landslide, is the most frequent and widespread manifestation of Himalayan fragility.[57] It is a natural process caused by steep slopes, micro-seismicity, underground seepages, weak rock structures and toe-cutting of slopes by rivers and streams.

Although the entire Himalayan ranges are prone to landslides, the areas proximate to the regional thrusts are extremely vulnerable to landslides. Frequent movements along the thrusts, have pulverized, fractured and crumpled the local rocks making them vulnerable during the summer monsoon.[58] The MCT zone is associated with the

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52 K.S. Valdiya (2002). Emergence and evolution of Himalaya: reconstructing history in the light of recent studies. Progress in Physical Geography, 26, 360-399.

53 B. Bookhagen, R.C. Thiede and M.R. Strecker (2005). Abnormal monsoon years and their control on erosion and sediment flux in the high, arid northwest Himalaya. Earth and Planetary Science Letters 231, 131– 146

54 V.K. Raina and D. Srivastava (2008): Glacier Atlas of India, Geological Society of India, Bangalore, 316 pp.

55 K. Hewitt, M.L. Bryne, M. English, & G. Young (eds). (2002): Landscapes in Transition: Landform Assemblages and Transformations in Cold Regions. Kluwer Academic, London.

56 C. K. Ballantyne (2002): Paraglacial geomorphology. Quaternary Science Reviews, 21, 1935–2017

57 J. Bahadur (2003): Indian Himalayas: An Integrated View, Vigyan Parisar, New Delhi, p.175.

58 K.S. Valdiya (2001): Reactivation of terrane-defining boundary thrusts in central sector of the Himalaya: Implications, Current Science, 81, 1418-1431

maximum concentration of both active and stabilized landslides in Uttrakhand. In fact due to high intensity rainfall and frequent seismic activity, watersheds in the proximity of the MCT are eroding much faster than their southern counterparts.[59] Many villages in Uttarakhand are located on old landslides debris or ancient glacial moraines. They are more vulnerable.

Road construction, quarrying and tunneling can trigger landslides or slope failures, damage to existing civil structures and disturbance of water sources. Blasting with the use of explosives is a common feature in all these activities. Unscientific blasting creates environmental problems in the form of ground vibrations, air overpressure and flyrock.

Tunneling in the young Himalayan ranges is a difficult engineering exercise. This is particularly the case in the vicinity of regionally extensive faults like the MBF, the North Almora Thrust, or MCT. Many major HEPs in Uttarakhand are in the vicinity of the last two. These zones are characterized by heavy shearing and faulting of the rocks leading to non-homogeneous rock masses, fissures, fractures and underground water flows or seepages. Adding to the slope instability hazards are rural civil structures some of which, like canals, are engineered but many, like houses, are non-engineered structures.

Technically correct tunneling procedures can mitigate or minimize the resulting engineering problems or environmental damages. The rock mechanic expert in the EB, Dr. H.S. Venkatesh, of the National Institute of Rock Mechanics has explained that "blasting is an integral part of any hydro electric project. Blasting is generally perceived as a non-environmental friendly means of rock excavation. Though many other activities at a construction site have adverse impacts but the sole culprit that stands aloof seems to be the blasting activity. This probably is because of the perception associated with blasting more so because of lack of understanding / communication between the stake holders. However, contrary to this, blasting technology is well developed and can be carried out keeping the adverse impacts like ground vibrations, air over pressure and flyrock within the permissible/acceptable limits. The most common method of controlling ground vibration is by minimising the charge weight per delay. Delay blasting permits to divide total charge into smaller charges, which are detonated in a predetermined sequence at specified intervals. Different countries adopt different standards of safe limits of vibration. In India, the permissible ground vibration for different types of structures for mining is specified by Directorate General of Mines Safety (DGMS), which considers PPV and the frequency of ground vibration for deciding the permissible levels. These standards are adopted by NIRM, CIMFR, educational

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[59] D. Vance, M. Bickle, S. Ivy-Ochs, P.W. Kubik (2003): "Erosion and exhumation in the Himalaya from cosmogenic isotope inventories of river sediments", Earth and Planetary Science Letters, v 206, pp. 273-288.

institutes and research organizations in India while blasting for civil applications. These standards are applicable in civil engineering projects as the response of structures due to blasting does not change with reference of the purpose for which blasting is carried out.

"Apart from ground vibration, air overpressure from blasting is generally an annoyance problem and may not cause damage but may result in confrontation between the operator and those affected. Air overpressure is not simply the sound that is heard, but it is an atmospheric pressure wave consisting of high frequency sound that is audible and low frequency sound or concussion that is inaudible. The weakest component of structures that may be affected is glass panes which is unlikely unless air overpressure levels exceed 160 dB.The air overpressure levels at critical structures are restricted to below 133dB being the permissible level as per US Bureau of Mines and IS code. At sound pressure levels below 130dB there will be audible rattle, mainly from windows and doors and from objects standing on shelves. With increasing amplitude, window panes begin to break at about 152dB. Most windows in an area would break at amplitude of 172dB, and structure damage would occur at 182dB or over (Siskind et al., 1980b. Anon, 1998. Konya et al., 1990). People living nearby blasting sites often complain about ground vibration if the noise produced from blasting is high, they feel that the vibration is high. Although it is not directly related to increased overpressures, another factor of interest is the time related to the occupancy of the area and residential activities. Certain times may be unfavorable for the residents of a given area, such as night, evening, early morning, or times when most of the people in the area are home and conditions are relatively quiet.

"In case of tunnels, caverns, canals and other civil construction sites even damage to rock mass due to blasting is of concern. Over break in rockmass leads to additional concreting, cost escalation and delay in project completion. However it is well established that extension of existing cracks in the rock mass is limited to a distance of 80 to 108 blasthole diameters (charge diameters) or 4.5 m at the most in case of underground excavations. Ramulu and Sitharam (2010), carried out research work on the effect of repeated dynamic loading imparted on the jointed rock mass from subsequent blasts in the vicinity at Loharinag Pala Hydroelectric Project. They too observed that the rockmass damage was limited to less than 4m from the tunnel. In order to study the behaviour of the caverns during construction stage, a detailed field instrumentation programme was taken up at one of the caverns in Himalayas (Sripad et al., 2003). The studies revealed that the load coming on to the 8m long bolts in the crown of such a large underground cavern (20m x 44m x 206m) was varying from 5T to 21T which is well within the capacity of the bolt and the deformations observed was less than 2mm at a depth of 25m inside the cavern crown. That means, if any surface structures are beyond this distance from this cavern there is hardly any impact in terms of subsidence/displacements. Moreover the cavern has stabilised within a period of 6 months indicating the excavation does not pose any long term stability problems.

“Generally houses contain numerous cracks of which the owner is unaware and which continue to increase in number and size each year with passage of time. Studies have indicated that the formation and extension of cracks is also a function of time and thermal variations. People are concerned that the existing cracks widen or new cracks are formed in their structure due to tunnel blasting. In India generally a permissible limit 5mm/s is recommended (Kutcha and cement and brick construction) and in cases structures with RCC and if the frequency is above 8hz a higher limit of 10mm/s as per DGMS standards are recommended. Studies on structural response to blasting in India by (Adhikari et al., 2005) have shown that no new damage or extension of existing cracks were observed in residential structures at PPV exceeding just above 20 mm/s. Adrian et al., (2002) from their studies with regard to structural response of brick veneer houses to blast vibration observed from their experiments in Australia that environmental strains and rainfall contribute to the extension of existing cracks in a structure and the strain induced due to these environmental loads upon conversion to equivalent PPV are much higher than from blasting. They reported, no observable damage occurred until the ground vibration levels (PPV) exceeded 70mm/s. The damage at vibration levels of 70 - 220 mm/s was confined to the lengthening of existing cracks and the formation of new cracks in plasterboard.

“Human beings are far more sensitive to ground vibrations and noise than structures. People inside buildings will respond differently than people outside and will respond more adversely inside their own houses than when they are inside other buildings. People tend to complain about ground vibrations even when the vibration level is below the minimum permissible limit of 5mm/s. One of the most important factors for complaining is the presence of secondary sounds such as rattling windows and doors. The threshold of perception for motion (without sound effects) is roughly 0.51mm/s (Anon, 1998) for most people at typical blasting frequencies.

“From the research publications, EC site visits and the data provided by the project authorities (Loharinag Pala, Singoli-Bhatwari) ground vibrations were monitored at different critical locations, villages as per the national norms and site predictor equations were established. Ground vibrations were restricted to the permissible levels as per Directorate General of Mines Safety (DGMS) norms. At Singoli-Bhatwari, blast designs were suggested and monitored by CIMFR from time to time and delay detonators were used during excavation ensuring the compliance of maximum charge per delay as per their recommendations. Proper controlled blast designs were used to minimize the rockmass damage. Similarly, NTPC official brought a file of tunnel blasting carried out during 2008 by Patel Engineering. The review of the designs showed that delay blasting was carried out and vibrations were measured by CIMFR using seismograph and vibrations were controlled within the permissible limits as per DGMS norms.

"It is obvious that every technology comes with advantages and disadvantages. Similar to how many complex issues are addressed by proper management even blasting activity can be managed by use of appropriate technology and management. In most cases pre-blast design evaluation vis-à-vis the site constraints and choice of appropriate blasting technology have ensured minimal complaints from the stake holders with satisfactory blast results. Successful execution of full scale blasting of hard rock in the city of Bangalore (Venkatesh et al., 2012) substantiates that blasting as such is and cannot be the real issue. Though mechanical means and alternative to blasting seems to have evolved with an intent to increase safety, production and productivity and minimal impact on the surrounding environment, none of these approaches have stand-alone applications under all conditions and they too rely on drilling and blasting for their effective utilization at one stage or the other. The project authorities should therefore monitor ground vibrations for all blasts that are conducted close to surface structures to ensure that vibrations are within the permissible levels. Any legislation without serious enforcement and compliance serves little purpose."

But it has been noticed that blasting is often done by local sub-contractors who do not always adhere to the norms of technically correct blasting. It is conceivable that such incorrect blasting can loosen masses of earth leading to a rock or debris slide, create fissures or enlarge existing ones, increase slope instabilities, change underground water courses, dry up springs and lead to cracks in houses and other structures. A few cases are discussed below and in Appendix 10.

In the case of storage reservoirs, impoundment of water in the reservoir causes the surrounding water table to rise. Hydrostatic pressure pushes the water into available spaces, pores and interstices of the surrounding rock masses. The rise of water reduces the shear strength of the soil cover and the rocks.[60] When the reservoir level falls due to the release of water from the dam, the drawdown sucks water out of the rock pores and the soil, weakening the slopes and often leading to slope failure or landslides.

Impact

Submergence impacts: It was known before the construction of the Tehri dam that there were unstable slopes around the rim of the proposed reservoir. The Geological Survey of India (GSI) surveyed villages on the rim in the Bhagirathi and Bhilangana valleys in 1989-90 and identified some weak zones above the FRL (El ±835m). A second survey in 1990-91 around Kangsali, Ghandiyal, Sem, Jhiwali and Raulakot villages identified active slides between the river bed level and El ± 960m. A third survey in 2001-02 also identified vulnerable zones in Barola, Dob and Barakholivillages besides a location near

[60] K.S. Valdiya (1993): *Op.cit*., p.20

Khola gad. It is not known what remedial measures were suggested as a result of these surveys.[61]

After the filling (up to 785m) and initial drawdown (to 740m) of the reservoir, GSI undertook further surveys in June 2006, September 2006 and October 2007. The problem had spread. Several new locations in the Bhagirathi and Bhilangana valleys were identified as being 'highly vulnerable and requir(ing) immediate attention'.

Fig. 2.8: Landslides around Tehri dam reservoir

A multi-disciplinary committee set up by the Government of Uttarakhand (GoU) conducted field visits to 16 villages in the two valleys in June 2007 and February 2008. In 2009 it reported on its investigations around the Chinyalisaur-Jogath road. In 2010 GoU formed a committee of subject experts from several institutions to investigate the impact of raising the water level to the FRL due to a heavy flood in the Bhagirathi during the monsoon season. It recommended rehabilitation in some villages and stabilization measures at other locations.

February 2008 observations: The multi-disciplinary expert team reported erosion due to draw down along two stream channels in Nandgaon (Pata) village in the Bhilangana valley. Slides appeared imminent below El ±835 m. It was feared that the problem would aggravate during later draw downs. A major fissure, about 300 m long and about 15 cm wide was observed near Khand village. But the slide was far enough and the village did not appear threatened. A 3 m vertical detachment and subsidence in the road near Kailbagi village was also attributed to draw down.

In the Bhagirathi valley slide scars were observed between El ±835 m and El ±860 m in Raulakot village settled on old river borne material (RBM). It reported an 'alarming' situation in Nakot village where fresh fissures were observed between El ±870 m and ±930 m in the main settlement. One major fissure 100 m long, 10 cm wide and 10 m deep was observed in the habituated part of Nakot. Some of the fissures had pierced the semi-compacted earth in front of houses. A similar problem was seen in a part of Sansyu village.

The team concluded that while there was no immediate threat to human settlements in the Bhilangana valley, the situation in Nakot and Raulakot villages of the

[61] Based on a summary of geological observations provided by UJVNL.

Bhagirathi valley was serious enough to warrant rehabilitation of the entire settlements. It also recommended rehabilitation of families living between Els ±835 m and ±850 m in Sansyu village.

April 2009 observations: The multi-disciplinary team undertook this visit to inspect potential hazards that might have been created by the filling and draw down in the area around the Chinyalisaur-Jogath road, in response to a request from the Directorate of Rehabilitation. It reported clear evidence of ground movement/ subsidence towards the valley. Further draw down would influence it.

Joint Expert Committee Report: GoU constituted a Joint Expert Committee (JEC) in September 2010 to study the extent of damages reported after the monsoon season. The JEC surveyed 44 villages/hamlets during three field visits between November 2010 and February 2011. It noted slope instabilities at various locations. But all were not attributed to the Tehri dam reservoir filling and draw down. For example heavy subsidence in Madan Negi was ascribed to saturation of the overburden material by heavy rains in September 2010 or construction on first order rivulets of the local Tadu nala. The JEC's major observations, in 19 of the 44 villages visited, due to the reservoir filling and draw down are summarized in Table 2.4 below.

From the above it is noteworthy that slope instabilities and subsidence problems ascribed to the reservoir filling and draw down exist even at levels more than 250 m above the FRL.

There is no denying that the reservoir rim is riddled with numerous landslides. Many are quite fresh suggesting that the slopes are in the processes of adjusting to the new hydro-meteorological conditions. When the equilibrium will be reached is a matter of conjecture. Since the water level will fluctuate periodically, the stable angle of repose may never be achieved. In 1999 GSI had meticulously identified different categories of vulnerable zones around the reservoir rim.[62] If THDC had taken note of this report and implemented its finding, much of the sufferings of the people would have been lessened if not mitigated.

[62] P.C. Nawani et. al.. (2006): TEHRI DAM PROJECT - A Geotechnical Appraisal, Geological Survey of India- Bulletin : Series B, No.62, ISSN:0445-622X.

Table 2.4: Villages with problems due to Tehri dam reservoir filling and draw down

S. No.	Village	River Bank	Elevation* (m)	Observations
Bhilangana Valley				
1.	Khand Dharmandal	Right	±845-±898	Fissures attributable to the filling and draw down in the reservoir observed in Chhateldu Name Tok. Recommended relocation of houses below the road level (898 m).
2.	Nargarh	Right	±960	Steep slopes. Area is unstable but no *prima facie* evidence of reservoir filling related instability. Recommended slope stabilization measures.
3.	Pipola khas	Left	±890-±970	Savitri Sain Name Tok is entirely affected by ground movement due to the reservoir filling and draw down. Apprehension of damage aggravation during future filling and draw down. Recommended relocation of the entire settlement.
4.	Bhatkanda (Luneta)	Left	±908	Luneta Name Tok contiguous to Savitri Sain Name Tok has identical problems as the latter. Recommended relocation of all habitations.
5.	Badkot	Left	±880-±920	*Prima facie* evidence of damage due to reservoir filling and draw down. Recommended shifting of houses located below the National Highway (NH).
6.	Nandgaon	Left	±860-±880	200 m ground crack at el- ±865m in Dungra Name Tok attributable to reservoir filling. Recommended shifting of some buildings and three habitations.
7.	Kailbaghi	Left	±850-±860	Steep slope. Failure at one location due to reservoir filling and draw down, Recommended relocation of habitations below road level (850 m).
8.	Gojiyana		±908-±920	Major ground crack at road level (El ±908) with 2 m vertical settlement. Ground movement towards the reservoir. Attributable to reservoir filling and draw down. Recommended shifting of houses.
9.	Pipola dhungmandar		Settlement above ±840	*Prima facie* lower part of the slope appears affected by the reservoir draw down. Recommended continuous monitoring.
10.	Paryavan		±950-±1135	Damage below the village caused by reservoir filling/draw down. Recommended relocation of village above ± 950 m.
Bhagirathi Valley				
11.	Gadoli	Left	±850-±945	*Prima facie* draw down effect observed in this village. Recommended relocation of village habitation.
12.	Raulakot	Left	±860-890	Glaring example of filling and draw down effect. Recommended relocation of habitation

				up to ± 865 m.
13.	Gojmer	Right	±1000-±1152	Area below NH influenced by filling and draw down. Recommended relocation of house below NH.
14.	Sila Uppu	Right	±845-±855	Reservoir filling and draw down effect in Khairkhola Name Tok hamlet. Recommended its relocation.
15.	Nagni Chhoti	Right	Above ±839	Damages due to reservoir filling and draw down. Recommended relocation of four houses.
16.	Sarot	Right	Above ±847	Front slope affected by reservoir filling and draw down. Recommended immediate relocation of houses at ±835 m.
17.	Baldogi	Left	Below ±900	Impact apprehension. Recommended continuing surveillance.
18.	Chaundhar	Left	Above ±975	Impact apprehension. Recommended continuing surveillance.
19.	Chinyalisaur	Right	River level and above	Major township. Colossal buildings damage at or below ±840 m along road to Devisaur bridge. Recommended adequate slope toe protection structures and continuing surveillance.

Source: JEC Report, April 2011.

Now most of the affected communities simply demand that they be relocated. THDC would prefer to relocate them at nearby location in the valley itself. But the people believe that this will only result in postponing the solution. They prefer being moved out to the more desirable location in the plains districts. But the government and THDC find it difficult to provide new lands there.

Other Slope Instability Cases: Since the expansion of HEP construction activities in Uttarakhand, particularly the excavation of tunnels in the mountain sides, reports of slope failure – slumping, sliding and subsidence – and problems encountered during tunneling have appeared from time to time. Analyzing the hazards faced during tunneling for the MB-I HEP, by the drill and blast method, Goel et. al. have written,"Problems of tunnel face collapse, with or without heavy ingress of water, cavity formation and large tunnel closures leading to buckling of steel ribs on account of squeezing ground. The absence of advance knowledge of the frequently changing rock mass and ground water conditions and, therefore, the inability of the tunneling engineers to modify the construction method and support system responsible for these problems."[63] This implies that the drill and blast method is not fool proof and can lead to slope instabilities and water related problems.

But usually the causes are contested by the affected local communities and the developers. Ambiguities are highlighted in each others' analysis. But the different perspectives persist. Two cases are discussed in this section as illustrative examples.

[63] R.K. Goel, J.L. Jethwa, and A.G. Paithankar (1995): "Tunnelling through the young Himalayas-a case history of the Maneri Uttarkashi power tunnel", Engg Geol., 39, 31-44, 1995

Mandakini Valley: The HRT of the Singoli-Bhatwari 99 MW project is roughly oriented N-S and is dug through the High Himalayan Crystallines (HHC). In its field visit the EB team noticed that the right flank slope of the Mandakini valley through which the HRT is excavated is riddled with discrete patches of landslides. A very conspicuous and extensive landslide was observed in the vicinity of Timriya and Damar villages (Fig. 2.9). Vaidyanathan et. al.. have shown that the area south of the MCT is undergoing high erosion.[64] Therefore any major geological intervention in such a terrain without adequate safeguards can lead to serious problems.

Fig. 2.9: Landslide located on the NE-SW trending ridge along the Mandakini valley. The head race tunnel opens behind the crest of the ridge (along a seasonal stream which is also the muck disposal site of L&T).

The local villagers and L&T officials hold opposing views. According to L&T officials the landslide was triggered by a cloud burst in 1962 and since then it is active. The local villagers, agree that the landslide was in existence prior to the start of the excavation. But they claim that its size began to increase after 2007 when the L&T started excavating the tunnel. Scientists from the Central Institute of Mining and Fuel Research (CIMFR), Regional Centre, Roorkee conducted a study commissioned by L&T of the blasting methods adopted at the location and concluded that the reported problems were due to causes unrelated to the blasting.

Further upstream of the barrage at Kund, the slopes on which Semi village and its agricultural fields are located are undergoing appreciable subsidence. Again, opinions about the causes of subsidence vary. The L&T officials say that subsidence is an ongoing process around Semi village and that it has been going on from before the onset of construction activities. But the local villagers contest their argument and ascribe it to the repeated blasting and the impounding (temporary) of the June 2013 sediment laden flood water behind the partially constructed barrage at Kund (see also ToR 2.1b). Based on its limited observations an EB team found it difficult to arrive at a definite conclusion about the problem of subsidence at Semi. After the disaster the state government has decided to relocate the village.

[64] N.S. Vaidyanathan, G. Sharma, R. Sinha, and O. Dikshit (2002): "Mapping of erosion intensity in the Garhwal Himalaya", Int. J. of Remote Sensing, v. 23, pp. 4125−4129.

Chãyeen village: The landslide at Chãyeen village is perhaps the most reported case. The 400MW Vishnuprayag HEP was commissioned in June 2006. A 12 km long head race tunnel carries water from the barrage at Lambagar to Hathi Parvat opposite Joshimath. A penstock delivers the water to the power house located about 950 meters below at Marwari just above the Alaknanda river.

Fig. 2.10a: Land subsidence at Chãyeen village

In September 2007 villagers began noticing water leakages in the vicinity of the tunnel. This was followed by ground subsidence in October 2007. Cracks appeared in several houses in Chãyeen village, located on the slope, deep fissures appeared in several fields and silt-laden water was seen by the villagers gushing into a small nearby mountain stream. In November 2007 a large arch-shaped section of the slope slid about 5-7 m (See Fig. 2.10a). A road on one side of the bridge over the mountain stream fell over 20 ft. as a result of the slide (See Fig. 2.10b). The slope failure led to house collapses, destruction of trees and fields, as well as road collapses. It also damaged a power line tower and threatened the power house itself. Twenty five households were rendered homeless.

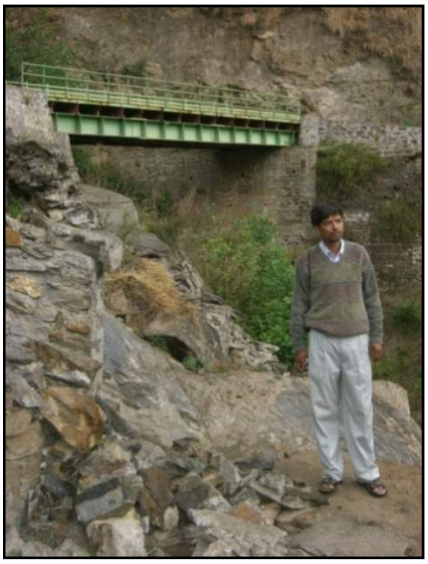

Fig. 2.10b: A portion of the link road to Chãyeen fell about 6 m

A preliminary report by an official team that visited Chãyeen village in December 2007 stated, "Seepage of water from any of the subsurface arteries supplying water to the turbines installed under ground beneath the Chãyeen village could be the most likely cause of subsurface erosion leading to ground subsidence."[65] The final report, however, ascribed the slope failure to other causes. Later, the project developer deposited an amount of Rs 80 lakhs with the district authority. It is not clear whether this was for payment of a fine or compensation for the damages.

High density flow: High density flow occurs when there is exceptionally high sediment-water ratio. Also known as hyperconcentrated flow, it is considered to be highly erosive especially in areas where the channels are relatively steep. During such flows, tens of

[65] R. Chopra (2012): Hydropower Development in Uttarakhand, Research report submitted to WWF-India, New Delhi

meters of vertical scours have been observed in <10 hours.[66] Hyperconcentrated flows can be triggered by lake outbursts, high intensity monsoon induced large-scale slope destabilization or anthropogenically induced sediment contribution from roads and hydropower construction projects. During its field trips the EB saw evidence of such hyperconcentrated flows in the Mandakini valley, in the Alaknanda valley at Lambagar in the vicinity of the Vishnuprayag project and in the Assiganga valley in Uttarkashi district.

The problem of muck has never been debated so intensely as after the recent flood. One of the reasons is the greater visibility of damage in the proximity of HEPs. Although there was an increase in sediment mobilization generally during the June 2013 flood, it is also suggested that at a local scale, wherever the HEP muck was kept along the river banks without proper protection, it was a contributing factor towards aggravating the flood damage.[67] For example, during its field visits the EB team saw that compared to upstream of partially completed barrages, the downstream suffered more damage, e.g., settlements like Pandukeshwar and Govindghat, located downstream of Vishnuprayag HEP suffered heavy damages because the hyper concentrated flows brought by the Khiron Ganga just upstream of the Vishnuprayag project blocked its barrage leading to a change in the river course. Srinagar town in the Lesser Himalaya is an example of sediment bulking partly caused by the addition of the project's muck to sediments coming from upstream. It aggravated sedimentation of some of the lower habitation sites as discussed in Chapter 3 (See box in Chapter 3: Erosion and Deposition on River Bed and Bank).

An Alternate View

It cannot be said with certainty that the HEPs added significantly to the damage downstream. Had there been no barrage the magnitude of damage would have been the same though the pattern may have differed. In the lower Mandakini valley the extent of damage to property increased enormously because of encroachments in the flood plain of the river.

- ***Ajay Verma, Member, EB.***

Social Infrastructural Impacts: As HEP construction activities in Uttarakhand have increased various communities across the state have complained of deleterious impacts on social infrastructure like water sources, houses, agricultural lands, illegal cutting down of trees and slope failures in the vicinity of HEPs. Formal investigations of these complaints by experts have generally cited causes other than the construction methods. Issues related to slope failures have been discussed above.

The EB too has received a number of representations about damages to the social infrastructure. [68] Most of the complaints, however, could not be investigated by it due to

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66 M. Jakob, and O. Hungr (2005): Debris flow hazards and related phenomena, Springer-Verlag, Berlin, pp. 733

67 N. Rana et. al. (2013):

68 See Annexures, Part II of this report.

lack of time. Also there was a strong opinion within the EB that many effects often ascribed to blasting were not actually due to it (See Box : Blasting: An Alternate View). A few other cases of social infrastructural impacts based on published research reports or official documents and field observations of the EB are summarized below as illustrative examples.

Impact on water sources: Faced with growing complaints against blasting, a few developers financial have also begun to use tunnel boring machines (TBMs) in the last few years. Till now, practical difficulties in using TBMs in the Himalayan region have deterred HEP developers from using them.[69] But in diverse Himalayan locations in Jammu & Kashmir, Himachal Pradesh, Sikkim and Assam

Piyush Rautela of the Disaster Mitigation and Management Centre, GoU, and M.P.S. Bisht of Garhwal University reported a major tunnelling accident in the vicinity of Joshimath where a TBM was employed.[70] It has resulted in a significant loss of water resource and the machine has been stuck inside the unfinished tunnel. Here the head race tunnel of the Tapovan-Vishnugad HEP traverses through the geologically fragile area below Joshimath. "A tunnel boring machine was employed for excavating the head race tunnel. On 24th Dec'2009, it punctured a water bearing strata some 3km inward the left bank of Alaknanda near Shelong village. The site was more than a kilometer below the surface, somewhere below Auli, according to project authorities. The water discharge was reportedly between 700-800 litres/sec. The aquifer discharge was about 60-70 million ltrs daily, enough to sustain 2-3 million people. Even after a month, the aquifer had not dried out."

Residents of Guniyala village in Uttarkashi complained to the EB that following the construction of the HRT of MB-II, the monsoon fed Kairigad stream had dried out. An EB team visiting the village saw some water trickling down in the lower reach of the stream but the upper segment was virtually dry. It seems the water is either captured by deep seated fissures or flowing under the thick pile of boulders that were generated (as per local version) during the tunneling activity. The rock types are dominated by ferruginous quartzites which are fractured and jointed. Terrains dominated by such rocks experienced land sliding during earthquake tremors (e.g., 1999 Chamoli earthquake). Local villagers mentioned that similar problems could be seen at several other villages in the vicinity of the MBP-II HRT. Are all these cases merely coincidences that the local water sources were affected after the construction of the MBP-II HRT? A more substantial investigation is required to look into these complaints.

An MoEF-appointed Committee consisting of officials and three Expert Members of the National Ganga River Basin Authority (NGRBA) visited the now abandoned under

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69 I. Macfeat-Smith (2008): Tunneling in the Himalayas

70 P. Rautela & M.P.S. Bisht (2010): "Disaster Looms Large Over Joshimath," in Curr. Sci., v 98 no. 10, May 25, 2010, p.1271.

construction Loharinag-Pala HEP in the upper Bhagirathi valley in January 2010 to investigate compliance with the project sanction conditionalities. The report of the NGRBA experts mentioned receipt of complaints of social infrastructure damage from a few villages in the zone of influence of the project. Due to paucity of time, however, it was only able to investigate the problems in Salang village where a spring used by the villagers and their animals had dried up. The developer (NTPC) appeared to accept responsibility for this damage but its physical response, to help the villagers overcome the resultant hardship, was considered inadequate by the experts. Cracks in several houses were also seen by the Committee but the report did not assess their possible causes.

Impacts on houses and fields: An EB team visited Payal village located on the right flank of the Koteshwar reservoir rim following complaints of land subsidence and damage caused to houses. The team observed roughly many NE-SW trending fissures on the phyllite dominated colluviums. The village approach road had subsided at a few locations, some of the houses had developed cracks, the boundary walls showed tilting and the RCC lined irrigation canal was vertically and laterally displaced. The villagers said that the subsidence began after when the Koteshwar reservoir water was released in September 2010. The villagers also claimed that the THDC officials were unaware of three exploratory tunnels (80m, 70m and 60m long) trending NE-SW below Payal village that were not adequately filled before filling the Koteshwar dam reservoir. Currently these tunnels are submerged under the reservoir water.

The fissures in and around Payal village are roughly oriented parallel to the extension of the reservoir rim. The fissured agricultural fields were once irrigated. Hence the villagers' suggestion that the fissures developed subsequent to the

An Alternate View

Attributing subsidence and cracks in kutcha houses to reservoir filling/draw down would be incorrect and against sound engineering principles. It is natural that instabilities do occur in hill slopes during heavy rainfall even without any reservoir.

The cracks in many houses (in Chaundhar village) were inspected. These cracks do not exhibit any pattern and most likely formed due to faulty construction and materials. While planning the buildings in the steeply sloping hill side, all precautions are to be taken. The houses are arbitrarily constructed without any engineering supervision.

The elevation of this place (Madan Negi village) is about 1140 m whereas the FRL of Tehri is at 830 m. After analyzing the nature and extent of cracks in the area it is felt that the issue needs to be investigated thoroughly before reaching any conclusions….. It is highly unlikely that cracks in the houses are due to subsidence of ground purely due to the reservoir and its operation, specially, when the houses are located more than 200 m above the reservoir surface.

- ***Extracts from field notes by T. K. Sivarajan, Director, CWC.***

formation of the reservoir appears logical. Villagers in general would not irrigate land under subsidence. A check is required whether the exploratory tunnels were adequately filled before the filling of the Koteshwar reservoir. An expert team should visit Payal village to assess the collateral damage as has been done in the neighbouring Dobhal village.

To investigate representations regarding land subsidence supposedly caused by the filling of the Tehri dam reservoir, the EB team visited Okhla (El±1000 m) and Madan Negi on the Pratapnagar side of the reservoir. Some team members visited a few agricultural fields in Okhla below the main road. The terraced fields had fissures and differential dislocations at places. The morphology of the dislocation mimics a fault scarp with height ranging from few cm to tens of cms (Fig. 2.11a). The scarp trending NW-SE, is sympathetic to the orientation of the Tehri reservoir and located ~400 m above the reservoir surface. The differential dislocations can be traced up to 50 m along the fields and across a seasonal stream which is well vegetated and show no sign of landslides.

The fissured fields are located on the debris that rest over a rather stable N-S trending spur. The debris laden southerly slopes on which the agricultural fields are terraced can be traced right up to the fringe of the reservoir and may be extending below the reservoir surface. The villagers claimed that the problems began after the reservoir started filling up. But they also add that the subsidence occurs when the reservoir level is lowered, not when it is being filled.

Similar subsidence on a major scale was observed around Madan Negi village. Most houses below the road had serious cracks. The plinth had separated in a few houses indicating ground subsidence. One of the major geomorphic expressions of land subsidence seen was a deeply fissured metalled road that leading to the village hospital (Fig. 2.11b). Here again the trend of the fissure is in accordance with the orientation of the reservoir. Though the main settlement is located around El ± 1100 m the severity of

Navin Juyal

Fig. 2.11a: Displaced fields

Navin Juyal

Fig. 2.11b: Fissured road in Madan Negi village

the cracks and fissures demand that the slope instability in this village should be regularly monitored in order to reach a definitive conclusion regarding the local community's demand for relocation.

Construction at the Phata-Byung project started in 2008. In July 2010, Shri Gangadhar Nautiyal, advocate and former Chairman, Zila Panchayat filed a complaint that houses in Shershi village had been damaged due to blasting for the HRT. The District Magistrate of Rudraprayag ordered the PWD to conduct an enquiry. The enquiry listed damages to 115 houses and other structures in the village. A sum of Rs. 13,57,228 was ordered to be given as compensation, after an agreement with the company officials.

Conclusions

The foregoing sections II.3 and II.4 have identified a number of impacts on the geological environment, which in turn have also impacted the social infrastructure. When the affected communities complain about damages to their property and other public utilities, the developers strongly contest their claims. Scientists and technologists are hired by them to investigate the complaints. Reports are filed by the consultants that usually cite causes other than faulty construction practices and absolve the developers.

But technical journals routinely carry scientific reports and papers of hazards faced during construction of HEPs.[71] Among the tunneling problems cited in the Himalayan region are poor rock quality, deep weathering, high rock stresses causing rock burst, large water inflows, silt flows, etc. They also mention earlier that engineers do not always have advance knowledge of localized discontinuities. It is therefore logical to assume that the uncertainties which befall the construction activities can also damage the local social infrastructure. Therefore local communities usually refuse to accept the veracity of "scientific reports" prepared by consultants hired by the developers.

It is also interesting to note from the above that official investigations like the JEC report on reservoir induced slope instabilities at Tehri or the PWD engineers in Rudraprayag mentioned above, usually reach more balanced conclusions. Given the massive scale of construction of HEPs in Uttarakhand it may be worthwhile to set up a formal institution or mechanism for investigating and redressing complaints about damages to social infrastructure. The functioning of such an institution can be funded by a small cess imposed on the developers. It is also suggested that to minimize complaints of bias, investigations should be carried out by joint committees of subject experts and the community. Local communities can get educated on the technical issues in the process and the experts may also begin to appreciate the loss and pain felt by the affected people.

[71] See citations listed in the papers by I. Macfeat Smith and Goel et.al cited earlier.

2.4 Conclusions

It is evident that land, environment, terrestrial and aquatic ecosystems get impacted by changes resulting from HEPs. But the Environmental Impact Assessments and Environmental Management Plans that are prepared stipulate mitigation measures to counter the anticipated degradation. Minimizing impact on important natural resources like acquisition of forest land is given the highest priority. Assessment and stipulation of adequate environmental flow is now mandatory. Alignment and driving of tunnels follow detailed geological mapping, stipulation of appropriate blasting technique and hazard estimation with adequate mitigation measures. Environmental monitoring at the construction and operation stages are also stipulated. If the operational HEPs and those under construction follow the above guidelines meticulously it would help minimize environmental degradation.

Reviews of the existing and under construction projects, particularly the older ones show significant impacts arising out of minimal flow releases downstream of projects and poor maintenance of muck dumps.[72] The most significant impact on forests is the loss of riverine ecosystems on the rim of storage reservoirs. It is surprising that HEP sites are located inside protected areas. Compensatory afforestation and catchment area treatment works have not been taken seriously enough by the State Forest Department. This work needs to be done by community institutions like van panchayats rather than the forest departments.

Geological impacts and impacts on social infrastructure remain a heavily contested area, as evident from the debate in this report also. But even official investigations looking into complaints of subsidence and landslides around Tehri reservoir have concluded that such impacts are visible in several villages.

Suggestions have been made in this chapter on more effective mitigation measures.

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[72] It should be kept in mind that the standards setting agencies have themselves been recommending minimum flow releases rather than environmental flow releases. It is only recently that MoEF has begun to set values for environmental flow releases.

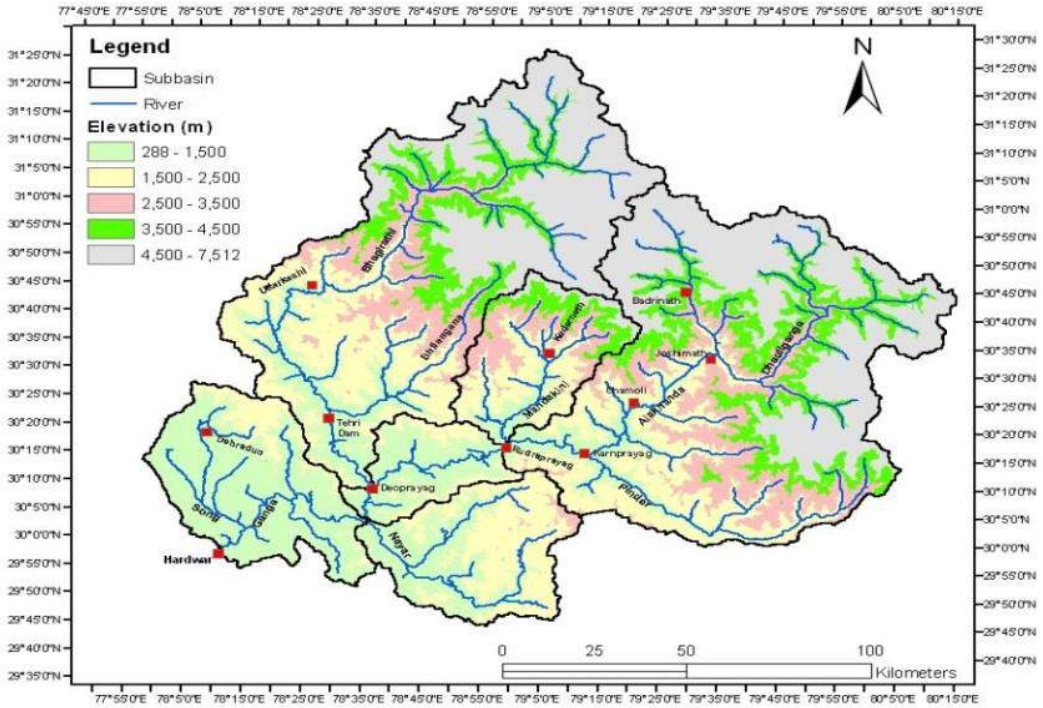
Chapter 3

ToR 2.1(b)

ToR 2.1(b): Assess whether the existing and ongoing/under construction hydropower projects contributed to the tragedy that occurred at Uttarakhand in the month of June. Also to make a detailed study and evaluate as to how far HEPs have contributed to the aggravation of damage caused by downstream floods.

Uttarakhand has a geographical area of 53,483 km^2 of which 88% is mountainous and 64.54% is covered with forests. The northern part is covered by high Himalayan peaks and glaciers while the southern part with lower foot hills is densely forested and drained by the mighty Ganga and its tributaries. Its climate, vegetation and geological features vary greatly with elevation, exhibiting glacier ice and barren rock in the north to subtropical forests at the lowest elevation. Uttarakhand consists of 13 districts nine of which received unusually heavy storm rainfall of 250 mm to 400 mm and above over a three day spell between June 15-17, 2013 ending at 8:00 am on June 18th (See Table 3.1).

The drainage area map of river Ganga upto Haridwar is shown as Fig 3.1. It may be noted that the upper basins of Bhagirathi, Mandakini, Alaknanda, Dhauliganga and Pindar are at elevations above 2000-2500 m rising to 3500 m in very short stretches of 50-60 km. This stretch contributed to rapid flash floods when torrential rain battered the region primarily between June 15-17, 2013.



Source: CWC

Fig. 3.1: Drainage Basin of Alaknanda & Bhagirathi

Table 3.1: RAINFALL DATA JUNE 2013

DATE 24hrs ending 8am	14	15	16	17	18
DISTRICT: ALMORA					
ALMORA	15.1	1.0	32.4	89.3	100.0
RANIKHET (G)	4.0	0.0	16.0	38.0	120.0
DISTRICT: BAGESHWAR					
BAGESHWAR (THMO)	15.0	3.0	61.0	161.0	63.0
KOSANI (U PROB)	43.2	20.2	105.0	205.0	83.2
DISTRICT: CHAMOLI					
CHAMOLI	1.0	37.0	58.0	76.0	100.0
JOSHIMATH	0.0	31.4	41.9	113.8	78.6
KARNAPRAYAG	8.2	7.0	88.0	89.6	82.3
THARALI	0.0	15.0	58.0	173.0	80.0
DISTRICT: CHAMPAWAT					
BAMBASA	0.0	0.0	3.0	99.0	230.0
CHAMPAWAT	0.0	1.0	34.0	97.0	222.0
DISTRICT: DEHRADUN					
DEHRA DUN	93.4	53.5	219.9	370.2	11.8
MUSSOORIE	16.0	44.0	137.0	155.0	8.0
DISTRICT: GARHWAL PAURI					
KOTDWARA	0.0	9.0	73.0	23.0	52.2
LANDSDOWN	16.0	0.0	64.0	51.0	28.0
PAURI	0.0	0.0	44.0	51.0	38.0
DISTRICT: GARHWAL TEHRI					
DEOPRAYAG	0.5	7.3	129.5	163.3	69.5
KEERTINAGAR	0.0	0.0	78.0	96.0	65.2
TEHRI	3.7	33.5	121.9	168.9	53.4
TEHRI (CWC)	0.2	0.0	124.0	168.4	17.6
DISTRICT: HARDWAR					
HARDWAR	10.0	20.0	107.6	218.0	14.0
ROORKEE	0.0	5.0	51.0	147.0	15.0
DISTRICT: NAINITAL					
HALDWANI	0.0	13.0	91.0	200.0	278.3
MUKTESHWAR	14.0	0.4	78.4	236.8	183.0
NAINITAL	14.8	18.6	43.6	175.6	170.2
DISTRICT: PITHORAGARH					
MUNSIYARI	4.0	25.0	44.0	85.0	75.0
PITHORAGARH	0.0	0.0	11.2	85.5	117.2
DISTRICT: RUDRAPRAYAG					
JAKHOLI	25.0	71.0	121.0	108.0	65.0
RUDRAPRAYAG	4.0	11.8	89.4	92.2	59.2
DISTRICT: UDHAM SINGH NAGAR					
KASHIPUR	0.0	65.0	2.0	31.0	35.0
PANTNAGAR	0.0	0.0	5.6	62.1	113.0
DISTRICT: UTTARKASHI					
BARKOT	10.0	15.4	112.6	20.0	20.0
BHATWARI	20.0	18.0	35.0	70.0	50.0
DUNDA	5.0	80.0	118.0	185.0	16.0
PUROLA	26.0	36.0	165.0	60.0	104.0
UTTAR KASHI	15.0	35.0	129.0	162.0	19.0
UTTAR KASHI (CWC)	4.2	48.2	121.8	207.4	21.2

3.1 Unusual Hydro-meteorological event of June 15-17, 2013

The entire Alaknanda and Bhagirathi basins (A-B basins) in Uttarakhand experienced the most intense storm of the century on June 15-17, 2013 which precipitated on an average about 250 mm to 400 mm in many parts of Uttarakhand during this spell. The upper basins of Bhagirathi, Alaknanda and its tributary Mandakini which have a glacial spread of about 2000 km^2 received almost 400 mm average precipitation between June 15-17. The warm rainwater of severe intensity (even upto 30 mm in an hour) in early June caused accelerated snow melt that along with large overland basin runoff from intense rain caused unusual flood havoc in most rivers of Uttarakhand upto Haridwar on the Ganga.

The storm event has been well documented.[1][2][3][4][5] According to IMD's analysis of this severe storm, "Wide spread very heavy to extremely heavy rainfall occurred over Uttarakhand and neighbouring states during 16-18 June 2013. This has caused severe flood, landslides, large scale loss of lives, properties and damages."

Meteorology officials explain that a collision of warm moist air from the southeast with cold air from the northwest created a low pressure region above Rajasthan and Haryana. "It sucked in moisture laden monsoon clouds from the Arabian Sea and moved in a northeast direction. When the latter collided with cold air above the mountain ranges in Uttarakhand and eastern Himachal Pradesh, they quickly dumped all their moisture over the region," explained Dr. Anand Sharma, Director, Meteorological Centre, Indian Meteorological Department (IMD) in Uttrakhand. The dynamic monsoon trough in the west also pulled the normal low-pressure southwest monsoon system from eastern India to rapidly traverse the entire state of U.P. in only 24 hours on June 14-15. The monsoon season thus arrived several days early.

Severity of Rainfall

Fig 3.2 gives a sense of the distribution of the rainfall between June 15-17, in 24 hour periods, ending at 8am on June 18th. It shows that on June 15-17 about half to two-third of the 36 IMD reporting stations shown in Table 1 received heavy (70-120 mm in 24 hours) or very heavy (120-250 mm in 24 hours). Two stations reported extreme rainfall (>250 mm in 24 hours) during this period.

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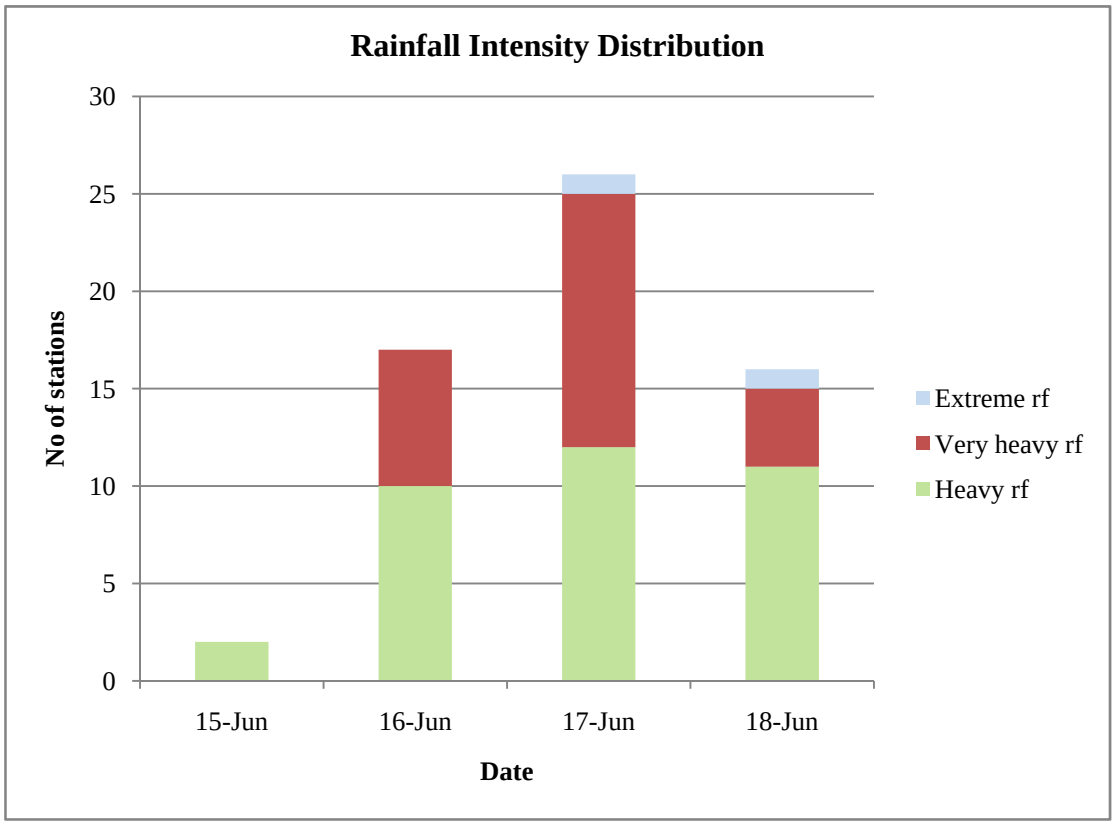
1 --------- (2013): "A Preliminary report on heavy rainfall over Uttarakhand during 16-18 June 2013", Ministry of Earth Sciences, IMD, GoI, New Delhi, July 2013

2 R. Ramachandran (2013): "Scientific Analysis of the reasons for the Disaster that Struck Uttarakhand", Frontine, Chennai, August 13, 2013

3 S. Kaur and P.K. Gupta (2013): "The Rainstorm of June 2013 in Uttarakhand", IMD, GoI, New Delhi

4 ISEG & CBIP (2013): Souvenir National Workshop on Natural Disasters with Special Reference to Uttarakhand, Indian Society of Engineering Geology and Central Board of Irrigation & Power, New Delhi, December 2013

5 K.H.V. Durga Rao et.al (2014): "Kedarnath Flash Floods: A hydrological and hydrolic simulation study", Curr.Sc., v.106, n.4, February 25, 2014



Source: Table 3.1 (Meteorological Centre, IMD, Dehra Doon)

Fig 3.2: Rainfall intensity distribution at 35 IMD stations

Durga Rao et al state, "During (June) 15-17, 2013, incessant rainfall centred at Uttrakahand caused devastating floods and landslides in the country's worst natural disaster since the 2004 tsunami. The disaster was due to an integrated effect of heavy rainfall intensity, sudden outburst of a lake (Chorabari) and very steep topographic condition. Accumulated rainfall computed in the Bhagirathi and Alaknanda catchment during 10-18 June 2013 was found to be 550 and 530 mm respectively. It was noticed that heavy rainfall occurred on 10 and 11 June 2013 as well; this antecedent heavy rainfall events raised the soil moisture to saturation level and the subsequent rainfall event resulted into full run-off in the catchments (Fig 3.3)." [6]

The daily rainfall pattern over the state of Uttarakhand is depicted for the 24 hour periods ending at 8 am on June 16, 17 and 18th as Fig. 3.4, 3.5, 3.6.[7]

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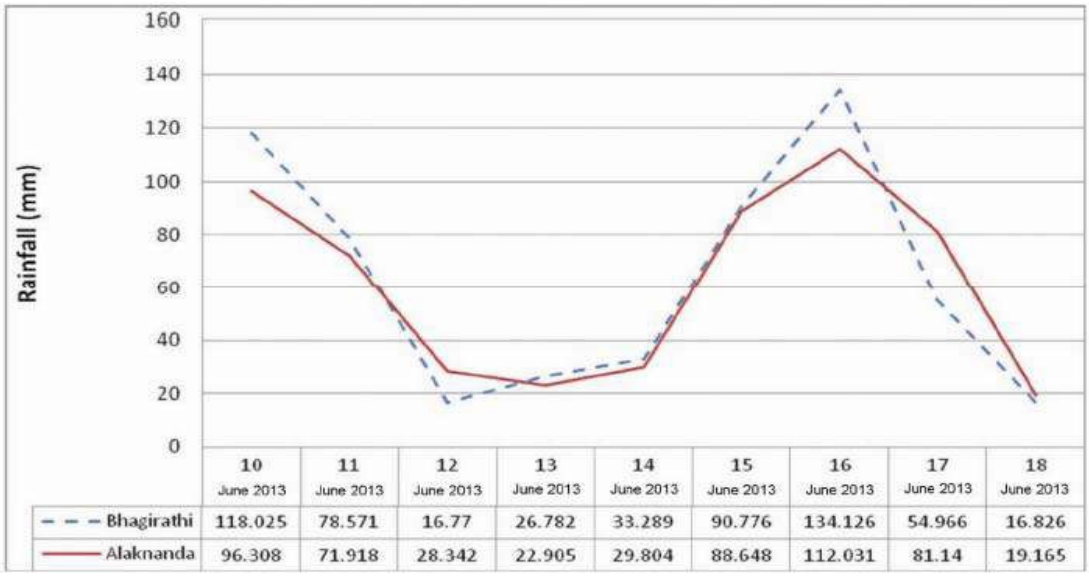
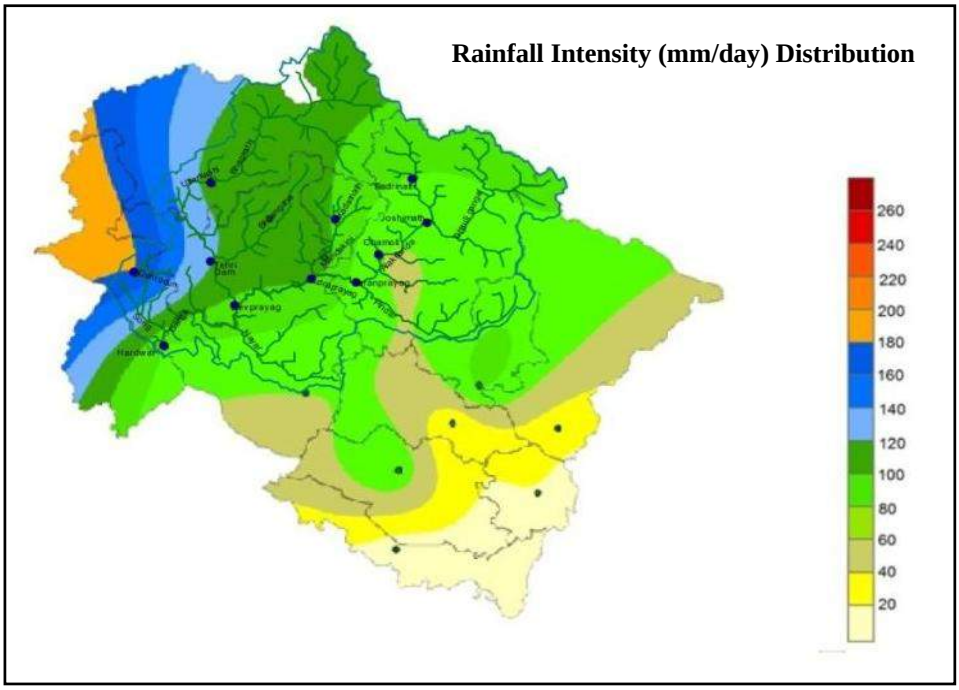
6 K.H.V. Durga Rao et. al (2014): *Ebid*

7 N.N. Rai (2014): "Hydrological Interpretation of Uttarakhand Flood of June 2013", Central Water Commission (CWC), New Delhi. Presentation made on March 4, 2014 to the EB



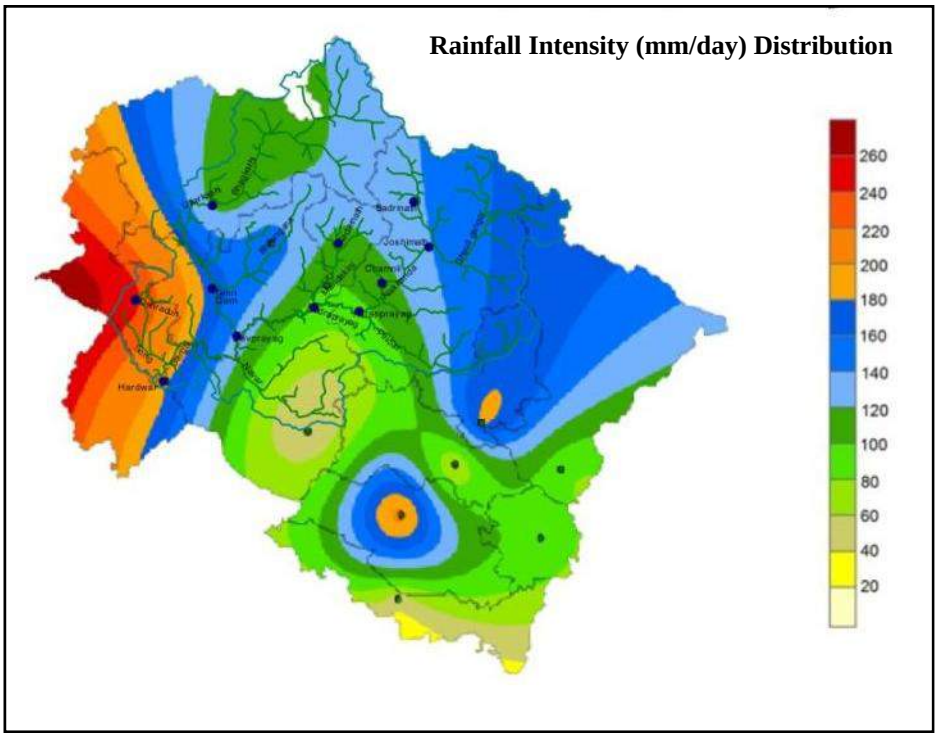
Source: TRMM data

Fig. 3.3: Temporal distribution of rainfall in the Bhagirathi & Alaknanda catchment during the flood event



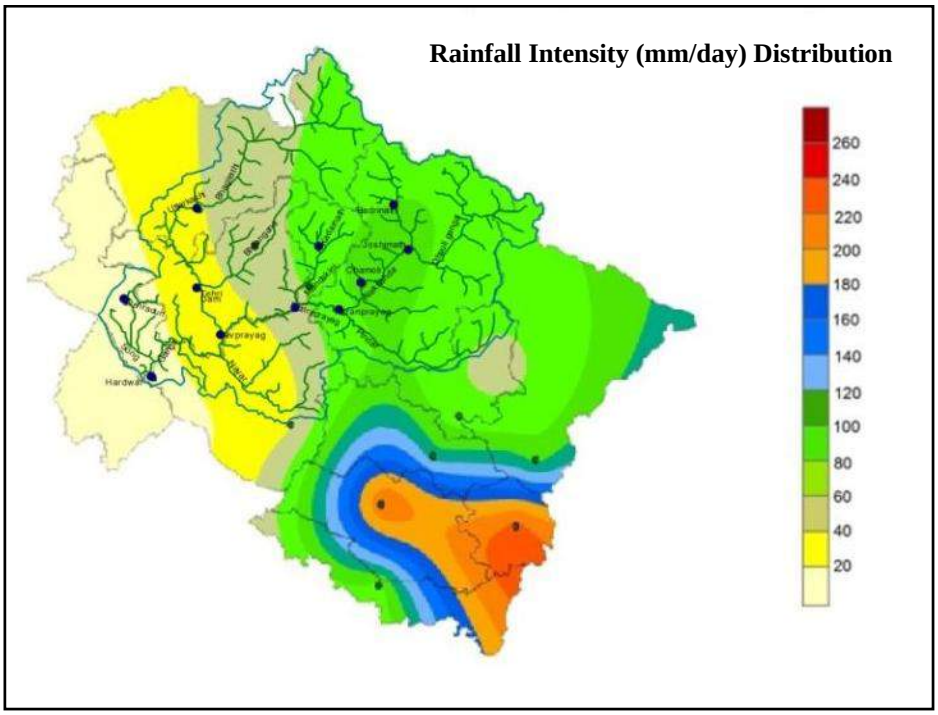
Source: Adapted from CWC

Fig. 3.4: Rainfall intensity (mm/day) distribution on June 16, 2013



Source: Adapted from CWC

Fig. 3 5: Rainfall intensity (mm/day) distribution on June 17, 2013



Source: Adapted from CWC

Fig. 3.6: Rainfall intensity (mm/day) distribution on June 18, 2013

The average daily rainfall in the A-B basins can be determined by taking a weighted average of the different intensity areas for June 15th, 16th and 17th. The estimated daily rainfall then is 103 mm on June 15th, 130 mm on June 16th and 60 mm on June 17th.

High Flood June 15-18, 2013

The entire region from Gangotri to Paonta-Sahib in the west to the Kali river in the east received rainfall of about 200 mm to 400 mm generally over a period of 48-72 hours between June 15-18, 2013. The glacial stretch above Gangotri, Kedarnath, Badrinath and Nandadevi Biosphere Reserve /National Park received almost 350-400 mm in this period. The central part in the elevation range of 700 m to 1500 m received almost 300 m, where as the southern most part below Rudraprayag and Tehri had on the average also 350 mm.

The consequential catastrophic flood originating from Chorabari lake outburst in conjunction with massive landslides principally in the Mandakini, upper Bhagirathi and Alaknanda basins ravaged Uttarakhand. The tragedy of colossal loss of human and animal lives along with infrastructure is expressed in figures in Table 3.2 below.

Table 3.2: Preliminary Assessment of the Uttarakhand Disaster 2013

S No	Nature Of Damage	Numbers
1	Affected persons	5 lakhs (approx)
2	Affected villages	4200
3	Severely affected villages	over 300
4	Persons injured	4,463
5	Number of dead persons	over 900*
6	Number of missing persons	5748
7	Number of pukka houses damaged	2679
8	Number of kuccha houses damaged	681
9	Number of animals lost	8716
10	Number of roads destroyed	2302
11	Number of bridges washed away	145
12	Number of drinking water schemes damaged	1418
13	Number of villages without power	3758

Source: DMMC, IAG, UNDMT, Internet.
*Note: *These are government figures. Unofficial estimates of dead and missing are higher.*

- More than 35 small, mini and micro hydro projects of UREDA, 7 projects of UJVNL and many other projects like Vishnuprayag and Dhauliganga (under operation), Srinagar, Phata-Byung and Singoli-Bhatwari (under construction) were damaged.

The Central Water Commission (CWC) has done a hydrological analysis of the floods in the Alaknanda and Bhagirathi basins.[8] Its data is summarized in Table 3.3.

[8] N.N. Rai (2014): *Op.cit*

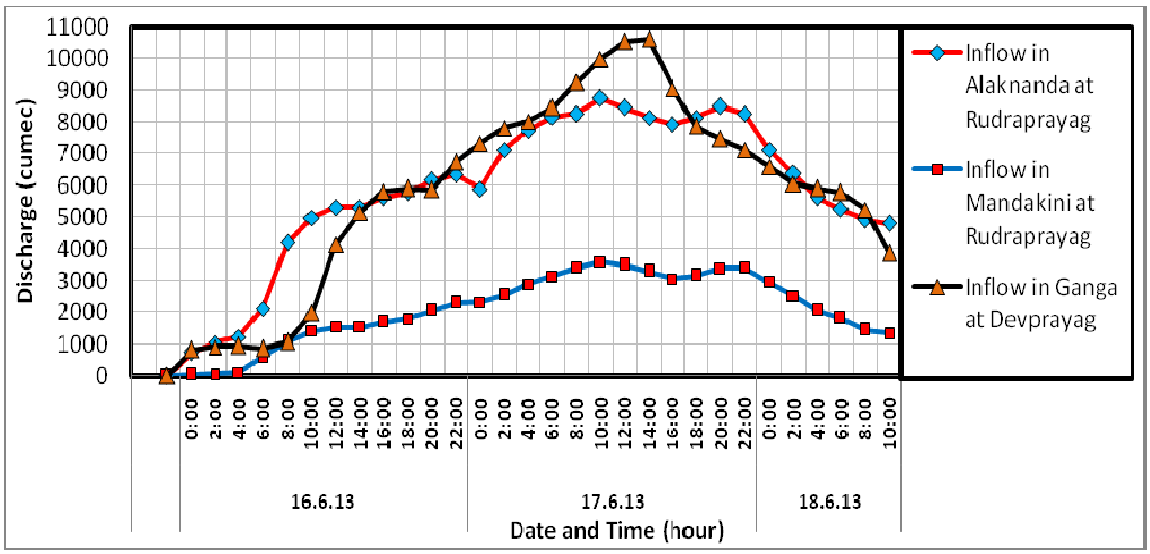
Table 3.3: Peak discharge (cumecs) at various stations, June 16-17, 2013

S.No.	Description	By CWC
A	Contribution of Mandakini from a basin area of 1645 Km^2	**Total 3590**
B	Alaknanda below Rudraprayag	**Total 8740**
C	Alaknanda at Srinagar	≈11500
D	Ganga at Devprayag	10647
E	Ganga at Haridwar	14457

Source: CWC

3.2 Conveyance of Flood Through the Projects

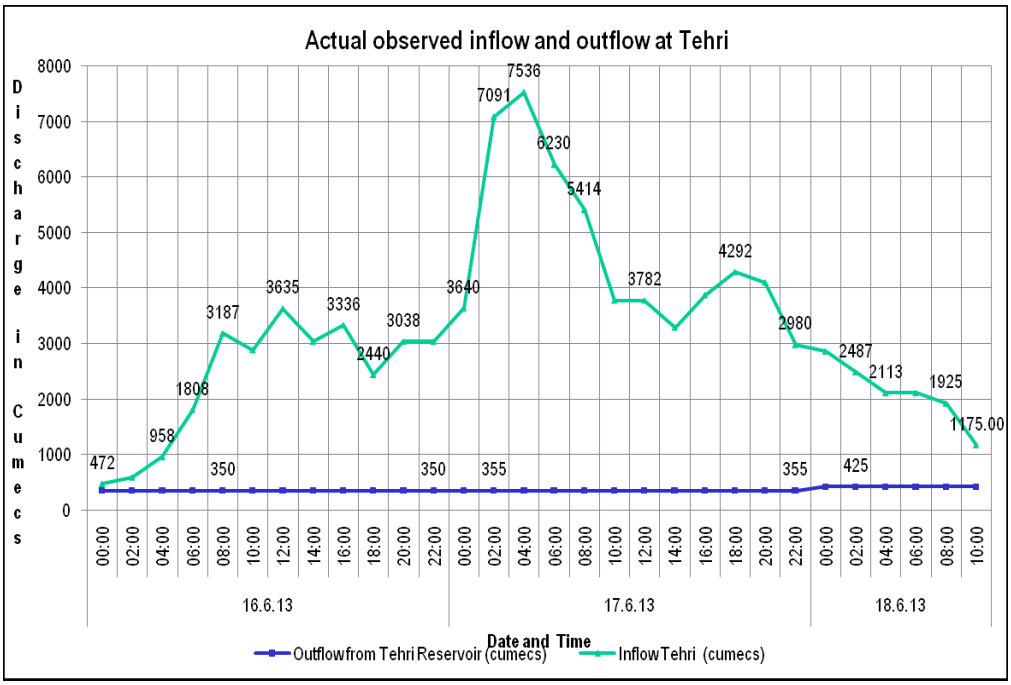
The Alaknanda, with a large basin of 11,500 km^2 area up to Devprayag, had a peak contribution of 3590 cumecs at Rudraprayag from the Mandakini basin including the Chorabari lake outburst flood (LOF). CWC's flood analysis indicates that the Alaknanda river enriched by several upstream tributaries conveyed 10,500 cumecs at Rudraprayag as shown in Fig.3.7. Further augmentation of the basin below Rudraprayag (approx 1000 km^2) led to an estimated peak discharge of 12,600 cumecs at Srinagar.



Source: CWC

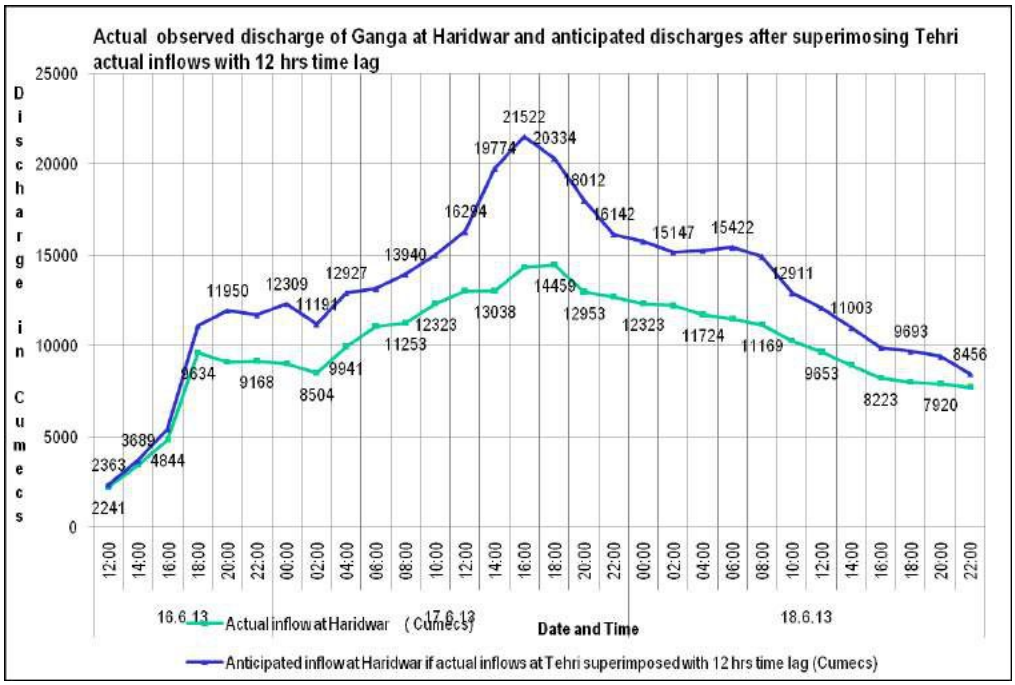
Fig. 3.7: Flood in the Alaknanda Arm

CWC has also estimated that the Tehri reservoir impounded a peak inflow of 7535 cumecs (Fig. 3.8). Its flood routing analysis indicates that the flood discharge at Haridwar would have exceeded 21,500 cumecs inundating parts of the twin religious towns of Rishikesh and Haridwar (Fig.3.9).



Source: CWC

Fig. 3.8: Inflow & Outflow at Tehri Dam



Source: CWC

Fig. 3.9: Actual and anticipated flood situation at Haridwar

The estimated flood peak of 21,522 cumecs at Haridwar assuming that there was no dam at Tehri would have been far above the highest ever observed flood of 18700 cumecs at Haridwar in 1924. The inflow-outflow at Tehri reservoir for the event is shown as Fig. 3.8. The anticipated hydrograph at Haridwar in the absence of Tehri Dam is shown as Fig. 3.9.

On the basis of CWC's flood routing analysis, CWC and THDC have asserted that the Tehri dam saved the Ganga basin below Devprayag and the towns of Rishikesh and Haridwar from catastrophic flooding and thus averted a major tragedy. This claim has been reiterated by the Chief Minister of Uttarakhand, Government of Uttarakhand officials and several others.

From the data made available by THDC and CWC, it is clear that the Tehri dam absorbed a peak inflow of 7535 cumecs (around 4am on June 17th into its reservoir and released only about 350 cumecs. Therefore it cannot be denied that the Tehri dam attenuated a major flood in the downstream Ganga basin. But this was a fortuitous circumstance since the flood occurred in mid-June, a few days before the normal onset of the monsoon season, when the Tehri reservoir was perhaps at its lowest level.

The Tehri dam is not designed to perform a flood control function. It does not have a mandated flood cushion. Hence it can hold back major floods only upto its mandated FRL. In Sept. 2010, to retain flood inflows in the face of water levels rising beyond the permitted FRL the dam authorities had to seek the permission of the Supreme Court.

An Alternate View

THDC officials informed the EB team during its field visit that its claim that Rishikesh and Haridwar were saved from catastrophic floods was based on an inundation analysis performed by its hydrologists and engineers. The inundation maps produced by THDC were reviewed and a ground survey was done in some of the areas shown as would be inundated by THDC. A ground survey team People's Science Institute (PSI), Dehra Doon directed by the EB Chairman noticed a major discrepancy between the stage-discharge graph provided by THDC and the record maintained at the CWC gauging station at Kharkhari in Haridwar.

Further, according to the CWC gauging station, the highest flood level (HFL) at Kharkhari in 2013 was about 296 m. THDC's inundation map for Kharkhari at 295.68 m shows a certain flooded area for this level. Residents of the area when interviewed in the ground survey conducted by the scientists from PSI, said that flood water never reached their area. According to them the flood did not breach the raised highway between their locality and the river.

Thus THDC's inundation analysis results could not be substantiated by the ground survey in Haridwar city. It therefore raises some doubts about the magnitude of flooding that was averted in Hardiwar.

- ***R. Chopra, Chairman, EB***

Then THDC was allowed to raise the FRL from about 830 m to 835 m. The actual maximum water level reached was about 831.2 m. This inundated the upstream town of Chinyalisaur and later after draw down from the maximum level fresh landslide zones were created around the reservoir rim as discussed in ToR 2.1a.

3.3 Assessing Flood Damages

The damage was due to a combination of the quantity of flood water and the sediment loads carried by the rivers. While the CWC analysis of the flood water conveyance appears to be adequate, it says little about the sediment loads. A first hand understanding of the floods damage was obtained through field visits and reviews of various official reports and research studies. The analysis is given in this section.

Both the basins were visited by the Expert Body (EB) in two spells, December 5-9, 2013 and January 8-11, 2014. In the first trip the EB team visited the Mandakini valley upto Sitapur – the barrage site of the 76 MW Phata–Byung HEP and the Alaknanda valley upto Lambagar, the barrage site of the 400 MW Vishnuprayag HEP. Besides these two projects the team also visited the Singoli-Bhatwari HEP on the Mandakini and the Srinagar HEP on the Alaknanda.

Mandakini River Valley

The valley can be divided into three major geomorphological domains. From northwest to southeast these are the upper glaciated regime (>4000 m) located above Kedarnath valley. The middle paraglacial domain (<4000 m to 2000 m) lies between Kedarnath and Sitapur and the lower fluvial regime (<2000 m) is below Sitapur till the confluence of the Mandakini river with the Alaknanda river at Rudraprayag and beyond (Fig. 3.10).

In the following, what happened above Sitapur during the disaster is summarized from the reports of two field visits carried out under the aegis of a DST sponsored project to evaluate the sediment transport mechanism. The impact of the flood at the project sites and downstream is based on the visit of the EB team.

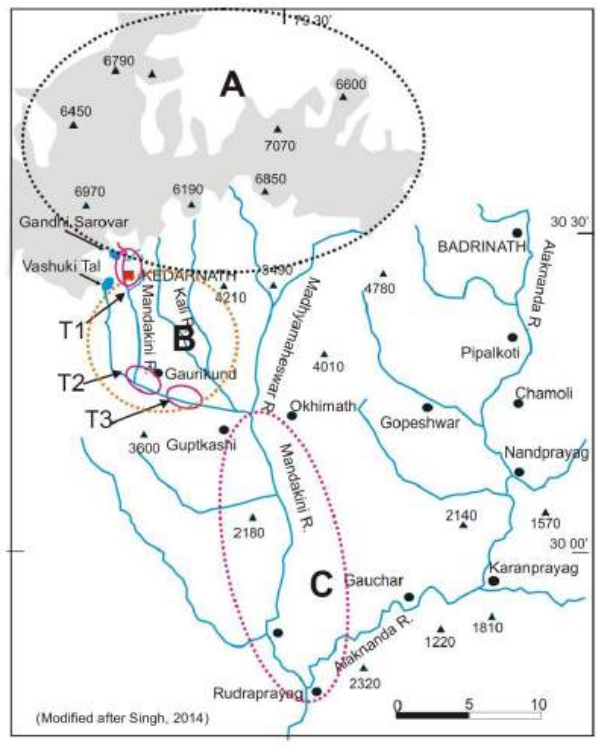


Fig. 3.10: Mandakini valley. Dotted circles A, B and C represent the upper glaciated regime, the middle paraglacial domain and the lower fluvial regime. T1, T2 and T3 are the three major locations where major sediment flux from Kedarnath and adjoining valleys was trapped.

During the DST project visits the following important observations were made:

(i) Chorabari lake (Gandhi Sarovar) is not a proglacial lake. It is only a depression between the right lateral moraine and the valley slope that is filled by snow-melt, rain and some melt water from the glacier.[9]

(ii) A water mark at the southern margin and the exposed lake sediments indicate that prior to the breach the water depth was <10m.

(iii) It is likely that the water depth increased temporarily between June 15-17 due to the heavy rain fall and snow melt, leading to the lake breach around 6.45 am on June 17 2013.

(iv) Prior to the breach, a flood solely caused by excessive rainfall (~325 mm) occurred on June 15-16 2013. It loosened the unconsolidated moraine and alluvial fan deposits around the Kedarnath valley.

(v) Continuing rainfall aided by the lake outburst resulted in the total destruction of Kedarnath town and transportation of large quantities of glaciogenic (moraine) sediments from the upper periglacial zone. The first trapping of the sediments occurred around Kedarnath (Fig. 3.11).

(vi) The sediments laden water flowed down valley causing significant lateral erosion of the steep valley slopes between Kedarnath and Gaurikund

Fig. 3.11: The part of the sediment (dominated by boulders and pebbles) scavenged from the moraines left by the receding glaciers were trapped around gently sloping Kedarnath (T1)

Fig. 3.12: The flood water collected additional sediments from the unstable valley slopes below Kedarnath, which were eventually deposited around Sonprayag (T2). According to local people the river bed was around 30 m deep near the large boulder seen in the picture.

[9] D.P. Dobhal et al. (2013): "Kedarnath Disaster: Facts and Plausible Causes", Curr. Sci., v.105, n.2, July 25, 2013, pp 171-174.

(river gradient 113.6 m/km)[10] thus increasing the bed load sediment concentration. The second major sediment deposition occurred at Sonprayag where the river gradient had decreased significantly (Fig.3.12).

Phata-Byung (76 MW) HEP

Information provided by the developer, M/s LANCO, revealed that rainfall of 200 mm occurred at the site by 8.00 am on June 16th and another 200 mm occurred upto 8am on June 17th. The flood level started rising very rapidly on the 16th morning and by 5.00 pm the dam with its crest at 1635 m was over-topped, because of large boulders rolling down from Rambara and blocking the vents.

Salient Features of the Phata Byung 76 MW HEP

Catchment Area	247.44 km^2
Barrage	26 m high, having 3 bays of 8 m (width) x 11 m (height)
River Bed Level	1611 m
Full Reservoir Level	1635 m
HRT	9.38 km long
Design Drawal	12.5 cumecs
Design High Flood Discharge	1106 cumecs
Underground Power House at Byung	Size 45.4 m x 14.4 m x 33.4 m

The barrage site of this project lies near Sitapur village. Infrastructure works commenced in 2008. The dam with spillway was complete prior to the disaster in June, 2013 but crest gates were not installed and the three bays were fully open.

The highest flood level attained was about 1647 m, about 36 m above the downstream bed at the site. The river bed upstream of the dam was filled up with boulders upto the FRL of 1635 m, thereby fully choking the live storage capacity of 0.5 Mm^3. The inlet to the HRT was also fully blocked. The approximate High Flood discharge conveyed at Phata-Byung was of the order of 2000 cumecs primarily contributed by a peak discharge from the Chorabari LOF amounting to 1597 cumecs. Given that the design flood was only 1106

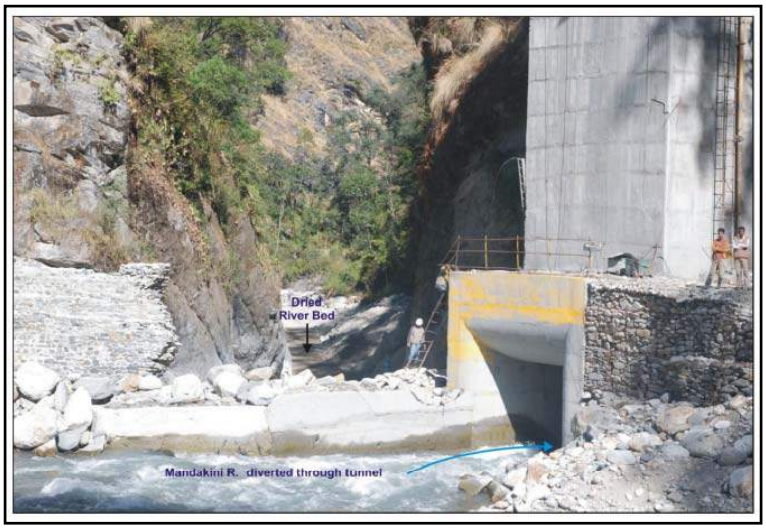


Fig. 3.13: Mandakini river was diverted through a tunnel and the natural river course was virtually dry before the flood of June 2013

[10] S.B. Chapekar & G.N. Matre (1986): Human Impact on Ganga Eco-system: An Assessment, Concept Publishing Company, New Delhi, p. 183.

cumecs, it is clear that a larger spillway capacity was required. Clearly the dam designers had not anticipated the LOF at Choragari.

The EB team noted that the spilled over sediments from Sonprayag were trapped at Sitapur because the outlet of Mandakini at Sitapur is through a very narrow gorge. This gorge section was the site for the barrage. According to project officials in June 2013 the river was flowing through a diversion constructed to facilitate building of the barrage structure (Fig. 3.13). The magnitude of sediments accommodated at Sitapur can be visualized by comparing figures 3.14a and 3.14b. The picture in Fig. 3.14a was taken on June 15, 2013 whereas the one in Fig. 3.14b was after the June 17, 2013.

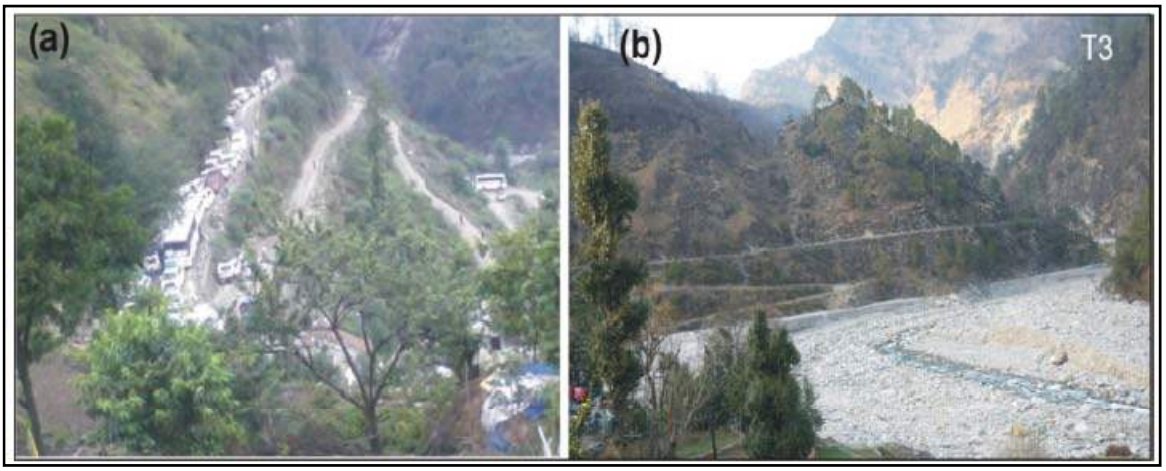


Fig. 3.14: The sediment spilled over from Sonprayag was trapped at Sitapur which served as a vehicle parking space (for Kedarnath yatris) on the bank of Mandakini river (a). Note the magnitude of valley-fill aggradation (b). Note the hairpin bends of the road with vehicles before the flood (a) and without vehicles after the flood (b) gives an idea of the amount of debris being aggraded at Sitapur.

According to local witnesses a temporary lake was formed at Sitapur which swept away the local bus stand with many yatra season vehicles parked there, adjacent houses and hotels and further upstream a bridge on the Sonprayag. The washing away of this bridge was calamitous. Survivors coming down from Kedarnath could no longer simply walk across into Sonprayag. Eventually the flood water over-topped the barrage and flowed downstream.

Considering the magnitude of sediments transported downstream between June 15 and 17, 2013, barrage or no barrage, the river would have eventually got obstructed by the boulders and uprooted tree stumps at the constricted passage downstream at Sitapur. Had the barrage and the diversion not been there it is quite possible that the river would have carried much more bed load further downstream and the maximum flood level would have been lower.

Downstream from Sitapur the concentration of bed load sediments decreases. The sediment pile on the river bed and on its banks begins to increase following the merger of the Kaliganga and Madhyamaheswari rivers with the Mandakini. However, after Kund there is appreciable increase in the river bed sediments.

Singoli-Bhatwari (99MW) HEP on Mandakini

The project construction commenced in 2008 and by 2013 the barrage was 50% complete with 3 bays constructed out of 5. The tunnel was 60% complete over the 10.5 km length. Its concrete lining had not begun. By June 2013 the powerhouse excavation and mat concreting had been done.

The barrage has not suffered major structural damage though about 30 m of the right flank has been scoured. However the rock ledge on which the right abutment would be founded is intact. The powerhouse has been substantially silted up.

According to a presentation by officials of the developer, L&T, a hydrograph of the recorded flood showed that the discharge in the river rose suddenly from about 80 cumecs on June 15 to 1378 cumecs by June 16 morning after which the gauge was washed away. Local water marks indicated that the highest discharge reached on the June 16/17 was of the order of 4032 cumecs. The completed barrage is designed to spill a flood of 4684 cumecs. Therefore the waterway provided for the barrage would be adequate.

Salient Features of the Singoli Bhatwari 99 MW HEP

Catchment Area	963 Km^2
Barrage	22 m high, having 5 vents of 8 m (width) x 11 m (height)
River Bed Level	998.5 m
Full Reservoir Level	1017 m
HRT	11.87 Km long
Design Drawal	59.6 cumecs
Design High Flood Discharge	4684 cumecs
Surface Power House at Bhatwari	Size 79 m x 19.6 m x 37.5 m

The barrage site of this project lies near Kund in the transitional zone between the Lesser and Higher Himalaya. The rocks here are dominated by the Higher Himalayan Crystallines (HHC). The proposed HRT is dug through the HHC.

Here it appears that the vents in the barrage were choked with boulders, sediments and debris. A temporary lake was formed. It is not clear, however, for how long it stayed. Although actual upstream extent needs to be ascertained, morphological features along the river bank, like toe erosion and partial erosion of the tunnel muck that was piled up along the right bank suggest that the ponding extended below Semi village.

The EB team observed major problems of land subsidence at Semi village located below a curvilinear scarp developed on the HHC. Due to land subsidence many houses have developed cracks and are unsafe for living. Based on the limited observations,

however, it is difficult to conclude unequivocally the role of hydropower projects in the subsidence of Semi village. In order to arrive at a definite answer a detailed study is warranted. In the meantime the state government has announced its intention to relocate the village.

As we move downstream from Kund, there appears to be a distinct and different pattern of damage. During the flood, property (built structures) located near the river banks and roads were the worst hit. The Mandakini river gradient drops significantly in this segment to 19.5 m per km.[11]

Studies have shown that under a hyperconcentrated flow regime, when a river is overwhelmed by its sediment supply, it tends to (i) aggrade in stretches where the velocity drops (wide valley expanses/meanders) and (ii) migrate laterally in order to follow a minimum resistance path.[12]. Both these processes cause bank erosion and flooding. Geomorphic expression of this process is visible in the relatively wider segment of Mandakini valley below the Singoli-Bhatwari HEP and between Chandrapuri upto Tilwara.

At several locations complaints were made by local communities that muck dumping by the river banks had aggravated the flood damage. Field observations by the EB team suggest that localized problems may have been caused at dump site I and in the vicinity of the switchyard. Below the under construction power house there was a significant lateral migration in the flow path of the Mandakini river due to a drop in the river gradient and high sediment supply. This could have led to lateral migration and erosion of non-cohesive river banks upto the stretch around Chandrapuri.

At other locations the devastating high flood caused intense erosion/landslides along concave bends. Urban settlements between Agastyamuni-Vijay Nagar and Tilwara and roads segments which were constructed on river borne material (terraces or old debris flows) were washed away due to toe erosion caused by the devastating high flood in the Mandakini river. Even houses which were above the flood level but were built on raised river terraces or old debris flows suffered significant damage.

It may be mentioned here that the extent of property damage in the Mandakini and Alaknanda valleys increased appreciably where the structures encroached the flood plains.

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[11] S.B. Chapekar & G.N. Matre (1986): *Op.Cit.*, p.198

[12] M. Jakob and O. Hungr (2005): Debris flow hazards and related phenomena, Springer-Verlag, Berlin, pp. 733.

Vishnu Prayag (400MW) HEP on Alaknanda

The project has been operational since June 2006. It has a barrage at Lambagar that intercepts runoff from a 1678 km^2 basin and utilizes a significantly high head of 955 m, the highest of any HEP in Uttarakhand. This is a run-of-the river project, with no provision for peaking in the lean season, but utilizes the available flow for power generation.

Salient Features of the Vishnuprayag 400 MW HEP

Catchment Area	1678 km^2
Barrage	22 m high, having 3 bays of 14 m (width) x 18 m (height)
River Bed Level	2261 m
Full Reservoir Level	2275.20 m
HRT	11.34 km long
Design Drawal	50 cumecs
Design High Flood Discharge	2050 cumecs
Underground Power House at Marwari village	Size 79 m x 13 m x 15.5 m

Vishnuprayag HEP has an 11.334 km long HRT ending with an underground power house that houses 4 units of 100 MW each. The barrage impounds a maximum 14 m of water in the non-monsoon months for optimizing generation. Its floor is kept at the original river bed level perhaps to allow sliding down of large bed material.

According to the project officials there is no meteorological record at the project. But Joshimath recorded a total rainfall of 265 mm from June 15 to17, with a maximum of 114 mm in 24 hrs ending on June 17th. The barrage received a massive flood with very large boulders and debris. Starting from a small flood of 155 cumecs at 1.00 am of June 16, the flow increased to almost 2000 cumecs against the design flood of 2050 cumecs on June 17. The maximum flood level attained at the barrage was 2278 m when its 3 bays were fully blocked by large boulders and sediments. The flood scoured a width of 50 m on the left flank at RL 2277 m, washing away site offices, a helipad and a large stretch of the national highway to Badrinath (Fig 3.15).

Courtesy: Ravi Chopra

Fig. 3.15: Circled area on the left flank of the Vishnuprpayag HEP was washed away. (National highway stretch not visible)

Senior officials of M/s Jaypee made a presentation which showed that the Khiro Ganga, a tributary on the immediate upstream right bank debouched a massive load of boulders into the Alaknanda on June 17. It blocked the barrage vents.

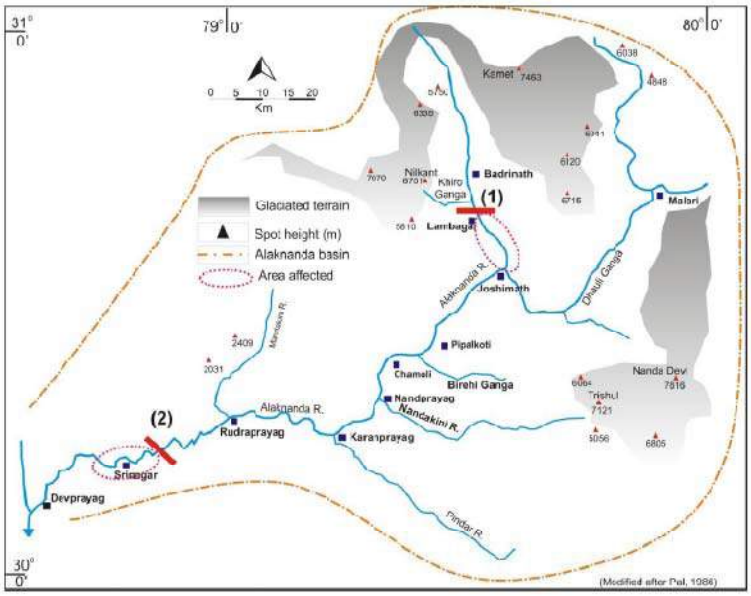

Fig. 3.16: Simplified drainage map of the Alaknanda river. (1) Location of Vishnuprayag hydropower project and (2) Srinagar Hydropower project. Dotted ellipsoid represent the downstream impact during the June 2013 flood

The Vishnuprayag HEP is a classic example for understanding how human structures can modulate river morphology during unusual weather events.

The project is constructed in a paraglacial zone. Since glaciers once existed in the paraglacial zones, these areas are not sediment limited. Plentiful sediments exist, left behind by receding glaciers and the ongoing mass wasting processes. During abnormal monsoons -- as was the case during June 2013 -- violent rainstorms cross over the southern orographic barrier into the Higher and Trans Himalaya where torrential rainfall events significantly increase and trigger extensive erosional processes, i.e., debris flows. Such events

Fig 17: Debris flows at the confluence of Khiro Ganga with Vishnu Ganga near Hanuman Chatti. Vishnuprayag project is located ~1 km downstream from this location

which seem to have decadal recurrence interval play an important role in the overall sediment flux toward the Himalayan foreland.[13] In view of the above phenomena, paraglacial zones in the Himalaya, like the terrain north of Lambagar can be considered as sediment hot spots which are continuously adjusting to changing climatic and environmental conditions.

Khir Ganga originates from the southern flank of the Nilkanth mountain. It is a major tributary which joins the Vishnu Ganga (Alaknanda river) on its right bank below Hanuman Chatti. According to the project officials, during June 15-17 2013 a major sediment pulse in the form of debris flow came from the Khir Ganga valley (Fig. 17). These sediments which have been incised to a depth of 5-10 m pushed the Vishnu Ganga towards the left flank (Fig. 18).

The morphology of the Khir Ganga valley (wide "U") suggests that during the geological past glaciers descended much below their present limit (~4000 m). Satellite images (source Google) indicate the presence of lateral and terminal moraines in the upper catchment of the Khir Ganga valley (between 3500 and 4000 m). Such paraglacial valleys are not sediment limited. In June 2013 abnormal monsoon rain in combination with an over-steepened river course transported the available sediments as debris flow which overwhelmed the river transport capacity. It is likely that during the sediment movement the Khir Ganga got temporarily blocked at a number of places. Breaching such blockades would have transmitted amplified flood surges down the valley in short time intervals. In areas which are not sediment limited, stream flow acquires energy (for downstream transport) by a combination of granular and fluid flow to maintain momentum. As a result large boulders are lifted and transported down valley

Fig 18: Hyperconcentrated sediment laden water was obstructed by the Vishnuprayag barrage which caused a temporary lake. The lake finally breached along the weak debris laden left flank. As a result the sudden sediment laden flood surge caused large-scale damage downstream (Pandukeshwar and Govindghat).

[13] B. Bookhagen, D. Fleitmann, K. Nishiizumi, M.R. Strecker and R.C. Thiede (2006): Holocene monsoonal dynamics and fluvial terrace formation in the northwest Himalaya, India. Geology, 34, 601–604.

due to buoyancy uplift. The affect was compounded due to the presence of barrage at Lambagar which obstructed the free flow of the hyperconcentrated debris flow creating a temporary lake behind the barrage.

Vishnuprayag project officials informed the EB team at Lambagar that a high load of suspended sediment concentration (>2000 ppm) in the wee hours (around 1.30am) on June 16th forced them to suspend power production and open the barrage gates. The EB team was informed that the gates were left open thereafter.

Unfortunately the gates are not designed to bypass the meter-size boulders. Further there is some ambiguity about the ease of operating gates quickly in an extreme event. On June 17th when a major flood pulse arrived at the barrage site, the 8.5 m radial gates were clogged with boulders and debris. Not finding an outlet the flooded river was forced to carve a channel through a minimum resistance path. This was available along the alluvial dominated left flank through which the river gushed out. Shifting to the left flank, it swept away the company's site offices, helipad and a large swathe of the main highway to Badrinath that was excavated through the old and stabilized alluvial fan.

Photo by Dr. Indresh Maikhuri, printed in Down to Earth, March 15, 2014

Once the boulder laden river struck hard rock on the left flank, with its amplified erosive potential, it migrated laterally towards the right bank, eroding the old terrace sediments. In the process the company's structures encroaching the river regime and the local market at Lambagar were destroyed. The geomorphic expression of accelerated erosion and deposition of the flood sediments can be seen by the presence of thick pile of sediments along the relatively wider river section between Lambagar and Govindghat and the narrow segment between Govindghat to Vishnuprayag.

The operation of the barrage during such extreme events leaves a lot of ambiguity as to when the gates should be fully lifted. Without any real time flood forecasting network or an automated weather station upstream and the possibility of massive landslides, the barrage is likely to face severe blocking with the errant monsoon behavior and insurmountable operational difficulty, particularly in June when the snow melt component is very high.

Srinagar (330 MW) HEP on Alaknanda

The Srinagar HEP is an ROR Project. It has a long reservoir (~26 km) with a gross storage capacity of about 78 Mcum. Construction began in 2008 and by June 2013 the civil works were almost complete, except for the turbo-generators trial run.

Flood Disposal: According to the project authorities the dam experienced a massive flood which attained a maximum level of 598 m over the crest. Project officials assessed the peak flood spill as 12,610 cumecs. Table A below was shown as the rise and fall of the flood.

Salient Features of the Srinagar 330 MW HEP

Catchment Area	11100 km^2
Barrage	19 m high, having 8 radial gates of 14 m (width) x 21.15 m (height)
River Bed Level	545 m
Full Reservoir Level	605.5 m
HRT	889 m long
Design Drawal	560 cumecs
Design High Flood Discharge	19200 (26400 ?) cumecs
Surface Power House on right bank	114.25 m x 22.8 m (machine hall)

The HRT leads to a 240 m long desilting basin (DS). A 3.05 km long open power channel takes off from the DS leading to a forebay and the power house. It has 4 units of 82.5 MW.

Table A: Flood spilled through Srinagar HEP

Date	Time	Discharge (Cumecs)
16-06-2013	9 AM	5120
	5 PM	5042
17-06-2013	9 AM	12610
	5 PM	8630
18-06-2013	9 AM	4650
	5 PM	4590

The CWC analysis given earlier indicates a peak flood of ~11,500 cumecs. The highest water level recorded on the spillway crest was 598 m, against an MWL of 609 m at which level, the spillway is capable of disposing of the Standard Project Flood of 19,200 Mcum.

Project officials determined an extremely high sediment concentration of 38000 ppm just downstream of the dam during the flood. (The maximum desired concentration for power generation is 2000 ppm.) The sediment concentration fell to about 24,790 ppm near the power house, about 7.5 km downstream of the dam.

Severe Scour at ITI and SSB: The high flood of 12,600 cumecs caused morphological changes to the river, extending several kilometers downstream of the dam. The river carved out a new course to the right immediately below the dam and kept attacking the

concave bank against the HNB University area scouring 100m of the bank. Deposition of fine sediment upto 7 to 8 m height occurred in Srinagar urban area, where velocity was lower of the order of 3 m/sec.

Role of Srinagar Dam in Flood Moderation and Minimizing Downstream Devastation

The Srinagar reservoir had a storage of 28 Mm^3 of water before the flood. While disposing the flood from about 1,000 cumecs (before June 13), to a peak of 12,600 cumecs the reservoir rose to almost 600 m at the dam thereby storing 37 Mm^3 (from 28 Mm^3 at 585 m to 65 Mm^3 at 600 m, from Area-Capacity Curve). As a consequence significant lowering of the outflow would have occurred when the peak was passing over Srinagar dam on the 17th June.

Local eye witnesses agree that the flow downstream indeed reduced till about 4am on June 17th when the highest level of the reservoir was reached. But thereafter the gates were opened further and the water level was reduced on June 17th at 9am. This led to a high flow and the flushing of downstream muck.

The project authorities said that an estimated 26 Mm^3 of sediments were stored behind the dam. Without Srinagar dam this material would have caused serious silting in Srinagar urban area adding to the damage to buildings in T_0, T_1 terraces.

Geological Analysis

Srinagar hydropower project is located upstream of Srinagar town in the lesser Himalaya (Fig. 3.19). This town was one of the worst hit during the June 2013 flood. The location that was flooded in June 2013 was also affected during the 1894 and 1970 floods. Whereas the earlier events of 1894 and 1970 impacted the entire Alaknanda valley, the June 2013 flood in the Alaknanda valley was focused on two locations, i.e., around Lambagar/Govindghat and downstream of Srinagar barrage till Bagwan.[14]

There are conflicting versions on the role of the hydropower project in aggravating the impact of the flood. Many people in Srinagar believe that the improper disposal of the muck generated by the HEP was largely responsible for raising the river bed and hence flooding the lower reaches of the town, e.g., Shakti Vihar and SSB campus. The rise in the river bed at a few locations below the barrage site is accepted by the dam officials. They ascribe it, however, to the sediments transported from the upper catchment above the barrage. Hence they attribute the sedimentation of lower Srinagar to exogenic sources outside the domain of the Srinagar HEP. A detailed investigation is warranted in order to arrive at a scientifically viable explanation.

[14] N. Rana, Sunil Singh, Y.P. Sundriyal, and N. Juyal (2013): Recent and past floods in the Alakanda valley: causes and consequences. Curr. Sci., 105, 1209−1212.

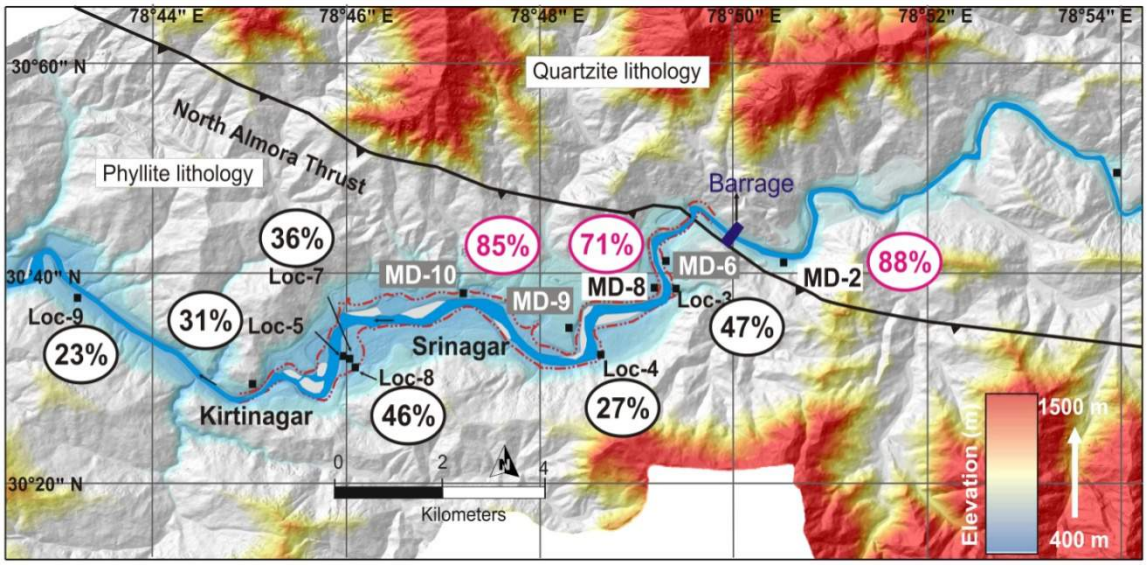

Fig. 3.19: The geochemical analyses of the muck kept at various locations indicate dominance of phyllite rocks. In the flood sediments collected along the course of the river below the barrage indicate that the phyllite contribution (from muck) varies from 47% to 23% implying significant contribution of muck in raising the river bed during the flood thus inundating the lower terraces around Srinagar. Black ellipsoid is the percentage of phyllite in flood sediment. MD is the percentage of phyllite in muck dumping sites.

At the request of the EB Chairman, Dr. N. Juyal, member EB, collected rocks, muck and river sediments upstream and downstream of the barrage. These samples were analyzed by Dr. Anil Shukla at the Physical Research Laboratory (PRL) in Ahmedabad for major element geochemistry in order to determine the contribution of the muck in raising the river bed and the sedimentation of lower Srinagar.

Srinagar valley is dominated by two major lithologies. These are the Quartzites above the the barrage and phyllite downstream of it.[15]As per the Srinagar hydropower project report volume-1, page 4-69, the reservoir extends over the well jointed but competent quartzite and metabasic rocks. There is no problem of slope instability due to draw down. The report, however, categorically states, “The excavated material from open channels and the muck from tunnel excavation have been posing major environmental problems for their disposal. The, muck presently disposed on the river bank without proper site selection and suitable precaution. This is causing addition of silt to the Alaknanda river throughout the year.”

The phyllite dominated muck is unfit for construction purposes. It was generated from digging the tunnel and the canal and power house excavation. The muck was kept at 10 locations along the river bank. Out of these substantial muck erosion occurred at the

[15] R. N. Srivastava and A. Ahmed (1979): Geology and structure of Alaknanda river valley, Garhwal Himalaya. Himalayan Geology 9: 225–254

muck dumping site 9 (university stadium) and 10 near the power house. The Srinagar project officials accept that contribution from the muck also led to raising the river bed.

Based on the CIA determination it was observed that the contribution of phyllite in the river bed sediments between Koteshwar (below barrage) to downstream of Kritinagar varies from 47% to 23% (Fig. 3.19). This implies that there was indeed a significant contribution of muck to inundating the settlements located on the lower terraces at Shakti Nagar and SSB. The project authorities have also stated that the total sediment deposit in the river upto 10.9 km from the dam site was 2.47 Mcum of which around 0.5 Mcum was from the muck erosion.

Geological evidences of past floods (e.g., slack water and palaeoflood deposits) are available in some sheltered locations around Srinagar, Bhainswara and Devprayag. At least 600 years floods history in the Alaknanda valley has been reconstructed.[16] These studies indicate that the 1970 flood was the highest magnitude flood during the last 600 years.

Measuring Muck (Phyllite) Contribution

In order to quantify the contribution of the muck (phyllite), the major compounds and its their derivative called the Chemical Index of Alternation (CIA) was used. Study in the Alakananda valley has shown that major element variability and CIA can be used successfully to differentiate contributions from different sediment sources in a flood sequence.. CIA is a quantitative measure of the extent of chemical weathering a rock or sediment has undergone. ** Its estimation is based on the calculation of the molecular proportion of major compound as shown below.*

$CIA = [Al_2O_3/ (Al_2O_3+CaO+Na_2O+K_2O)] \times 100$

* *Srivastava et. al (2008): "Fashion and phases of late Pieistocene aggradation and incision in the Alaknanda River Valley, Western Himalaya, India", Quaternary Research, v.70, pp 68-80,*

** *H.W. Nesbitt & G.M. Young (1982): "Early Proterozoic climates and plate motions inferred from major element chemistry of lutites", Nature, v.299, pp 715-717*

Detailed field mapping undertaken immediately after June 18, 2013, however, reveals the following:[17]

(i) The June 2013 flood deposits invariably overlie the 1970 flood sediment below the Srinagar project barrage in the Alaknanda valley implying that the June 2013 flood was the highest flood recorded there in the last 600 years. For example the highest flood level at ITI was 536 m during the June 2013 flood against the previous highest flood level of about 533.5 m at the same location.

(ii) But in the upstream segment between Rudraprayag and Joshimath nowhere did the June 2013 flood sediments overtop the 1970 flood sediments which are still

[16] R.J. Wasson, Y.P. Sundriyal, S. Chaudhary, M.K. Jaiswal, P. Morthekai, S.P. Sati and N. Juyal (2013): A 1000-year history of large floods in the Upper Ganga catchment, central Himalaya, India. Quaternary Science Reviews 77, 156−166

[17] N. Rana et. al (2013): *Op.Cit.*

visible at Kaleshwar (Karanprayag), Chamoli, Chinka and at the confluence of Birehi and Alaknanda rivers.

(iii) The June 2013 flood sediments are incised into two surfaces indicating that the flood peak came in two distinct pulses.

Conclusion of Geological Analysis: According to Wasson et al., all the large floods in the Alaknanda river basin appear to be the results of landslide-induced dam bursts rather than glacial lake bursts.[18] These are likely to worsen as the monsoon intensifies due to global warming. Floods generated by the breaching of landslide- induced dams carry very large amounts of sediments that may dominate the sediment yield in the Himalaya.[19] The sediment yields associated with the breaching of landslide induced dams are second only to post volcanic eruption yields but are greater than yields from glacier lake outbursts.[20] The past floods (at least 1894 and 1970) were associated with landslide-induced dam breaching. The June 2013 flood does not belong to such a category.

An Alternate View

Regarding percentage calculation of presence of fillite in the river bed upstream and downstream of Srinagar Dam by Dr. Naveen Juyal, based on CIA method is appreciated, however the quantities of fillite, thus calculated cannot be agreed upon. It is because of the sampling has been done from river bed surface while the total sediment brought down by Mandakini and Alaknanda is the result of various landslides and erosion that has occured in upstream areas. It has been rightly explained & presented in the meetings by Dr Dass by comparing the quantities of deposition in the riverbed and excavated filite from power channel through river X- sections. This shows that large quantities of sediments has been brought by Alaknanda river & its tributries in comparison to very less quantity of excavated muck. It is also to be seen that how much muck was excavated and how much washed away.

- ***Ajay Verma, Member, EB***

It has been demonstrated earlier that deforestation coupled with a cloudburst in the upper Alaknanda catchment was the major factor responsible for the 1970 flood.[21] Commercial deforestation in the region is banned since 1980. Hence deforestation cannot be implicated for the recent flood. Neither can landslide-induced dams be held responsible because their breaching sends short-lived high intensity flood surges into the lower

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18 Wasson et. al (2013): *Op.cit.*

19 D. Brunsden, D.K.C. Jones (1984): The geomorphology of high magnitude-low frequency events in the Karakoram mountains. In K.J. Miller (ed) The International Karakoram Project, Vol. 1, Cambridge University Press, pp 383-388

20 O. Korup (2012): Earth's portfolio of extreme sediment transport events. *Earth-Science Reviews* 112: 115-125:DOI10.1016/j.earscirev.2012.02.006

21 M.M. Kimothi and N. Juyal, (1996): Environmental impact assessment of a few selected watersheds of Chamoli district (Central Himalaya) using remotely sensed data. International Journal of Remote Sensing. 17, 1391-1405.

reaches with enormous sediment loads. This raises an important question about the mechanism for the generation of such large quantities of sediments which were flushed down the rivers of the Alaknanda-Bhagirathi basins between June 15-17, 2013.

On the basis of the foregoing the following conclusions are made:

(i) The massive natural pile of sediments in the upper catchment of the Mandakini valley (around Kedarnath) were largely trapped between Kedarnath and Sitapur. In the lower Mandakini and Alaknanda valleys the landslides-affected slopes are not all that spectacular, for example when compared to those observed during the 1998 Madhyamaheshwar Ganga tragedy near Ukhimath. Therefore it is clear that the sediments were locally generated by a mechanism other than land sliding.

(ii) Downstream from Kund to Tilwara in the Mandakini valley it was sediment bulking caused by a combination of muck and collapse of unconsolidated banks due to lateral migration of the Mandakini river channel under hyperconcentrated flow.

(iii) The Srinagar hydropower project officials appear to have been unable to retain the muck which got washed into the river and assisted in aggravating the damage in the lower reaches of Srinagar town. A significant contribution to the flood sediment was made locally available by the muck disposal sites No.6 to 10 (Fig. 3.19). The geochemical analysis indicate that the phyllite contribution (muck) in the June 2013 flood varied from 47% (proximal to the barrage) to 23% (distal location below Kirtinagar), Fig. 3.19.

Fig. 3.20: Temporal changes in the landscape around Chauras. (a) 2007 when there was no muck dumped at the river bank. (b) 2009 muck dumping in progress and (c) after the flood when a part of the muck and the university stadium ground was washed away.

(iv) Finally can it be a mere coincidence that the maximum destruction of land and property occurred in areas downstream of hydropower projects at Singoli-Bhatwari, Vishnuprayag or Srinagar hydropower project?

The above conclusions reached on the basis of the sediments transport and quantitative geological analysis have been disputed by Dr. Das, Co-Chair, EB. Dr. Das' conclusion is given in the box below. Further details are given in Appendix-3.

Dr. Das' Conclusion

The Srinagar project generated a total muck of 6.69 Mm^3 which was deposited on 10 muck dumping (MD) sites. Out of this 0.859 Mm^3 of muck was generated from excavation of power channel of 3.2 km length. In the power channel phyllite is encountered 0.22 km to 1.05 km and from 1.275 km to 1.475 km. The quantity of phyllite excavated and deposited at MD site 9 (chainage 5.2 km) was around 0.073 Mm^3.

Significant erosion of 0.5 Mm^3 occurred from MD 9 during the 2013 June flood which got conveyed with the torrential flood. The MD 9 site being on the concave bank was severely attacked by the highly intense velocity of 7m/sec. and a 10 to 12 m deep flow.

It has been stated that the sediment concentration at Supana bridge which was as high as 38230 ppm got reduced to 24790 ppm at power house (PH) site, which means significant deposition on the left bank would have occurred.

It is important to note that the river flows along a convex bend from 3 km upstream of PH location to about 5 km downstream. Thus 8 km of urban area was impacted by the sediment laden flow. That a convex bank is a deposition zone is well known. The deposited material on the urban stretch came from the suspended sediment mostly from landslides and bank erosion of the Mandakini and Alaknanda. The eroded muck got transported along with the high flood.

Because of the slack zone in the convex bend massive deposition occurred. While recognizing that fine to coarse phyllite will move with flow, it is definite that phyllite would deposit in a short distance below chainage 5.2 km. The overall deposition quantity in urban area is 1.2 Mm^3 up to PH site and another 1.3 Mm^3 up to ITI totaling 2.5 Mm^3, attributable to flow changing its path from right bank to left bank. Since the quantity of 0.073 Mm^3 of phyllite is only 3% and the total muck eroded is 20% of the deposition on Srinagar terraces, it is obvious that the role of phyllite eroded and visible on the urban stretch of the deposition is minimal in damages caused by the tragedy.

From the logic that deposition occurs on the convex bend, it is definite that even in the absence of the Srinagar project, massive deposition would have occurred on the lower terraces of the Srinagar urban area from the suspended sediments, which was extremely high (38230 ppm) before the flood negotiated the project area. The deposition was accentuated because of buildings obstructing the flow on the convex overland area.

The higher the flood, the larger is the sediment deposition which becomes exponentially higher. Alaknanda experienced 12600 cumecs devastating flood against the highest of 4500 cumecs in the last 50 years and hence the unusual 3.5 meter deposition.

Recommendations

The foregoing report reveals serious shortcomings in the state-of-readiness of projects' authorities to tackle the floods emergency. To cite a few examples:

1. Phata-Byung HEP was under-designed. It was only designed for a 1 in 50 years flood of 1106 cumecs, woefully short of the actual 2000 cumecs.

2. Singoli-Bhatwari HEP lost its gauging equipment on June 16th and had no recorded discharge data thereafter.
3. Vishnuprayag HEP did not have a weather station of its own.
4. There was ambiguity regarding gates operation at Vishnuprayag and Srinagar HEPs between what the project authorities reported and what local eye-witnesses said.

The EB did not have an opportunity to examine Disaster Management Plans of any of the projects. But it is doubtful if these were used in June 2013, or if they were, whether they were effective. DMPs need to be an integral part of EIA Reports. The DMP needs to be carefully reviewed and approved by local communities in the probable zone of influence also.

For the operation of the Tehri dam to safely meet the objective of flood moderation, particularly during the later part of the monsoon, can only be done by installation of a Real Time Flow Forecasting Network which would transmit hydrometeorological data to enable forecast of inflow into Tehri reservoir at least 12 to 18 hours in advance.

Such a forecast is also required for advance information on the contribution of Alaknanda at Devprayag and of the basin below Devprayag to Haridwar. This is only possible by analysis of real time data which Tehri dam authorities must get. It will enable decisions on appropriate releases so as to prevent synchronisation of Bhagirathi (Tehri release) and Alaknanda floods. Until such time Tehri reservoir level should be around 825 m in the mid-September to be filled up judiciously from the receding monsoon flow.

Disaster preparedness is critical because all of Uttarakhand lies either in seismic Zone IV or V. These are the most vulnerable to strong earthquakes. A recent study from the National Geophysical Research Laboratory, Hyderabad shows that seismicity has increased in the North Almora Thrust after the filling of the Tehri dam reservoir.[22]

Muck management is a crucial issue. Current practices need to be reviewed and technically sound and ecologically sustainable ways of muck management in Uttarakhand have to be proposed to protect the people and the terrain from a June 2013 type of situation.

Learning lessons from the 2013 calamity it is important to take note of the heavy bed load in the rivers during floods while designing the structures. It will be useful to carry out model studies of structures across the rivers to develop a prior understanding of river behavior after construction and particularly during massive floods.

- ***Ajay Verma, Member, EB***

The river bed profiles at Phata-Byung, Singoli-Bhatwari, Vishnuprayag and Srinagar HEPs have changed significantly. This requires a fresh analysis of the project hydrology and redesigning them if necessary.

[22] Gupta et al. (2012):

All projects must undertake restoration works after prior clearance from MoEF. It was noticed that project developers were engaged in projects' restoration only. MoEF needs to conduct a formal review of the environmental damages at all the HEPs in Uttarakhand and prepare guidelines for restoration. Till then none of the projects should begin power production.

Chapter 4

ToR 2.2

ToR 2.2 Examine as observed by Wildlife Institute of India (WII) in its Report, as to whether the proposed 24 projects in Uttarakhand are causing significant impact on the biodiversity of Alaknanda & Bhagirathi river basins.

4.1 Introduction

The Hon'ble Supreme Court had directed the Expert Body to examine whether the 24 hydropower projects as observed by WII in its Report caused significant impacts on the biodiversity of Alaknanda and Bhagirathi basins.

During a meeting of the Expert Body (EB) held at UJVNL office in Dehradun on 05.12.2013, a critique of WII's Report was presented by Dr. Sabyasachi Dasgupta, HNB Garhwal University and consultant to UJVNL. His comments largely pertained to the short duration of the study, a shortcoming discrepancy in the form of non availability of data on forest land area that would be impacted by some HEPs and a few inconsistencies in the tables of the report. WII's responses to the comments made by UJVNL were circulated to all members of the Expert Body and accepted.

The Expert Body requested WII to make a presentation of its report. It was done by Dr. V.B. Mathur, Dean, WII on 07.01.2014. After deliberations, the Expert Body decided to get the WII report reviewed by an independent expert and accordingly requested Prof. Brij Gopal, an eminent ecological scientist who had worked extensively on river ecosystems.

In his review, Prof. Gopal mentioned that the methodology adopted by WII had certain limitations (See Appendix 7a). But he agreed with WII's findings that the 24 proposed hydropower projects would impact the biodiversity of Alaknanda and Bhagirathi basins significantly. He added that WII could have gone further in its recommendations. Based on his own analysis, Prof Gopal recommended that several more projects should be dropped.

Later, another detailed presentation specifically on the significant impacts on biodiversity due to the 24 proposed projects was made on 19.02.2014 by Dr. S.Sathyakumar, Scientist and Member of the Committee.[1]

Biodiversity profile of Uttarakhand

The state of Uttarakhand is well recognised for its rich natural resources and varied ecosystems, both terrestrial and aquatic. Four major rivers flowing through north India originate from the higher elevations of this Himalayan State, *viz.*, Ganga, Yamuna, Ramganga and Sharada.

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[1] The 'proposed projects' refers to those projects that were still on the drawing board and ideally meant that no work was initiated at the field site during the period December 2010 to March 2012 when WII carried out its study.

Uttarakhand is endowed with a rich and diverse array of forest types from tropical to alpine. The major categories of forests in the State include:

(i) Tropical Moist Deciduous Forests in the Terai and Bhabar tracts dominated by Sal (*Shorea robusta*) and associates.

(ii) Subtropical Pine Forests with Chir Pine (*Pinus roxburghii*) as the dominant species are primarily found in the lower regions (< 2,000m above mean sea level) of the Himalaya.

(iii) Himalayan Moist Temperate Forests occurring between 1,600 and 2,900 m are further divisible into temperate broad leaved and conifer forests. Broad leaved forests are dominated by one or other species of oak (*Quercus* spp.), maple (*Acer* spp.) and associated species, while the coniferous species are *Cedrus deodara, Picea smithiana, Abies* spp, and *Pinus wallichiana;*

(iv) Sub-alpine Forests occur between 2,900 m and 3,500 m characterised by high altitude oak (*Qurecus semecarpifolia*), birch (*Betula utilis*) and rhododendron. The vulnerable 'tree line' is formed by alpine scrub comprising of stunted and dwarf rhododendrons interspersed by alpine meadows locally called "*Bugyals*" that extend up to the perpetual snow line.[2]

The mammalian diversity of Uttarakhand represented by more than 85 species is one of the richest in the country. Some of the threatened or vulnerable mammals in the State include snow leopard (*Panthera uncia*), Himalayan brown bear (*Ursus arctos isabellinus*), Asiatic black bear (*Ursus thibetanus)*, Tibetan wolf (*Canis lupus chanko*) and Musk deer (*Moschus* spp.).[3] It is estimated that about 650 species of birds (51% of India's avifauna) occur within the State. Some of the threatened birds in the State include Western Tragopan *(Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichi*) and Sarus Crane (*Grus antigone*). The reptile diversity in Uttarakhand encompasses over 60 species including crocodiles, turtles, tortoises, snakes and lizards.[4] The State of Uttarakhand which is a home for many perennial rivers of the country also has a good fish diversity represented by about 125 species.[5]

Protected Areas of Uttarakhand: The State has considerable area (13.68% of its geographic area) under a protected area network as compared to the national average of 4.8%. There are six National Parks, six Wildlife Sanctuaries, one Biosphere Reserve, and two Conservation Reserves. The Nanda Devi National Park (NP) and Valley of Flowers NP have been inscribed on the UNESCO's World Heritage List. In

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[2] A. Rajvanshi, et. al (2012): Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand, Wildlife Institute of India, Technical Report. pp 203 plus Appendices.

[3] A. Rajvanshi, et. al (2012): *Op.Cit*

[4] K. Vasudevan & S. Sondhi (2010) Amphibians and Reptiles of Uttarakhand, India. Wildlife Institute of India, Dehradun. 94 pp.

[5] S.P. Badola (2001): Ichthyology of Central Himalaya, Transmedia Publisher, Srinagar (Garhwal).

terms of floral wealth, the State harbours about 4,500 species of vascular plants, of which 116 species are endemic.[6]

The Bhagirathi and Alaknanda river basins represent two important riparian ecosystems that have significantly contributed to the richness of the biodiversity of the State. Many species of flora and fauna fall under the RET category *i.e.*, rare, endangered and threatened. These two river basins encompass a wide range of habitats that are home to over 1000 plants (55 RET species), 85 mammals (5 RET), 530 birds (6 RET) and 76 fishes (16 RET). In addition to this, there are 24 RET species of herpetofauna (7 turtles, 6 lizards, 10 snakes, 5 amphibians) in the two basins.

Three National Parks, viz., Nanda Devi, Valley of Flowers, Gangotri, the Kedarnath Wildlife Sanctuary, and substantial portions of Nanda Devi Biosphere Reserve fall in these two basins. Most importantly, the edges of the distribution range of three highly endangered species occur in these two basins viz., (i) snow leopard with its south western most distribution in Uttarakhand ending in the upper reaches of Alaknanda, Bhagirathi and Dhauliganga basins, (ii) the Himalayan brown bear's eastern most distribution in India ending in Dhauliganga (W) and (iii) The Western Tragopan's eastern most distribution in India ending west of Mandakini river.

While most of the biodiversity values are well protected in the protected areas, there are many areas outside protected areas that are very rich in biodiversity values and/or are critically important wildlife habitats that connect protected areas or act as corridors for the movement of large mammals such as leopards, bears and other carnivores. Similarly, there are two rain-fed rivers, *viz.*, Nayar and Balganga that are critical for fish conservation as they are the only breeding areas left intact in the wild for migratory fishes such as the mahseer.[7] The wildlife protected areas and the critical wildlife areas identified for wildlife in different sub-basins of Alaknanda and Bhagirathi along with locations of commissioned, under-construction and proposed HEPs are shown in Figure 4.1.

4.2 Significant Impacts on Biodiversity Values

In the Alaknanda and Bhagirathi basins, 17 HEPs have been commissioned with a total installed capacity of 1851 MW; 14 projects of 2538 MW capacity are in different stages of construction and 39 projects with an installed capacity of 4644 MW are in different stages of planning. WII in its Cumulative Environmental Impact Assessment study had mentioned that five scenarios could be used to improve upfront the process of decision making and forward planning of the hydropower sector. These scenarios distinctly present options to decision makers in respect of approval or relocation of HEPs based on potential risk to biodiversity values and reflection, if required. The scenarios also provide adequate basis to make decisions with respect to

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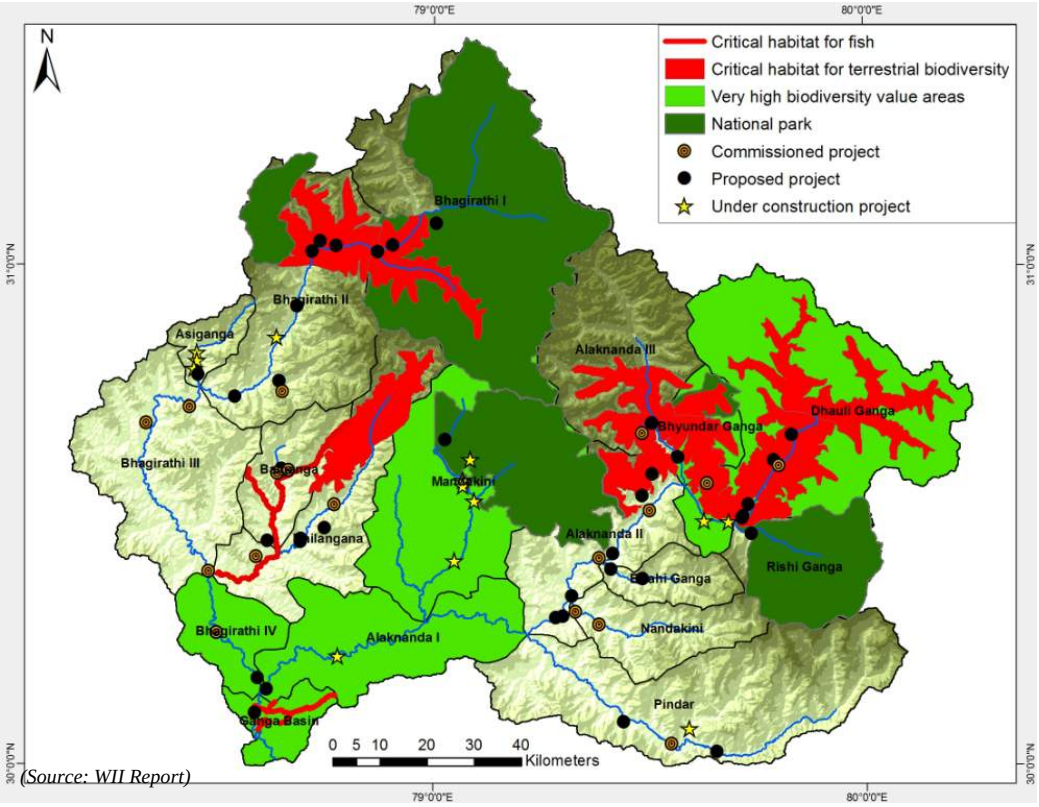
[6] S.K. Srivastava and D.K. Singh (2005): Glimpse of the plant wealth of Uttaranchal, Bishen Singh and Mahendra Pal Singh, Dehra Doon, p.35

[7] A. Rajvanshi, et. al (2012): *Op.Cit*



(Source: WII Report)

Fig. 4.1: A map of Alaknanda and Bhagirathi Basins showing the river sub-basins, protected areas, critical wildlife habitats, areas of high biodiversity value and locations of the 70 Hydropower Projects

applying 'exclusion approach' across the two basins for securing key biodiversity values in key biodiversity sites, critically important habitats and designated protected areas.

For acceptable outcomes from hydropower development for biodiversity conservation and societal well-being, WII recommended that 24 proposed projects may be reviewed for combined benefits of reducing impacts on both, aquatic and terrestrial biodiversity. The significant impacts of these 24 proposed HEPs, which lie in 13 sub-basins of the Alaknanda-Bhagirathi basin, on biodiversity values are outlined below sub-basin wise.

1. Bhagirathi Sub-basin I (Areas above Bhagirathi- Jadhganga confluence)

This sub-basin is drained by the Bhagirathi and its main tributary, Jadhganga encompasses the Greater Himalaya, Trans-Himalaya, and the transition zones between the Greater and Trans-Himalaya. This sub-basin is well recognized for its high landscape values. Temperate forests, temperate scattered tree and scrub habitats, subalpine forests and scrub, alpine scrub and meadows, moraines and glaciers characterise this sub-basin. The entire catchment of Bhagirathi forms the Gangotri National Park including a considerable stretch of snow-clad mountains and glaciers. The National Park area forms a viable continuity between the Govind NP and the

Kedarnath Wildlife Sanctuary located in Alaknanda Basin. High ridges, deep gorges and precipitous cliffs, rocky craggy glaciers and narrow valleys characterize the area.

RET species include 5 mammals, 1 bird and 8 plants. This sub-basin encompasses ideal habitats for snow leopard, brown bear and musk deer. It holds good populations of blue sheep, the main prey of snow leopard. The Bhagirathi I sub-basin supports large alpine grasslands with more than 170 species of flowering plants which provide an excellent habitat for Himalayan brown bear and Himalayan musk deer.

Two proposed HEPs are located on river Jadhganga within this sub-basin namely, Karmoli (140 MW) and Jadhganga (50 MW). The Zone of Influence of Karmoli and Jadhganga projects fall within the Gangotri NP and would cause irreversible impacts on flora and fauna. In addition, the entire sub-basin is a part of the Eco-Sensitive Zone[8] (ESZ) notified by the Ministry of Environment and Forests, Government of India based on the recommendations of the National Ganga River Basin Authority (NGRBA) and hence no projects above 2 MW can be allowed there anymore. These two projects fall within the Gangotri ESZ notified by MoEF.

In its report WII gives this basin a high terrestrial biodiversity value and medium aquatic biodiversity value.

2. Bhagirathi II sub-basin (From Bhairongati to Asiganga confluence)

This sub-basin falls in the high and mid elevation Himalayan ranges and encompasses wildlife habitats such as Himalayan moist temperate forests, coniferous and moist mixed forests and scrub habitat, alpine scrub and meadows. There are many critically important wildlife habitats in this sub-basin that connect protected areas Govind NP and WS to Gangotri NP and act as corridors for the movement of large mammals such as leopards, bears and other carnivores. RET species include 3 mammals, 4 birds, 10 plants and 4 fishes. This sub-basin has wildlife habitats that are critical for the highly endangered western tragopan, musk deer and cheer pheasant. HEPs such as Maneri Bhali I (90 MW), Maneri Bhali 11 (304 MW) and Pilangad (2.25 MW) are commissioned and four more HEPs are proposed in this sub-basin *viz*., Bhairon Ghati (381 MW), Kakoragad (12.5 MW), Siyangad (11.50 MW) and Jalandharigad (24 MW). The under construction Lohari Nagpala HEP (600 MW), Pala Maneri (400 MW) and the proposed Bhairon Ghati (381 MW) were specifically cancelled by NGRBA.

The threatened species of fishes recorded from this basin are golden mahseer (*Tor putitora*), snowtrout (*Schizothorax richardsonii*), and stone suckers (*Garra gotyla gotyla* and *Gara lamta*). This sub-basin serves as a migratory route for golden mahseer and snow trout, whose abundance has now become very low. It is also infested with invasive brown trout, which appears to be expanding its range in this sub-basin due to barriers downstream. On account of the presence of existing dams

[8] National Ganga River Basin Authority and Ministry of Environment and Forests, Government of India order dated December 2012

across Bhagirathi River near Uttarkashi, the upward movements of mahseer and snow trout species have also been reduced or stopped.

Three proposed HEPs, Jalandharigad, Siyangad and Kakoragad are all located on small streams that fall within important wildlife habitats connecting Protected Areas and also fall within the ESZ notified by MoEF. They will cause significant impacts on flora and fauna of Gangotri NP and also the critical wildlife habitats that connect PAs. Because of the ESZ now, none of these projects can be taken up.

Overall, WII gives this basin a high terrestrial biodiversity value and high aquatic biodiversity value in its report.

3. Bhagirathi IV sub-basin (From Bhagirathi-Bhilangana confluence to Devprayag)

It falls in the lower Himalaya and has patches of riverine habitats along the river and mixed sub-tropical forests in the middle and higher slopes. Anthropogenic pressures and developmental activities in the whole sub-basin have resulted in degradation of forested habitats. RET species include 2 mammals, 3 birds, and 12 fishes. Two HEPs are proposed in the sub-basin namely, Kotlibhel IA (195 MW), and Tehri stage II (1000 MW). Tehri stage 1 (1000 MW) and Koteshwar (400 MW) are commissioned HEPs.

The Bhagirathi IV sub-basin harbours 63% of the total fish species in the study area and 12 out of the 16 threatened species in the two major basins. It is also home for two endemic species such as *Glyptothorax garhwali* and *Glyptothorax alaknandi*. Due to Tehri I and Koteshwar the fish habitats and populations are now fragmented. The stretch from Koteshwar to Devprayag is the only remaining stretch available in Bhagirathi where fish migrations are now occurring and the population is connected to fish population in the Ganga. The Kotlibhel 1A HEP would a have high impact potential on fish fauna and fish habitats.

WII gives this basin a high terrestrial biodiversity value and very high aquatic biodiversity value in its report.

4. Balganga sub-basin (Balganga valley)

The Balganga sub-basin is drained by the Balganga river and its tributary Dharamganga that joins Balganga at Budhakedar. This sub-basin falls in the middle and greater Himalayan ranges and is a broad valley with many lakes and glaciers in the higher altitudes. Habitats such as temperate mixed forests, temperate scattered tree and scrub with open grassy slopes, pine forests are present in this sub-basin including patches of riverine forests along the Balganga.

RET species include 3 mammals, 4 birds, 5 plants and 11 fishes. It harbours "high" fish biodiversity value largely due to the presence of breeding/congregational sites and migratory pathways for species such as golden mahseers and snow trouts which have great conservation value.

A total of 38 species of fishes, which include 24 restricted range species and 11 threatened species have been recorded in this sub-basin. These include: golden mahseer, black mahseer (*Tor chilinoides*), snow trout, stone suckers, hillstream catfish (*Glyptothorax telchitta*, *Glyptothorax caviai*), barbs (*Chagunius chagunio*), hillstream loaches (*Nemacheilus multifasciatus* and *Pseudecheneius sulcatus*). This river is one of the critically important habitats for mahseers and snow trouts which occurs in Tehri Dam and associated rivers. Many migratory species congregate along the rivers for breeding especially after the monsoon.

In this sub-basin, there is one existing HEP, i.e, Agunda Thati (3 MW) on Dharmganga. Two HEPs, Balganga II 7 MW) and Jhalakoti (12.50 MW) are proposed on Balganga and both will have significant irreversible adverse impacts on fish fauna and their habitats. This is one of the two rain-fed rivers that encompass critical breeding habitats for fish in the Bhagirathi Basin. This river has also been identified as a river to be maintained in 'pristine condition' by the IMG and is also proposed as a Fish Conservation Reserve.[9]

In its report WII gives this basin a high terrestrial biodiversity value and high aquatic biodiversity value.

5. Mandakini sub-basin (Mandakini valley)

A collection of waters from Son Ganga, Kali Ganga, Mandani Ganga, and Madh Maheshwar Ganga, the River Mandakini is one of the main tributaries of Alaknanda. The sub-basin extends from middle to the high Himalayan ranges and encompasses subtropical mixed and chir pine forests at the lower elevations (Rudraprayag), temperate forests with tree and scrub in the middle elevations, progressively rising to oak and coniferous mixed sub-alpine forests, alpine scrub and meadows, moraines, glaciers and high altitude lakes in the higher elevations.

RET species include: 5 mammals, 5 birds, 10 plants and 8 fishes. This sub-basin forms the eastern most distribution limit for the endangered western tragopan and is home for endangered mammals such as snow leopard, common leopard, brown bear, black bear and most importantly the musk deer and other mountain ungulates and pheasants. The higher reaches of this sub-basin fall within the Kedarnath WS. This sub-basin serves as a breeding habitat for mahseers and it is reported that during monsoons mahseers from Alaknanda migrate up to Mandakini river for breeding. The proposed Rambara HEP (76 MW) falls within the Kedarnath WS.

WII gives this basin a very high terrestrial biodiversity value and high aquatic biodiversity value in its report.

6. Alaknanda I Sub-Basin (Devprayag to Karnaprayag)

This sub-basin is drained mainly by Alaknanda River and its major tributary Mandakini that joins the Alaknanda at Rudraprayag. It mainly falls in the lower to

[9] A. Rajvanshi, et. al (2012): *Op.Cit*

middle Himalayan ranges and has high ridge mountains and a number of side valleys in its catchment. This sub-basin has subtropical mixed forests, pine in the lower elevations and temperate forests in the higher elevations.

RET species include: 2 mammals, 4 birds, 1 plant and 12 fishes. The Alaknanda I sub-basin harbours 64% of the total fish species in the study area. This sub-basin supports about 49 species of fishes, including 2 endemic species namely *Glyptothorax alaknandi* and *Glyptothorax garhwali*. These two species occur only in the upper reaches of the Ganga. It also has 12 threatened species *viz.* golden mahseer, black mahseer, snow trout, stone suckers, hillstream catfish, barbs, and hillstream loaches. It also has 31 restricted range species. This sector of the river is a major migratory route for golden mahseer and other migrants.

The stretch from Devprayag to Srinagar and downstream to the Ganga is the only remaining stretch available in Alaknanda as the under-construction Alaknanda - Srinagar HEP would fragment fish populations in Alaknanda. The Kotlibhel 1B HEP (320 MW) has high impact potential on fish fauna and fish habitats as it will further fragment the Devprayag to Srinagar stretch.

Overall, WII gives this basin a high terrestrial biodiversity value and very high aquatic biodiversity value in its report.

7. Alaknanda II Sub-basin (Karnaprayag to Vishnuprayag)

In this sub-basin receives tributaries such as the Kalpganga, Birahi Ganga, Mandal, Nandakini and Pindar rivers drain into the main Alaknanda River. The sub-basin encompasses subtropical mixed and chir pine forests at the lower elevations, temperate forests and scrub in the middle elevations (near Vishnuprayag) and oak and coniferous mixed sub-alpine forests, alpine scrub and meadows in the higher elevations (Tungnath, Rudranath regions). Some high altitude areas of this sub-basin fall within the Kedarnath WS.

RET species include 2 mammals, 4 birds, 6 plants and 5 fish. Endangered mammals such as snow leopard, common leopard, brown bear, black bear, musk deer, other mountain ungulates and endangered birds such as cheer pheasant and monal are reported to occur in this sub-basin**.** The power house and TRT of Vishnuprayag HEP (400 MW) on Alaknanda and Urgam (3 MW) on Kalpganga are located in this sub-basin. The zone of influence of the proposed Urgam II HEP (3 MW) falls within critical wildlife habitats connecting Protected Areas.

In its report WII gives this basin a high terrestrial biodiversity value and high aquatic biodiversity value.

8. Alaknanda III Sub-Basin (Origin to Vishnuprayag)

The stretch of Alaknanda from its origin up to its confluence with Dhauliganga falls in this sub-basin. Tributaries such as Khironi Ganga and Bhyundar Ganga drain into the Alaknanda. A major proportion of this sub-basin falls within the

buffer zone of Nanda Devi Biosphere Reserve and includes habitat for several RET and other species of high conservation significance. RET species include 5 mammals, 1 bird, and 8 plants. Endangered mammals such as snow leopard, common leopard, brown bear, black bear, musk deer and endangered birds such as cheer pheasant and monal occur in this sub-basin**.** There are two existing HEPs in this sub-basin, i.e., Badrinath II (1.25 MW) and Vishnuprayag HEP (400 MW).

The proposed Alaknanda-Badrinath HEP (300 MW) and Khironi Ganga HEP (5 MW) are not only located in the buffer zone of Nanda Devi BR in the stretch between Vishnuprayag and Badrinath, but also fall within 10 km of the Valley of Flowers NP, a World Heritage Site. These HEPs fall in the critical wildlife habitats connecting Protected Areas such as Kedarnath WS and Valley of Flowers NP. Any further developmental activities in the form of proposed HEPs on the rivers Alaknanda and Khironi Ganga would have significant irreversible impacts on the wildlife values of this sub-basin. These HEPs will seriously hamper the movement of species such as snow leopard and brown bear in Nanda Devi BR as this is the only remaining stretch that is an important corridor for movement of these species.

In its report WII gives this basin a high terrestrial biodiversity value and medium aquatic biodiversity value.

9. Bhyundar Ganga Sub-Basin

The main river of the Bhyundar sub-basin is the Bhyundar river that is recognized by this name from the point where the Pushpawati river originating in the Valley of Flowers NP and Lakshman Ganga originating in the Lokpal lake meet and later flow down through the Bhyundar Valley for about 15 km to join the Alaknanda at Govindghat.

This sub-basin is a small narrow valley with steep terrain. A major proportion of this sub-basin falls within the buffer zone of Nanda Devi Biosphere Reserve and includes habitats of several RET and other species of high conservation significance. RET species include 5 mammals, 4 bird, and 21 plants. Endangered mammals such as snow leopard, common leopard, brown bear, black bear, musk deer and endangered birds such as monal occur in this sub-basin.

The Valley of Flowers NP is a UNESCO World Heritage Site (WHS) that is well recognized for its ‘exceptional beauty, floral biodiversity and aesthetic values’. In order to preserve these ‘outstanding universal values’ (OUVs) of this NP, Uttarakhand has declared a buffer zone which is also required to be conserved and sustainably used as the integrity of the WHS is very much dependent upon the integrity of the buffer zone also. Numerous developmental activities and disturbances in the buffer zone are a serious threat to the maintenance of the OUVs of the WHS and may lead to listing of the WHS in the ‘danger list’.

The Bhyundar HEP (24 MW) is located within 10 km from the Valley of Flowers NP and also falls in the critical wildlife habitats connecting Protected Areas

such as Kedarnath WS and Valley of Flowers NP. Approval for the construction of this HEP must also come from the National Board for Wildlife.

WII gives this basin a very high terrestrial biodiversity value and low aquatic biodiversity value in its report.

10. Dhauliganga Sub-Basin

The River Dhauliganga originates from the high peaks along the eastern border of Chamoli District (also the international border) and runs south west to join Alaknanda near Joshimath. The sub-basin encompasses Greater and Trans-Himalayan regions and has high habitat diversity ranging from temperate forests, scattered tree and scrub in lower elevations to subalpine forests, alpine scrub and meadows, glacier moraines, trans-Himalayan scrub and grasslands in the higher elevations.

The uniqueness of this sub-basin is the gradual transition from Greater Himalayan elements to Trans-Himalayan elements. RET species include 5 mammals, 5 bird, and 14 plants. Important mammals and birds that are reported to occur in the sub-basin are snow leopard, common leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow, Himalayan monal and raptors. Typical Trans-Himalayan fauna that occur in this sub-basin include snow leopard, Tibetan wolf, Tibetan woolly hare and Himalayan marmot. Snow leopard was photo-captured many times in this sub-basin.

Four HEPs, *viz*., Malari-Jhelum (114 MW), Jhelum-Tamak (126 MW), Tamak-Lata (250 MW) and Lata-Tapovan (170 MW) are proposed in this basin. The entire sub-basin forms the buffer zone of Nanda Devi BR and contains habitats and corridors for RET and other species that are of high conservation significance. The rare and endangered Himalayan brown bear has its eastern most distribution limits in this sub-basin. In addition, this sub-basin is critical for the highly endangered snow leopard, the apex predator in this high altitude ecosystem.

Long distance movements across this sub-basin are extremely critical for these highly endangered large carnivores. These HEPs fall in the critical wildlife habitats connecting the two core zones and WHSs, Valley of Flowers NP and Nanda Devi NP. The proposed HEPs will lead to irreversible impacts on the wildlife values of this sub-basin, particularly hindering movement paths of large carnivores such as snow leopard and brown bear in this sub-basin. Further, numerous developmental activities and disturbances in the buffer zone are a serious threat to the maintenance of the OUVs of the Nanda Devi WHS.

Overall, WII gives this basin a very high terrestrial biodiversity value and medium aquatic biodiversity value in its report.

11. Rishiganga Sub-Basin

The river Rishiganga originates at the base of Nanda Devi west peak (7817m) and flows northwest to join Dhauliganga at Reni village. This area lies within the Nanda Devi NP and its buffer zone, which was inscribed as a UNESCO World

Heritage Site due to its 'Outstanding Universal Values'. This region encompasses the temperate, subalpine, alpine habitats and many glaciers.

This sub-basin is very rich in flora and fauna particularly RET species and many of the RET species occur in high densities in this NP when compared to other PAs in the Western Himalaya. RET species include: 4 mammals, 5 birds and 15 plants. The Nanda Devi NP has remained closed to human activities since 1983 with exception of limited community based ecotourism only to some portions of the NP. This NP is a control site for monitoring long-term natural changes and field surveys are carried out only once in every 10 years.[10]

The Rishiganga (13.20 MW) is under construction on Rishiganga near the Reni bridge. Two HEPs viz., Rishiganga I (70 MW) and Rishiganga II (35 MW) are proposed in this sub-basin within the Nanda Devi NP. These two HEPs would have very significant and irreversible impacts on the wildlife values of the Nanda Devi NP WHS. The Outstanding Universal Values of this WHS would be threatened if these two HEPs are constructed.

WII gives this basin a high terrestrial biodiversity value and medium aquatic biodiversity value in its report.

12. Birahi Ganga Sub-Basin

The sub-basin consists of Trishul and Nandaghunti rivers, flowing east-west to form the Birahi Ganga, which finally joins with Alaknanda near *Pipalkoti*. This area encompasses subtropical mixed and chir pine forests at the lower elevations (<2000m), temperate forests and scattered tree and scrub in the middle elevations (2000 – 2500m) and oak and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations.

RET species include 3 mammals, 5 birds and 4 fishes. This sub-basin is very important as several species especially snow trout, *Schizothroax* spp. move into this river to breed. It was observed that snow trouts from main Alaknanda River move up near Vishnuprayag but due to steep slope they do not further move upward but return and then move to Birahi Ganga for breeding. Many RET and scheduled species *viz.* snow leopard, common leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow, Himalayan monal and raptors are found here.

While Birahi Ganga HEP (7.30 MW) is already commissioned, three more HEPs, viz., Birahi Ganga I (24 MW), Birahiganga II (24 MW) and Gohana Tal (50 MW), all on Birahi Ganga have been proposed. Birahi Ganga I and II HEPs would have high impact potential on aquatic wildlife values as the Birahi serves as breeding grounds for migratory fishes such as snow trout. Apart from this, the upper reaches of Birahi sub-basin form a part of Nanda Devi BR and have several RET species.

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[10] S. Sathyakumar (2004): Conservation status of Mammals and Birds in Nanda Devi National Park – Assessment of changes over two decades. Biodiversity Monitoring Expedition Nanda Devi 2003, A Report submitted to the Ministry of Environment & Forests, Govt. of India, Uttaranchal State Forest Department, Dehradun. pp.1-14.

In its report WII gives this basin a high terrestrial biodiversity value and high aquatic biodiversity value.

13. Ganga Sub-Basin

The stretch of Ganga from Devprayag to Rishikesh falls in the lower Himalayan range. A major spring fed perennial river Nayar joins Ganga near Byasi and several small streams also drain into this basin. This area encompasses the subtropical sal and mixed forests, open grassy slopes and scrub, and patches of riverine forests along the river. This sector of the river has many deep pools and rapids, which are the most preferable habitat for large size fishes like mahseers and barbs. It is heavily used for adventure activities such as river rafting, camping, rock climbing and also for religious/spiritual purposes.

This is the richest sector of the entire Ganga river basin in terms of fish diversity and abundance in Uttarakhand. A total of 56 species of fishes, including 30 restricted range fishes, 16 threatened fishes and 2 endemic fishes namely *Glyptothorax alaknandi* and *Glyptothorax Garhwali* have been recorded in this sub-basin. These two species are endemic to the upper reaches of Ganga. The threatened species of this basin are: *Tor putitora, Tor chelinoides, Schizothorax richardsonii, Bagarius bagarius, Garra gotyla gotyla, Garra lamda, Chagunius chagunio, Nemacheilus multifasciatus, Pseudecheneius sulcatus, Puntius arana, Puntius chola, Botia dario, Amblyceps mangois, Crossocheillus latius latius, Glyptothorax cavia* and *Glyptothorax telchitta*.

In the entire Ganga this is the only sector with viable population of golden mahseer. This population moves along the Nayar river during monsoon for breeding. Based on the present survey, the Nayar river is recognised as one of the critical habitat for mahseer and associated species, and therefore proposed as 'Fish Conservation Reserve'. There are reports on the presence of otters, but potential otter habitats are present in some stretches along this basin.

WII gives this basin a high terrestrial biodiversity value and very high aquatic biodiversity value in its report.

The above analysis is summarized in Table 4.1 below.

Table 4.1: Values of rivers and the sites likely to be impacted by the 24 proposed projects in the Alakananda and Bhagirathi basins

Sub-basin	Proposed HEPs to be excluded	River/ Stream (*gad)*	Biodiversity Impacts	Remarks
Bhagirathi I	Karmoli (140 MW)	Jadhganga	Terrestrial	The HEPs are located within the Gangotri NP and within the Gangotri Eco-sensitive Zone notified by MoEF and are likely to cause irreversible impacts on wildlife species and habitats
	Jadhganga (50 MW)	Jadhganga	Terrestrial	
Bhagirathi II	Bhaironghati (381 MW)	Bhagirathi	Terrestrial	The HEP falls within the Gangotri NP and within the Gangtori Eco-sensitive Zone notified by MoEF and are likely to cause irreversible impacts on wildlife species and habitats
	Jalandharigad (24 MW)	Jalandharigad	Terrestrial	These HEPs fall within important wildlife habitats connecting Protected Areas, and also falls within the Gangotri Eco-sensitive Zone notified by MoEF and are likely to cause irreversible impacts on wildlife species and habitats
	Siyangad (11 MW)	Siyangad	Terrestrial	
	Kakoragad (12.50 MW)	Kakoragad	Terrestrial	
Bhagirathi IV	Kotlibhel 1A # (195 MW)	Bhagirathi	Aquatic	High Impact Potential
Balganga	Balganga II (7 MW)	Balganga*	Aquatic	Balganga identified as critical aquatic habitat for fish and hence proposed as 'Fish Conservation Reserve' and these HEPs are likely to cause irreversible impacts on wildlife species and habitats
	Jhalakoti (12.50 MW)	Balganga*	Aquatic	
Mandakini	Rambara (76 MW)	Mandakini	Terrestrial	This HEP is located within Kedarnath WS and is likely to cause irreversible impacts on wildlife species and habitats
Alaknanda I	Kotlibhel 1B (320 MW)	Alaknanda	Aquatic	This HEP is likely to have High Impact Potential and would cause irreversible impacts on wildlife species and habitats
Alaknanda II	Urgam (5 MW)	Kalpganga	Terrestrial	This HEP fall within important wildlife habitats connecting Protected Areas
Alaknanda III	Alaknanda (300 MW)	Alaknanda	Terrestrial	These HEPs fall within the buffer zone of Nanda Devi Biosphere Reserve and are located in important wildlife habitats that connect Protected Areas. These HEPs are within 10 km from the Valley of Flowers NP – UNESCO World Heritage Site and would cause
	Khironi Ganga (4.00 MW)	Khironi Ganga	Terrestrial	

				irreversible impacts on wildlife species and habitats
Bhyundar Ganga	Bhyundar Ganga (24.30 MW)	Bhyundar Ganga*	Terrestrial	This HEP fall within buffer zone of Nanda Devi Biosphere Reserve and in important wildlife habitats connecting Protected Areas, and within 10 km from the Valley of Flowers NP - UNESCO Natural World Heritage Site and would cause irreversible impacts on wildlife species and habitats
Dhauliganga	Malari-Jhelum (114.00 MW)	Dhauliganga*	Terrestrial	Zone of Influence of these HEPs fall within Nanda Devi Biosphere Reserve and are important wildlife habitats connecting Protected Areas. These HEPs are within 10 km from the Nanda Devi NP - UNESCO Natural World Heritage Site and would cause irreversible impacts on wildlife species and habitats
	Jhelum-Tamak (128.00 MW)	Dhauliganga*	Terrestrial	
	Tamak-Lata (280 MW)	Dhauliganga*	Terrestrial	
	Lata-Tapovan (171 MW)	Dhauliganga*	Terrestrial	
Rishiganga	Rishiganga I (70 MW)	Rishiganga*	Terrestrial	These HEPs are located within the Nanda Devi National Park – UNESCO Natural World Heritage Site and would cause irreversible impacts on wildlife species and habitats
	Rishiganga II (35 MW)	Rishiganga*	Terrestrial	
Birahi Ganga	Birahi Ganga I (124 MW)	Birahi Ganga*	Terrestrial & Aquatic	These HEPs are likely to have High Impacts and would cause irreversible impacts on wildlife species and habitats
	Gohana Tal (50 MW)	Birahi Ganga*	Terrestrial & Aquatic	
Ganga	Kotlibhel II (530 MW)	Ganga	Terrestrial & Aquatic	This HEP is likely to have Very High Impacts and would cause irreversible impacts on wildlife species and habitats
13 Sub-basins	**24 HEPs**			

* The IMG in its report (2013) had recommended that some river segments of Alaknanda and Bhagirathi should be maintained in pristine form. Six rivers *viz*., Nayar, Balganga, Rishiganga, Asiganga, Dhauliganga (upper reaches), Birahi Ganga and Bhyundar Ganga were identified to be kept in pristine form.

\# Recommended to be dropped from the list of 24 HEPs.

WII has tabulated the terrestrial biodiversity and aquatic biodiversity values in separate tables of Chapter 5. To determine the overall biodiversity value of each sub-basin the higher of these two values for each sub-basin is taken because they are independent values and cannot be averaged. The resulting overall values (See Table 4.2 below) show that all the 13 sub-basins with 24 projects have an overall high or very high biodiversity value. Therefore conservation in these sub-basins is of paramount importance.

Construction of HEPs in these river stretches have multiple impacts, not all of which can be resolved by ensuring high environmental flows. For example, adequate environmental flows can minimize the impact on aquatic biodiversity. But an HEP can still act as a barrier to the migration of mammalian species besides other problems. The problem is of location in a high or very high biodiversity value area.

In discussions on WII's analysis and other terms of reference of the EB it was also realized that some of the HEPs would lie at elevations above 2200-2500 m. Field visits and published scientific literature, cited in Chapter 3 earlier, show that these altitudes come in the paraglacial and glacial zones. In these zones the rivers are capable of mobilizing tremendous amounts of sediments, under intense rainfall conditions, from the morainic material left behind in the past by receding glaciers. In such situations, they cause havoc in the vicinity of HEPs as witnessed at the Vishnuprayag HEP barrage site and below during the June 2013 disaster.

Table 4.2: Sub-basin wise biodiversity values

S.No.	Sub-Basin	Terrestrial Biodiversity Value	Aquatic Biodiversity Value	Overall Biodiversity Value(1)	"Proposed'(2) Projects Affected
1	Bhagirathi I	H	M	H	Karmoli (140 MW) Jadhganga (50 MW)
2.	Bhagirathi II	H	H	H	Bhairaon Ghati (381 MW) Jalandharigad (24 MW) Siyangad (11 MW) Kakoragad (12.50 MW)
3.	Bhagirathi IV	H	VH	VH	Kotli Bhel IA (195 MW)
4.	Balganga	H	H	H	Balganga II (7 MW) Jhala Koti (12.50 MW)
5.	Mandakini	VH	H	VH	Rambara (76 MW)
6.	Alaknanda I	H	VH	VH	Kotli Bhel IB (320 MW)
7.	Alaknanda II	H	H	H	Urgam (3.8 MW)
8.	Alaknanda III	H	M	H	Alaknanda (300 MW) Khiron Ganga (4 MW)
9.	Bhyundar Ganga	VH	L*	VH	Bhyundar Ganga (24.3 MW)
10.	Dhauliganga	VH	M	VH	Malari-Jhelam (114.0 MW) Jhelam-Tamak (128.0 MW) Tamak-Lata (250 MW) Lata-Tapovan (170 MW)
11.	Rishiganga	H	M	H	Rishiganga I (70 MW) Rishiganga II (35 MW)
12.	Birahi Ganga	H	H	H	Birahi Ganga I ( ) Gohana Tal (MW)
13.	Ganga	H	VH	VH	Kotli Bhel II ( )

Notes: (1) H=High, VH= Very High, M= Medium, L=Low; * Bhyundar Ganga is in a no fish zone.
(2)Overall Biodiversity Values also indicates impact potential.
(3) The term 'proposed' refers to HEPs that were still on the 'drawing board until December 2012 when WII submitted its Report

4.3 Conclusion

After considerable discussions and analysis, the Expert Body concluded that of the 24 proposed Hydropower Projects (HEPs) that Wildlife Institute of India (WII) recommended for Review, 23 HEPs would have significant irreversible impacts on biodiversity values. Only one HEP i.e., Kothlibhel 1A was recommended to be dropped from the list of 24 HEPs as it is located in a stretch of Bhagirathi where the fish populations have already been fragmented**.**

An Alternate View

satisfactory environmental flow from each head work in all seasons of the year. The projects Jhelam Tamak and Tamak Lata have already been redesigned with significant reduction (about 25%) in their installed capacity to allow more water to the downstream and also with longer gap between PH and downstream reservoir tip. These projects therefore need to be relooked by the EAC of MoEF into whether mitigation measures can eradicate irreversible adverse impact. The project features may need to be re-examined to take a realistic view on the acceptability of the HEPs, by a further project to project and cumulative study from the terrestrial bio diversity angle.

- *HNB Garhwal University, Srinagar a central university has a study as a critique of WII study and has opined that the projects in Alaknanda Bhagirathi basin would not irreversibly impact the terrestrial biodiversity.*
- *The review of the WII study by Dr. Birj Gopal needs to be looked into again by referring the HNB Garhwal report to Dr. Brij Gopal.*
- *Rejecting 23 projects only from bio diversity consideration needs to be examined in the context of the issues of water and energy handled by MOWR and Ministry of Power and their concurrence or view taken in the greater interest of the acute power insecurity in the country.*
- *The bumper-to-bumper schemes are not really so because no fragmentation of the river is occurring with 70% of monsoon flow being laid down and minimum hydrological modification envisaged. In the non-monsoon the Expert Body is recommending 50% to be released to the downstream.*
- *The EAC of MoEF has not so far discussed the WII report comprehensively. Certain clarification sought and reservation of the EAC are yet to be settled.*

- ***B.P. Das, Co-Chair, EB***

abstract only 25 to 30% of the Monsoon flow, thereby leaving 75% (even 90% in good years of the total monsoon flow to flow down the purported dry reach of the river, the hydrological regime is therefore minimally altered. With high flows being allowed to the downstream, the wild life will have minimal problem of shortage of water. It is my considered opinion that with minimal hydrological change for power generation, small barrage ponds and relatively small structures as barrage or power houses (local 10km apart), the wild life will have no problem in migration.

Recommendations

The EB recommends that of the 23 HEPs that would have significant impacts on the biodiversity of Alaknanda and Bhagirathi basins, the HEPs that fall in any of the following conditions may be rejected.

(a) Proposed HEPs that fall inside wildlife Protected Areas such National Parks and Wildlife Sanctuaries

(b) Proposed HEPs that fall within the Gangotri Eco-sensitive Zone

(c) Proposed HEPs that (i) Encompass critical wildlife habitats, high biological diversity, movement corridors; (ii) That fall above 2,500m. This zone is fragile in nature due to unpredictable glacial and paraglacial activities.

(d) Proposed HEPs that fall within 10 km from the boundary of Protected Areas and have not obtained clearance from the National Board for Wildlife.

An Alternate View

The 24 projects studied by WII with respect to biodiversity and thereafter opined for review is appreciated for the valuable studies but at the same time the project proponents should get an opportunity to revise/ restructure the parameters of the projects & see if this exercise brings a balance between environment and development is achieved. It is also to be seen that how much area is being affected in this new situation.

The 24 projects have been evaluated and examined in great detail through EIA and EMP studies. The possible impacts of these projects have been quantified and mitigation measures have been planned out. Therefore the qualitative examination cannot be considered adequate for revisiting the statutory clearances already awarded. A strong monitoring and evaluation mechanism is needed to ensure that the commitments made are adhered to in letter and spirit.

- ***Ajay Verma, Member, EB (See also dissent note submitted on April 13, 2014 in Appendix 6)***

Chapter 5

ToR 3.1, 3.2, and 3.3

3.1 Assess and review extent of progress made in respect of ongoing/under construction hydroelectric power projects as on the date of occurrence of the tragedy vis-a-vis progress made in compliance of environmental conditions/safeguard measures.

3.2 Review compliance of existing protocols for construction activities in the basins of Alkananda and Bhagirathi.

3.3 Assess Status of progress in respect of proposed 24 projects.

Context

The state of Uttarakhand has geographical area of 53,483.00 sq km, which constitute 1.63% of the country's total area. The state has 34519.5 sq km of forest land constituting 64.54% of its geographical area. The reserved forest area is 24,637.32 sq km (46.7%, ownership of Forest department), civil soyam land 4768.703 sq km (8.93%, ownership of Revenue department) and village panchayat land 4961.85 sq km (9.28%, ownership of village panchayat). Out of duly notified forest land 1434.278 sq km (5.79%) is covered with snow and is desert and devoid of any vegetation.

Regarding forest cover the state's has 24496 sq km forest cover, which is 45.80% of the state's geographical area. The forest including tree cover (TOF) constituted 25138.0 sq km which is 47% of state's geographical area.

After promulgation of Forest Conservation Act, total 808.26 sq km (2.34%) forest land has been diverted for non forestry purpose (82 proposal involving 73057.81 ha. forest land approved by MoEF, New Delhi and 3657 proposal involving 7769.10 ha forest land approved by MoEF, Regional Office, Lucknow).

The diversion of 5312.11 ha (53.1211 sq km) forest land has been cleared for a total 99 hydropower projects by the MoEF including Regional Office, Lucknow (85 proposals of HEP with the diversion of 268.64 ha by the MoEF Regional Office, Lucknow and 14 proposal of HEP with the diversion of 5043.47 ha by the Ministry, Appendix-3A and 3B). The State Government of Uttarakhand has again de-notified 4768.703 sq km of civil soyam land (Protected Forest) vide notification number No. 866/X-3-2011/8(21)/2010 dated 28/09/2011. Thus the total reduction of forest land on account of diversion of forest land for non-forestry purpose is 808.26 sq km, de-notification of civil soyam land (4768.703 sq km) and snow covered area which is devoid of any vegetation (1434.278 sq km) is 7011.241 sq km. Therefore, the actual

forest land for performing the ecological services and catering the needs of local communities of the state is only in tune of 27508.26 sq km. i.e., 51.43% is instead of 64.54% earlier. Further, it is reduced by the forest land settled in favor of private persons, area under encroachment and forest area used by the department for construction of official/ residential buildings check Nakas and forest roads.

The State Government claimed having 64.54% forest cover while in reality only 45.80% forest cover exists (based on FSI report). As per Indian Forest Policy, in hilly state for ecological and environmental balance 2/3 (67%) forest cover is required while in Uttarakhand state actual forest cover stand is 45.80% only.

The Hon'ble Supreme Court in writ petition No.460/2004 Goa Foundation Vs. Union of India order dated 04.12.2006 directed that MoEF would also refer to the Standing Committee of National Board for Wild Life, under Section-5(b) and 5(c) (ii) of the Wildlife (Protection) Act, 1972, the cases where environmental clearance has already been granted within 10 km zone of National Park/Wildlife Sanctuary, Appendix-3C.

The Ministry has issued a circular vide letter No. L-11011/7/2004-IA II(I)(Part), dated 27.02.2007 which says that if the project falls within 10 Km of the boundary of National Park/ Wild life Sanctuary, it will be mandatory for the Project Proponent to obtain clearance under Wildlife (Protection) Act, 1972. Further, the Ministry vide it letter no. J-11013/41/2006-IA.II(I), dated 2.12.2009 laid a specific condition that the Environmental Clearance is subject to their obtaining prior clearance from forestry and wildlife angle including clearance from the Standing Committee of the National Board for Wildlife as applicable, Appendix-3D and 3E.

Additionally, the Ministry has issued Public Notice on 1.1.2009 in National News Papers and Regional News Papers bringing to the Notice of all that "all tHEPs activities which are located within 10 km within the boundary of Wildlife Sanctuary/ National Park should seek clearances under the Wildlife (Protection) Act, 1972 from the NBWL by 31.01.2009 even if Environmental Clearance has been granted".

Alaknanda and Bhagirathi basins having large numbers of Hydropower Projects and also having three notified National Parks, one Wildlife Sanctuary and Gangotri Eco-Sensitive Zone. Detail of above mentioned National Parks/Wildlife Sanctuaries are as follows:

i. "Valley of Flower National Park" is declared as National Park under Wildlife Protection Act, 1972 under Section-35 vide notification No. 4278/14-3-66/80, dated 6.9.1982, Appendix-F.

ii. "Nandadevi National Park" is declared as National Park under Wildlife Protection Act, 1972 under Section-35, vide notification No. 3912/14-3-35/80, dated 9.9.1982, Appendix-G.

iii. The Valley of Flower National Park and Nanda Devi have been declared as ***World Heritage*** by Director General of UNESCO, dated 17.07.2005 and declared that Valley of Flowers has exceptional and universal value of a cultural or natural site which requires protection for the benefit of all humanity, Appendix-H.

iv. Gangotri has been declared as eco-sensitive zone notified by MoEF vide notification No. SO.2930(E) dated 18.12.2012, Appendix-I.

v. Map of Nanda Devi National Park/Valley of Flower National Park, Appendix-J.

vi. Map of Kedarnath Wildlife Sanctuary, Appendix-K.

Summary of the status of HEPs

Total Projects	Commissioned	Under Construction	Proposed	Closed	Work not started in spite of getting clearances
45 (ToR 3.1)	22	23	0	3	0
18 (ToR 3.2)	0	18	0	0	0
24 (ToR 3.3)	0	3	17	1	3

i. Total 99 HEPs are sanctioned under Forest (Conservation) Act, 1980 out of which 32 HEPs proposals involves <1.00 ha forest land. As per guidelines of Forest (Conservation) Act, 1980 *"3-2(iii) No compensatory afforestation shall be insisted upon in respect of the following:- (b) Proposal involving diversion of forest land up to 1.00 ha (However, in such cases, plantation of ten times the number of tress likely to be felled will have to be carried out by way of compensatory afforestation or any number of trees specified in the order*)" *. Compensatory afforestation in such projects is not required on degraded forest land/non-forest land.

ii. The total 47 forest diversion cases of HEPs were monitored involving 4482.487 ha forest land about 84.38% of the total forest land diverted up to March, 2014 in which commencement of work not started. The monitoring reports are attached as Annexures.

Impact of forest land diversion in favour of Hydropower Projects in State of Uttarakhand/Mitigation:-

The loss of biodiversity and depletion of natural resources due to submergence of forest areas and degradation by other associated activities of hydropower projects can be partly mitigated by Compensatory Afforestation (CA) and Catchment Area Treatment (CAT). Some adverse impacts such as those on aquatic biodiversity due to fragmentation of riverine habitats and deterioration in water quality are not easily compensated. In case of Uttarakhand state the existing scenario of CA and CAT activities pertaining to the HEPS are discussed below:

1. Compensatory Afforestation Land:

As per Forest (Conservation) Act, 1980 guidelines 3.2.(i) *"Compensatory Afforestation shall be done over equivalent area of non-forest land"*.

a) As per Forest (Conservation) Act, 1980 guidelines 3.2.(iii) *"In the event that non-forest land of compensatory afforestation is not available in the same district, non-forest land for compensatory afforestation may be identified anywhere else in the State/ UT as near as possible to the site of diversion, so as to minimize adverse impact on the micro-ecology of the area."*

b) As per Forest (Conservation) Act, 1980 guidelines 3.4.(i) – *"Equivalent non-forest land identified for the purpose are to be transferred to the ownership of the State Forest Department and declared as reserved/ protected forests, so that the plantation raised can be maintained permanently. The transfer must take place prior to the commencement of the project."*

1.1. About 50% of total forest land was diverted for HEP projects prior to the creation of separate Environment and Forest Ministry and at that time it was part of Agriculture Ministry, so most of the conditions of the present guidelines were neither in existence nor were imposed.

1.2. In 99 forest land diversion proposals for HEPs, non-forest land of 4548.899 ha has been provided in the district of Hardoi, Jhansi, Kanpur and Lalitpur of Uttar Pradesh for compensatory afforestation. This is 86.64% of total non-forest land provided for compensatory afforestation in lieu of diverted forest land. These are located in east- and south part of united Uttar Pradesh far from the HEP-affected area in Uttarakhand.

1.3. The HEPs involved diversion of forest land 314.05 ha in favour of private user agencies require compensatory afforestation on equivalent non-forest land but

on the recommendation of the State Government it was sanctioned on double degraded forest land.

1.4. The non-forest land/civil soyam land provided for compensatory afforestation has not been mutated and notified as reserved/protected forest which is violation of guidelines/Hon'ble Supreme Court order. Only in one proposal (Khiro Ganga, 2.62 ha) Civil Soyam land has been mutated in favour of State Forest Department.

1.5. In the beginning some of the HEP proposals were submitted by the Irrigation/ Power Dept. of the State Govt. but subsequently these HEP projects were transferred to the Private companies and they should provide non forest land as per guidelines e.g. Lakhwar Vyasi HEP, Srinagar, Alaknanda HEP etc.

2. Compensatory Afforestation:

As per Hon'ble Supreme Court order dated 30.10.2002 in IA 566 of 202/1995 *regarding creation of Compensatory Afforestation Management and Planning Agency (CAMPA), the money for CA, NPV and CAT Plan shall be deposited in the CAMPA*[*].

2.1 About 84.38% Compensatory Afforestation has been done in Hardoi, Kanpur, Jhansi and Lalitpur districts of Uttar Pradesh, which has not leading to mitigative environmental impact for the state of Uttarkhand.

2.2 In forest diversion proposals up to 2002, the user agencies had deposited the money for compensatory afforestation to the respective State Govt. The State Govt. has usually not utilized this fund for the implementation of compensatory afforestation and instead divert it for other non-forestry work.

2.3 Therefore, Hon'ble Supreme Court directed to MoEF to deposit these Compensatory Afforestation (CA), Net Present Value (NPV) and Catchment Area Treatment (CAT) fund should be deposited under the CAMPA. The funds have been deposited in CAMPA from 2002 – 2010 but these funds were not released for implementation of above mentioned work up to 2010. As a result the negative environmental impacts of deforestation have taken place but not mitigated.

2.4 Local indigenous species have not been planted therefore success of plantation is not satisfactory.

3. Catchments Area Treatment Plan (CAT):

As per guideline 4.8(ii) of Forest (Conservation) Act, 1980 – *"Proposals for diversion of forest land for Hydro-electric projects shall invariably be accompanied by detail catchment area treatment plan. However, in respect of small hydel projects (maximum up to 10 MW capacity), which are either canal head or run-off the river projects without involving impounding of water/ submergence of forest land, catchment area treatment plan will not be insisted"* *.

3.1 The guideline has been imposed in later stage; therefore in most of HEP clearances the CAT plan condition was not imposed.

3.2 The money for CAT Plan has been deposited in CAMPA but due to non-release of fund from CAMPA in time the implementation of CAT plan is very poor.

3.3 Local indigenous species have not been planted therefore success of plantation is not satisfactory.

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*Hand Book of Forest (Conservation) Act, 1980, Forest (Conservation) Rules, 2003 and Guidelines and Clarifications, Government of India, Ministry of Environment and Forests, New Delhi

4. Submergence:

4.1 Due to construction of Hydro Electric Power Project, a large chunk of area of adjoining river banks are submerged in water causing loss of a number of trees.

4.2 In THDC reservoir, which is 42 Km long and about 1.00 km wide involving submergence of 2400 ha forest land causes submergence of many villages/towns and some historical and religious monuments. Similarly, in Srinagar HEP reservoir the Dhari Devi temple has been relocated.

5. Landslides:

5.1 The soil/sand/stones and plant debris deposited in river bed results in elevation of riverbed up to 5-10 meters and obstruct the water flow.

5.2 The landslides causes extra forest land loss which was not diverted in favour

of HEPs. For example, the Tehri reservoir has led to about 80 landslides, out of which some are still active. This has caused loss of about 200 ha forest loss on left side of reservoir.

(Land slide in forest area due to submergence of Tehri Dam Reservoir)

6. Impact on Fish and Aquatic life:

6.1 The Hydro Electric dam results in fragmentation of the river. The aquatic biota cannot migrate upstream and downstream. Sediments, which carry the elements that impart special qualities to the river water, and organic debris, which is food for downstream aquatic life, cannot flow downstream. The huge reservoir impounds the inflow contributed by the basin. The rivers get converted into a very big and deep reservoir that completely changes the local environment.

6.2 In Run of River (RoR) HEPs, water running through tunnels disrupts the free flow of the river. The developers used maximum water for generation of electricity and thus the river becomes dry in stretc.h of 5-15 Km which badly

affects the fishes and other aquatic flora and fauna. There is no mechanism yet in place to verify the implementation of e-flow releases by HEPs.

7 Impact on Water Pollution:

Construction gives rise to large quantity of dust which causes air pollution. The dust also settles into river water and pollutes the water. The large quantity of organic debris and animal's bodies get accumulated in the reservoir. This can especially be seen at THDC reservoir Chilyanisaur which causes bad smell and unhygienic air and water conditions.

(Photograph of drift wood and other waste material in THDC Reservoir at Chinaulisar caused bad smell and unhealthy environment).

7. Impact on Cultural and Religious Places:

i) The river water flow is diverted through tunnel/power channel due to HEPs. The flow of water in the river is either totally discontinued or very much reduced due to which the local public cannot take holy bath in the river on various religious occasion and they are not able to perform last rituals of the

deceased family members. Local people have to request the PP at Vishnu Prayag HEP to release some water in the river so that they could immerse the ashes of the deceased into the river.

ii) HEPs create a water body which is very long and deep. The villages situated along the banks of the river are not able to cross the reservoir and they become cut off from their relatives on the other side even if the areal distance is as less as a kilometer.

iii) Some historical monuments and religious temples have been submerged in the reservoir like Dhari Devi Temple in Srinagar HEP and many other Temples/Mosque/Gurudwara in Tehri HEP.

8. Impact on River Length:

The HEPs lead to discontinuation of free flow in large lengths of the river because the river either turns into a reservoir or flow is diverted through channels. River Ganga is known for its holiness, religious, cultural and water quality not only in India but in the entire world. The discontinuity of river water affects the water quality and the people are saying now the river Ganga is a dead river. The Nation has declared "The Ganga" as National River, therefore it is our duty to make the flow of the river as continuous as "AVIRAL Dhara" along with "Nirmal Dhara".

Recommendations/Suggestions based on ToR 3.1, 3.2 and 3.3:

1) (a) It must be made mandatory for all projects should display the all project related information (including Name of the project, EC, FC, consent from PCB, Cost of the project, land uses, forest area, reservoir, muck disposal site information, submergence, etc.) on sign boards around the respective project locations.

(b) Hydropower Projects should display all necessary data/information (Consent from PCB, E.C., F.C. and its compliance report, details data of inflow, amount diverted, amount released as e-flow, power generation, etc., except the classified data) on its website.

(c) It is already mandatory for the project to construct the boundary pillars on the diverted forest land. However, this is mostly not done. A provision must be made that forest land will be diverted only after the pillars are constructed.

(d) Online linkage of the all HEPs with MoEF, CEA, CWC, GSI, ISRO, Government of Uttarakhand with regard to disaster management and sharing

of data during operation and crises. This data must specifically include water flows (inflow, e-flow and diversion), sediment load, rainfall, etc.

(e The committee noted extremely slow pace of execution of the Compensatory Afforestation (CA) and Catchment Area Treatment (CAT) plan by State Forest Department.

The committee suggests executing the same within the construction period of the project. This is to be monitored by a committee comprising of concerned CCF of Garhwal/Kumaon region, one representative from State Irrigation Department, two representatives from local communities, Renowned Environmentalist and one member from SBCP and Regional Office of MoEF, Dehradun. The committee should be headed by APCCF, MoEF, RO, Dehradun.

2) (a) All projects $\geq$ 2 MW, which entails tunneling, barrages and construction of reservoir, shall require prior Environmental Clearances (EC) from MoEF and subsequently, such projects falling in the eco-sensitive zones of notified National Park and Wildlife Sanctuaries of Uttarakhand should take prior permission from National Board for Wildlife (NBWL), as per the Hon'ble Supreme Court order on Goa foundation case dated 4.12. 2006. Construction activities in all under-construction HEPs which have failed to obtain clearance from NBWL must come to a stop immediately till such clearance is obtained and considered by EAC.

(c) An Authority along the lines of EAC may be constituted to consider representations and also initiate suo moto assessment of areas that may be declared as eco-sensitive zone along the lines of MoEF notification dated 18.12.2012 issued for Gangotri eco-sensitive zone.

(d) As per the EIA notification 14 September, 2006, the validity of approved EC is 10 years. It has been noticed that in a number of cases the validity of EC is 5 years only. The validity should not be extended, unless fresh appraisal is done.

(e) The committee during examination/analysis of the EIA/EMP reports has observed incorrect information provided by project proponent. An appropriate action is required to be taken by MoEF in such cases in cases reported.

(f) It is seen that PPs appoint the EIA Agency. This leads to the EIA Agency having a bias towards the PP. For future EIAs it is suggested that an independent agency may be constituted to commission and scrutinize the EIAs before they are given to the PP and placed before the EAC. EACs are not in a position to discharge this duty because they are regulatory in nature and do not have the administrative apparatus required for this work.

3. (a) Cumulative Environmental Impact Assessment (CEIA) including Regional Environmental Impact (REI) and Strategic Impact Analysis (SIA) should be done by MoEF for all river basins.

(b) LCA (Life Cycle Assessment) of hydropower projects should be done by MoEF to compile a data base and EC and FC shall be accorded based on above data base. This should include the carbon footprint and costs of decommissioning of the HEPs.

(c) Social-cultural impact assessment of the project must be carried out under the Akwekon guidelines by convention on Biological Diversity (CBD).

(d) The committee also noticed during site visit that most of the instruments (sediment measurement, flow rate, meteorological data, water quality monitoring etc.) installed at site were inadequate.

The committee noted with concern that none of the project visited has real time telemetry network which comprise of automatic weather stations. The transmission of real time, weather time data, rainfall, discharges etc. is important for officials to operate project safely and optimally. This is the reason why committee felt poor quality of data management. Therefore, EB recommends before Monsoon each project (commissioned/construction) should install all required automated instruments and aerial real time telemetry and its online management to share this data for proper operation of the project and warning etc.

3) (a) The committee recommends to implement IMG recommendations to maintain the pristine form of six rivers (*Nayar, Bal Ganga, Rishi Ganga, Assi ganga, Birhi Ganga and upper riches of Dhauliganga*).

(b) River Regulation Zone (R.R.Z.) guidelines should be issued immediately by the Ministry of Environment and Forests and should be executed accordingly.

(c) The problem of fragmentation of river and prevention of migration of aquatic life is not addressed; and that of downstream flow of sediments is only very partially addressed by the release of e-flows. The Ganga River Basin management Plan being made by IIT Consortium has underscored the need to maintain riverbed connectivity. Suggestion has been received by the Committee that it may be possible to abstract water from the river by making an partial obstruction across the river bed. The Committee recommends that an ambitious project to work out the technical details of such a proposal may be undertaken.

4) (a) Committee recommends all HEPs should have a detailed Disaster Manager Plan (DMP) which shall be reviewed/drill periodically under the presence of monitoring committee/local Govt. authority and representatives from National Disaster Management Authority (NDMA) officials.

(b) Committee recommends that Weather Forecast System (WFS) should be strengthened for the ecological sensitive area of Uttarakhand and properly/timely conveyed to Govt. officials/HEPs/local people to take prior safety precautions to avoid loss of lives and property.

ToR: 3.1: Assess and review extent of progress made in respect of ongoing/under construction hydroelectric power projects as on the date of occurrence of the tragedy vis-a-vis progress made in compliance of environmental conditions/safeguard measures.

Status of ongoing/under construction HEPs before devastation of 15 to 17 June, 2013

As per the available record in the Ministry of Environment and Forests, Regional Office, Lucknow, hydroelectric projects (HEPs) accorded Environmental Clearance (E.C.) in the State of Uttarakhand from Ministry of Environment and Forests (MoEF). Detail status of all project basins are depicted below:

SN	Contents	No.	Name of tHEPs
Under Forest (Conservation) Act, 1980			
i.	Number of HEPs required Forest Clearance	45	Asi Ganga-I, Asi Ganga-II, Kaldigad, Limchigad, Bhairon Ghati, Loharinag pala, Pala Maneri, Tehri PSP*, Kotlibhel-1A, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Sarayu-I, Sarayu-II, Sarayu-III, Gangnani, Badiyar, Agunda Thati, Bhilangana, Swati Bhilangana, Birahi Ganga, Dewali, Kotbudha Kedar, Kali Ganga-I, Maneri Bhali-II, Rajwakti, Rishi Ganga, Milkhet, Tehri Dam, Koteshwar, Urgam, Banala, Phulana Mini, Vishnuprayag, Moti Ghat, Loharikhet, Dhauliganga, Tanakpur, Hanuman Ganga.
ii.	Number of HEPs applied for Forest Clearance	43	Asi Ganga-I, Asi Ganga-II, Kaldigad, Limchigad, Loharinag pala, Pala Maneri, Kotlibhel-1A, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Sarayu-I, Sarayu-II, Sarayu-III, Gangnani, Badiyar, Agunda Thati, Bhilangana, Swati Bhilangana, Birahi Ganga, Dewali, Kotbudha Kedar, Kali Ganga-I, Maneri Bhali-II, Rajwakti, Rishi Ganga, Milkhet, Tehri Dam, Koteshwar, Urgam, Banala, Phulana Mini, Vishnuprayag, Moti Ghat, Loharikhet, Dhauliganga, Tanakpur, Hanuman Ganga.
iii.	Number of HEPs accorded final Forest Clearance	42	Asi Ganga-I, Asi Ganga-II, Kaldigad, Limchigad, Loharinag pala, Pala Maneri, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Sarayu-I, Sarayu-II, Sarayu-III, Gangnani, Badiyar, Agunda Thati, Bhilangana, Swati

			Bhilangana, Birahi Ganga, Dewali, Kotbudha Kedar, Kali Ganga-I, Maneri Bhali-II, Rajwakti, Rishi Ganga, Milkhet, Tehri Dam, Koteshwar, Urgam, Banala, Phulana Mini, Vishnuprayag, Moti Ghat, Loharikhet, Dhauliganga, Tanakpur, Hanuman Ganga.
iv.	Number of HEPs accorded in principle approval for Forest Clearance	01	Kotlibhel-1A
v.	Number of HEPs in which Forest Clearance stands canceled due to non compliance of condition.	04	Asi Ganga-I, Asi Ganga-II, Bhyundar Ganga, Singoli Bhatwari.
vi.	Number of HEPs in which Forest Clearance was rejected	Nil	--
vii.	Number of HEPs in which forest proposals have not submitted to the Ministry	1	Bhairon Ghati.
viii.	Number of HEPs which are closed by NGBRA/GOM	3	Bhairon Ghati, Loharinag Pala, Pala Maneri
Under Environment (Protection) Act, 1986 (EIA Notification, 2006)			
i.	Number of HEPs requires Environmental Clearance#	17	Swati Bhilangana**, Bhairon Ghati, Loharinag pala, Pala Maneri, Tehri (Koteshwar) Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Gangnani, Maneri Bhali-II, Vishnuprayag, Dhauliganga, Tanakpur.
ii.	Number of HEPs have applied Environmental Clearance	15	Swati Bhilangana, Loharinag pala, Pala Maneri, Tehri (Koteshwar), Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Maneri Bhali-II, Vishnuprayag, Dhauliganga.
iii.	Number of HEPs accorded Environmental Clearance	15	Swasti Bhilangana, Loharinag pala, Pala Maneri, Tehri (Koteshwar), Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar, Maneri Bhali-II, Vishnuprayag, Dhauliganga.
iv.	Number of HEPs rejected Environmental Clearance	Nil	--
v.	Number of HEPs in which Environmental Clearance in ToR/Clearance stage	Nil	--

vi.	Number of HEPs in which proposal for Environmental Clearance is not submitted	02	Bhairon Ghati, Tanakpur.
vii.	Number of HEPs which are within National Park/Wildlife Sanctuaries	Nil	--
viii.	Number of HEPs which falls within 10 Km of National Park/Wildlife Sanctuary.	11	Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan vishnugarh, Vishnugarh Pipalkothi, Kali Ganga-I, Rishi Ganga, Urgam.
ix.	Number of HEPs which falls within 10 Km from boundary of National Park/Wildlife Sanctuary and requires permission from National Board for Wild Life.	05	Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan vishnugarh, Vishnugarh Pipalkothi.
x.	Number of HEPs which have taken permission from National Board of Wild Life.	01	Vishnugarh Pipalkothi.
xi.	Number of HEPs which are coming in Gangotri Eco-Sensitive Zone	07	Asi Gang-I, Asi Ganga-II, Kaladigad, Limchigad, Bhairon Ghati, Loharinag Pala, Pala Maneri.

* Tehri PSP project not required further forest land, it is in same forest land require for Tehri Project.
** Swasti Bhilangana 11 MW project accorded EC on dated 2004.
# As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects $\geq$ 50 MW hydroelectric power generation; and $\geq$ 10,000 ha. of culturable command area come under category A and below < 50 MW $\geq$ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs $\geq$ 25 MW required Environmental Clearance from the MoEF and respective SEIAA.

In summary, on the basis of the monitoring report, it has been noticed that the major non-compliances were noticed on the following issues:

1. Execution of catchment area treatment (CAT) plan. It has been found that in majority of cases project proponents deposited the appropriate fund in CAMPA etc. The State forests department has not executed/started the work.

2. Compensatory Afforestation of native species on the reservoir area or near to project site. It has been noticed that in major cases project proponents deposited the appropriate fund in CAMPA. State forests department has not executed/started the work.

3. At present biodiversity conservation and wldlife conservation is a small part of the EIA and its managment is left to the PP. It is recommeneded all commissioned, under-construction and proposed HEPs be required to submit a biodiversity- and wildlife conservation plan. The format of six-monthly progress reports submitted to MOEF may specifically be required to give infomation about progress in respect of these plans.

4. For State Governmnet, private owners of HEPs the compensatory afforestaion land should be non forests land. However, in the most of the cases CA is permitted on double degraded forests land. PPs often produce letters from farmers agreeing to plant trees on private land and submit these as proof of CA. This is not adequate because the farmer may, or may not, actually plant and/or maintain the trees. It must be mae mandatory for the PP to acquire land for purposes of CA.

5. The project falls within 10 km from the boundary of National Parks/Santuries required prior permission/approval of NBWL. In most of the cases it has been noted that the project proponents statared the construction work without obtaining the NBWL permission. Costruction activites in repsect of such projects must be stopped forthwith till NBWL clearance is obtained and considered by EAC and FAC.

6. Most of the project proponents have not demarcated the forests land by making boundry pillers. It should be done prior to start of any construction work.

7. Muck disposal and its management (Slope, toe wall, plantation etc.). In all cases it has been noticed that the project proponent has not properly managed the muck disposal site and its management. This is a major compliance issue. It is noticed that MOEF RO is understaffed and is able to undertake inspection of the HEPs infrequently—sometimes once in 2 years. Clear guidelines may be issued to MOEF RO to re-inspect the project within 3 months where violations have been noted and to order stoppage of construction of work if these are not addressed within 3 months.

8. Development of fish nursery. It has been noticed that in major cases project proponents deposited the appropriate amount to the state government, and they have not executed/started the work.

9. Minimum lean season flow not been propely mainatined. An Independent mechanism may be established to oversee these releases. Participation of Gram Pradhan and other local representatives must be made mandatory in such mechanism.

10. In addition to the conditions stipulated by Minsitry of Environment and Forests, Number of projects proponents have not taken requsite permission (Consent to Establish/Operate/Hazardous waste) from Uttarakhand Environment Protection and Pollution Control Board (UEEPCB) for batching plant, DG sets, power house etc. and subsequently its compliance. Construction activities in such under-construction projects must come to an immediate stop till such NOC are obtained by them.
11. Number of hydropwoer projects constructed the colony/houses for the staff, without any Sewage Treatment Plant (STP), solid waste management etc. They have disposed off their lid/solid waste directly or indirectly to the respective river.

Table : 3.1 Status as on May 31, 2013 of ongoing/under construction HEPs Forest Clearance and Environment Clearance in various HEPs of Uttarakhand State.

S. N	Name of HEP	Capacity (MW)	Status	River/ Tributary / Gad etc.	Forest Area Approved (ha)	Forest Clearance Date	Environ-ment Clearance with date*	Distance from NP/ Sanctuary**	Remarks
Under Construction									
1.	Asi Ganga I	4.5	Under Construction	Asi Ganga/ Bhagirathi	1.24	24/8/2010	NA	It is in Gangotri Eco Sensitive Zone	• Damaged in 2012 • FC stand cancel due to non mutation of civil-soyam land
2.	Asi Ganga II	4.5	Under Construction	Asi Ganga/Bhagirathi	1.58	19/8/2010	NA	It is in Gangotri Eco Sensitive Zone	• Damaged in 2012 • FC stand cancel due to non mutation of civil –soyam land
3.	Kaladigad	9.0	Under Construction	Kaladi Gad/ Bhagirathi	2.351	04/3/2008	NA	It is in Gangotri Eco Sensitive Zone	• CA on Nalda Soyam Land should be muted and notified as RF/PF within three month. The work could be resumed.
4.	Limchigad	3.5	Under Construction	Limchigad / Bhagirathi	0.99	13/4/2006	NA	It is in Gangotri Eco Sensitive Zone	_
5.	**Bhairon Ghati***	381.0	Under Construction/ Closed	Bhagirathi	PNS	PNS	PNS	It is in Gangotri Eco Sensitive	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was

								Zone	discontinued. • WII report found significantly impacting the Biodiversity of valley.
6.	**Lohari Nagpala***	600.0	Under Construction/ Closed	Bhagirathi	139.03	2/8/2005	8-38/2005-FC dt 02.08.2005	It is in Gangotri Eco Sensitive Zone	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued. • EC and FC should be revoked. • Restoration work should be required. • Ministry of Power has provided Rs. 436 crs to NTPC as compensation.
7.	**Pala Maneri***	480.0	Under Construction/ Closed	Bhagirathi	53.3	6/6/2006	J-12011/34/ 2005.IA.I dt 07.12.2005	It is in Gangotri Eco Sensitive Zone.	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued.
8.	**Tehri PSP***	1000 (4x250 MW)	Under Construction	Bhagirathi	NA	NA	2-19/81-HCT/IA01 dt. 14.07.1990	_	• Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not

									developed.
9.	**Kotlibhel-IA***	195.0	Under Construction	Bhagirathi	261.047	In principal approval accorded on 13.10.2011	J-12011/5/2007-IA.II Dt. 09.05.2007	_	• Final FC is awaited. • WII report found significantly impacting the Biodiversity of valley.
10.	Kali Ganga-II	6.0	Under Construction	Kali Ganga/Mandakani	3.13	6/3/2007	NA	Approximately 2.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA on double degraded forest land.
11.	Mad Maheshwar	15.0	Under Construction	Mandakini	5.0	6/3/2007	NA	Approximately 2.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA on double degraded forest land.
12.	**Phata Byung***	76.0	Under Construction	Mandakini	16.37	2/5/2008	J-12011/64/2007-IA.I, Dt. 18.03.2008	It is approximately 1.0 Km from KedarnNath Wild Life Sanctuary.	• Damaged in 2013 devastation. • CA on double degraded forest land. • N.B.W.L recommendation is not obtained. • Muck disposal management need to be review and

									constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not developed. • CAT plan are not executed so far.
13.	**Singoli Bhatwari***	99.0	Under Construction	Mandakini	34.34	16/1/2009	J-12011/50/2007-IA.I, Dt. 24.08.2007	Approximately 6.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA land is not mutated and notified within six month of the forest clearance. • Forest clearance stands cancel by 15.07.2009 due to non mutation of non forest land. • Permission not taken from NBWL. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site.

									• Fish nurseries not developed. • CAT plan are not executed so far.
14.	Bhyundar ganga	24.0	Under construction (About 25% work accomplished)	Bhyundar ganga	4.89	19/2/2009	NA	Approximately 7.0 Km from Valley of Flower NP	• Forest clearance stands cancel on the 18.8.2009 due to non mutation of civil-soyam land. Work continued in violation of FCA (1980). • Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
15.	**Lata Tapovan***	171.0	Under construction (Work started in non forest land and only road construction in forest land)	Dhauli ganga/ Alaknanda	70.83	30/4/2007	J-12011/57/2006-IA.I dt 21.02.2007	Approximately 4.5 Km from Nandadevi NP	• Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
16.	**Tapovan Vishnugarh***	520	Under Construction	Dhauli Ganga	76.00	13/3/2000	J-12011/36/2004-IA.I dt 08.02.2005	Approximately 7.0 Km from Nandadevi NP	• Permission not taken from NBWL. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck,

									sausage-gabion walls and plantation on muck disposal site.
17.	**Vishnugarh Pipal Kothi***	444.0	Under Construction (work started on non forest land)	Alaknanda	80.507	28/5/2013	J-12011/29/2007-IA.I dt. 22.08.2007	Approximately 1.0 Km from Kedarnath Wild Life Sanctuary	• The Forest land is not mutated in favour of Forest Department and notified as PF/RF. • Permission obtained from National Board for Wild Life.
18.	**Srinagar HEP***	330.0	Under Construction	Alaknanda	338.06	15/4/87	J-11016/8/1982-Env, 5 dt 03.05.1985	_	• The CA land is provided in Lalitpur, Jhansi district of UP. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not develop. • CAT plan are not executed so far.
19.	Sarayu I	4.0	Under Construction	Sarayu	3.673	8/6/2007	NA	_	• CA on double degraded forest land. It should be on non forest land.

20.	Sarayu II	3.0	Under Construction	Sarayu	4.305	28/6/2007	NA	_	• CA on double degraded forest land. It should be on non forest land.
21.	Sarayu III	2.0	Under Construction	Sarayu	4.041	8/6/2007	NA	_	• CA on double degraded forest land. It should be on non forest land.
22.	**Gangani**	28.0	Under Construction	Gangani /Yamuna	3.0	8/6/2007	NA	_	• CA on double degraded forest land. It should be on Non forest land.
23.	Badiyar HEP	5.0	Under Construction	Yamuna	2.735	8/6/2006	NA	_	• CA on double degraded forest land. It should be on non forest land.
Commissioned									
24.	Agunda Thati	3.0	Commissioned	Bhagirathi	2.33	3/1/2005	NA	_	• CA on double degraded forest land. It should be on Non forest land.
25.	Bhilangana	22.5	Commissioned	Bhilangana/ Bhagirathi	8.33	13/3/2007	NA	_	• CA on double degraded forest land. It should be on Non forest land.
26.	Swasti/ Bhilangana #	11.0	Commissioned	Bhilangana/ Bhagirathi	3.182	8/5/2001	J-12011/28/2000-IA.II (I) Dated 21.03.2001 and 23.06.2004	_	• CA on double degraded forest land. It should be on non forest land.
27.	Birahi Ganga	7.2	Commissioned	Birahiganga/ Alaknanda	4.66	24/8/2005	NA	_	• CA on double degraded forest land. It should be on non forest land.
28.	Dewali	9.0	Commissione	Nandakini/	2.21	14/8/200	NA	_	• CA on double degraded

			d	Alaknanda		6			forest land. It should be on Non forest land.
29.	Kot-Budha-Kedar	6.0	Commissioned	Bal ganga/ Bhilangana	0.59	16/8/2004	NA	_	_
30.	Kali Ganga-I	4.0	Commissioned	Kali ganga/ Mandakini	4.1	13/3/2007	NA	Approximately 1.0 Km from Kedarnath Wild Life Sanctuary	• CA on double degraded forest land. It should be on Non forest land. • Damaged in 2013 devastation.
31.	**Maneri Bhali II**	304.0	Commissioned	Bhagirathi	4.0	3/6/2004	14/48/80-ENV-5 Dt : 19.01.1983	_	• Working without Consent to operate of HEP, DG sets etc. by UEEPCB. • Dharasu Power House Consent to operate validity is up to 31.03.2013.
32.	Rajwakti	3.6	Commissioned	Nandakini/ Alaknanda	3.84	11/6/99	NA	_	• CA on double degraded forest land. Itshould be on non forest land.
33.	Rishiganga	13.2	Commissioned	Rishi ganga/ Dhauli ganga	2.92 3.993 (Ext.)	3/3/2000 6.07.2007	NA	Approximately 1.5 Km from Nandadevi NP	• CA on double degraded forest land. Itshould be on non forest land.
34.	Melkhet	0.1	Commissioned	Pinder/ Alaknanda	3.44	13/2/2000	NA	_	• CA on double degraded forest land.
35.	**Tehri Dam**	1000	Commissioned	Bhagirathi	2582.9	10/3/1983	2-19/81-HCT/IA01	_	• In operation. The CA land is provided in Lalitpur, Jhansi

							dt. 14.07.1990		district of UP. Reservoir has active and land slide damage about 1500 ha forest land • Muck disposal management need to be review and constructed above 1 m. of HFL and maintain that proper sloping of the muck, sausage-gabion walls. • Fish nurseries not develop.
36.	**Koteshwar**	400.0	Commissioned	Bhagirathi	338.93	23/10/2002		_	• In operation. The CA land is provided in Lalitpur, Jhansi district of UP. • Reservoir has active and land slide damage about 1500 ha forest land. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintain that proper sloping of the muck, sausage-gabion walls. • Fish nurseries not develop.
37.	Urgam	3.0	Commissioned	Kalp ganga/ Alaknanda	0.921	19/8/1990	NA	Within 10.0 Km of Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation.
38.	Vanala	15.0	Commissione	Nandakini/	6.83	21/3/200	NA	_	• CA on double degraded

			d	Alaknanda		5			forest land. It should be on non forest land. • Damaged in 2013 devastation.
39.	Pulana Mini HEP	1.3	Commissioned	Bhyundar ganga/ Alaknanda	1.662	17/8/2000	NA	_	• CA on double degraded forest land. It should be on non forest land. • Damaged in 2013 devastation.
40.	**Vishnu Prayag**	400.0	Commissioned	Alaknanda	80.0	15/10/1996	J-11016/29/1983-IA.III dt. 30.11.1995	_	• Damaged in 2013 devastation. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintain that proper sloping of the muck, sausage-gabion walls. • Fish nurseries not develop.
41.	Motighat	3.0	Commissioned	Sharagad	4.259	31/1/2006	NA	_	• CA on double degraded forest land. It should be on non forest land.
42.	Loharikhet HEP	4.8	Commissioned	Kali Ganga/ Goriganga	2.876	31/10/2000	NA	_	• CA on double degraded forest land. It should be on non forest land.
43.	Dhauliganga	280.0	Commissioned	Dhauliganga	138.617	16/3/1989	_	_	• 138.61 ha non forest land provided in Kanpur district.
44.	Tanakpur	120.0	Commissioned	Sarada	293.35	5/6/1986	EC not obtained	_	• Non forest land is Kanpur Dehat district.

45.	Hanuman Ganga	4.98	Commissioned	Yamuna/ Ganga	2.098	8/5/200	NA	_	• CA on double degraded forest land. It should be on non forest land.

Note: # Swati Bhilangana 11 MW project accorded EC dated 2004. PNS, Proposal not submitted; TOR, Term of Reference; NA, not applicable; MW, Mega watt; NP; National Park; NFL, non forest land; CA Compensatory afforestation; FC, Forest Clearance; EC, Environmental Clearance; FCA, Forest Conservation Act.

The Regional Office MoEF has taken appropriate action in conformity/compliances of guidelines of Forest (Conservation) Act, 1980, Environmental (Protection) Act, 1986 and Direction of Hon'ble Supreme Court. Action taken report has also been enclosed with monitoring report.

The distance from boundary of National Park/Wildlife Sanctuary mention on the basis of information provided by concerned Divisional Forest Officers/ measurement from the scaled map.

*As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects $\geq$ 50 MW hydroelectric power generation; and $\geq$ 10,000 ha. of culturable command area come under category A and below < 50 MW $\geq$ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs $\geq$ 25 MW required Environmental Clearance from the MoEF and respective SEIAA.

ToR 3.2 : Review compliance of existing protocols for construction activities in the basins of Alaknanda and Bhagirathi.

Status of project as on May 31, 2013 (before devastation 15 to 17 June, 2013)

As per the available records in the Ministry of Environment and Forests, Regional Office, Lucknow, the status of projects which are under construction discussed below:

SN	Contents	No.	Name of Projects
Under Forest (Conservation) Act, 1980			
ix.	Number of HEPs required Forest Clearance	18	Asi Gang-I, Asi Ganga-II, Kaladigad, Limchigad, Bhairon Ghati, Loharinag Pala, Pala Maneri, Tehri PSP*, Kotlibhel-1A, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
x.	Number of HEPs applied for Forest Clearance	16	Asi Gang-I, Asi Ganga-II, Kaladigad, Limchigad, Loharinag Pala, Pala Maneri, Kotlibhel-1A, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
xi.	Number of HEPs accorded final Forest Clearance	15	Asi Gang-I, Asi Ganga-II, Kaladigad, Limchigad, Loharinag Pala, Pala Maneri, Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
xii.	Number of HEPs accorded in principle approval for Forest Clearance	01	Kotlibhel-1A.
xiii.	Number of HEPs in which Forest Clearance stands canceled due to non compliance of condition.	04	Asi Gang-I, Asi Ganga-II, Singoli Bhatwari, Bhyundar Ganga.
xiv.	Number of HEPs in which Forest Clearance was rejected	Nil	--
xv.	Number of HEPs in which forest proposals have not submitted to the Ministry	01	Bhairon Ghati.
xvi.	Number of HEPs which are closed by NGBRA/GOM	03	Loharinag Pala, Pala Maneri, Bhairon Ghati.

MoEF-Ro for EB (ToR 3.1)

Under Environment (Protection) Act, 1986 (EIA Notification, 2006)			
xii.	Number of HEPs requires Environmental Clearance#	11	Bhairon Ghati, Loharinag Pala, Pala Maneri, Tehri PSP**, Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
xiii.	Number of HEPs have applied Environmental Clearance	9	Loharinag Pala, Pala Maneri, Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
xiv.	Number of HEPs accorded Environmental Clearance	9	Loharinag Pala, Pala Maneri, Kotlibhel-1A, Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi, Srinagar.
xv.	Number of HEPs rejected Environmental Clearance	Nil	--
xvi.	Number of HEPs in which proposal for Environmental Clearance is not submitted	01	Bhairon Ghati.
xvii.	Number of HEPs which are within National Park/Wildlife Sanctuaries	Nil	--
xviii.	Number of HEPs which falls within 10 Km of National Park/Wildlife Sanctuary.	08	Kali Ganga-II, Mad Maheshwar, Phata Byung, Singoli Bhatwari, Bhyundar Ganga, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi.
xix.	Number of HEPs which falls within 10 Km from boundary of National Park/Wildlife Sanctuary and requires permission from National Board for Wild Life.	05	Phata Byung, Singoli Bhatwari, Lata Tapovan, Tapovan Vishnugarh, Vishnugarh Pipalkothi.
xx.	Number of HEPs which have taken permission from National Board of Wild Life.	01	Vishnugarh Pipalkothi.
xxi.	Number of HEPs which are coming in Gangotri Eco-Sensitive Zone	07	Asi Gang-I, Asi Ganga-II, Kaladigad, Limchigad, Bhairon Ghati, Loharinag Pala, Pala Maneri.

*Tehri PSP project has not required further forest land. It is in same forest land accorded for Tehri project.

** Environmental Clearance to Tehri has been accorded by Ministry on dated 14.07.1990 including Tehri PSP (1000 MW) and Koteshwar (400 MW)

As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects $\geq$ 50 MW hydroelectric power generation; and $\geq$ 10,000 ha. of culturable command area come under category A and below < 50 MW $\geq$ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs $\geq$ 25 MW required Environmental Clearance from the MoEF and respective SEIAA.

MoEF-Ro for EB (ToR 3.1)

In summary, on the basis of the monitoring report, it has been noticed that the major non-compliances were noticed on the following issues:

1. Execution of catchment area treatment (CAT) plan. It has been found that in majority of cases project proponents deposited the appropriate fund in CAMPA etc. The State forests department has not executed/started the work.

2. Compensatory Afforestation of native species on the reservoir area or near to project site. It has been noticed that in major cases project proponents deposited the appropriate fund in CAMPA. State forests department has not executed/started the work.

3. Biodiversity conservation and its managment need to implemented in totality.

4. For State Governmnet, private owners of HEPs the compensatory afforestaion land should be non forests land. However, in the most of the cases CA is permitted on double degraded forests land.

5. The project falls within 10 km from the boundary of National Parks/Santuries required prior permission/approval of NBWL. In most of the cases it has been noted that the project proponents statared the construction work without obtaining the NBWL permission.

6. Most of the project proponents have not demarcated the forests land by making boundry pillers. It should be done prior to strat any construction work.

7. Muck disposal and its management (Slope, toe wall, plantation etc.). In all cases it has been noticed that the project proponent has not properly managed the muck disposal site and its management.

8. Development of fish nursery. It has been noticed that in major cases project proponents deposited the appropriate amount to the state government, and they have not executed/started the work.

9. Minimum lean season flow not been propely mainatined.

10. In addition to the conditions stipulated by Minsitry of Environment and Forests, Number of projects proponents have not taken requsite permission (Consent to Establish/Operate/Hazardous waste) from Uttarakhand Environment Protection and Pollution Control Board (UEEPCB) for batching plant, DG sets, power house etc. and subsequently its compliance.

11. Number of hydropwoer projects constructed the colony/houses for the staff, without any Sewage Treatment Plant (STP), solid waste management etc. They have disposed off their liquid/solid waste directly or indirectly to the respective river.

Table : 3.2 Status as on March 2014 of under construction HEPs Forest Clearance and Environment Clearance in various HEPs of Alkananda and Bhagirathi Basin

S.N	Name of HEP	Capacity (MW)	River/ Tributary/ Gad etc.	Forest Area Approved (ha)	Forest Clearance Date	Environment Clearance with date*	Distance from NP/ Sanctuary**	Remarks
1	Asi Ganga I	4.5	Asi Ganga/Bhagirathi	1.24	24/8/2010	NA	It is in Gangotri Eco Sensitive Zone	• Damaged in 2012 • FC stand cancel due to non mutation of civil-soyam land
2	Asi Ganga II	4.5	Asi Ganga/Bhagirathi	1.58	19/8/2010	NA	It is in Gangotri Eco Sensitive Zone	• Damaged in 2012 • FC stand cancel due to non mutation of civil – soyam land
3	Kaladigad	9.0	Kaladi Gad/ Bhagirathi	2.351	04/3/2008	NA	It is in Gangotri Eco Sensitive Zone	• CA on Nalda Soyam Land should be muted and notified as RF/PF within three month. The work could be resumed.
4	Limchigad	3.5	Limchigad/ Bhagirathi	0.99	13/4/2006	NA	It is in Gangotri Eco Sensitive Zone	_
5	**Bhairon Ghati***	381.0	Bhagirathi	PNS	PNS	PNS	It is in Gangotri Eco Sensitive Zone	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued. • WII report found significantly impacting the Biodiversity of valley.
6	**Lohari Nagpala***	600.0	Bhagirathi	139.03	2/8/2005	8-38/2005-FC dt 02.08.2005	It is in Gangotri Eco Sensitive Zone	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued. • EC and FC should be revoked. • Restoration work should be required. • Ministry of Power has provided Rs. 436 crs to NTPC as compensation.
7	**Pala Maneri***	480.0	Bhagirathi	53.3	6/6/2006	J-12011/34/ 2005.IA.I dt 07.12.2005	It is in Gangotri Eco Sensitive Zone.	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued.
8	**Tehri PSP***	1000 (4x250 MW)	Bhagirathi	NA	NA	2-19/81-HCT/IA01 dt. 14.07.1990	_	• Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-

								gabion walls and plantation on muck disposal site. • Fish nurseries not developed.
9	**Kotlibhel-IA***	195.0	Bhagirathi	261.047	In principal approval on 13.10.2011	J-12011/5/ 2007-IA.II Dt. 09.05.2007	_	• Final FC is awaited. • WII report found significantly impacting the Biodiversity of valley.
10	Kaliganga-II	6.0	Kali ganga/Mandakani	3.13	6/3/2007	NA	Approximately 2.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA on double degraded forest land.
11	Mad Maheshwar	15.0	Mandakini	5.0	6/3/2007	NA	Approximately 2.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA on double degraded forest land.
12	**Phata Byung***	76.0	Mandakini	16.37	2/5/2008	J-12011/64/ 2007-IA.I, Dt. 18.03.2008	It is approximately 1.0 Km from Kedarnath Wild Life Sanctuary.	• Damaged in 2013 devastation. • CA on double degraded forest land. • N.B.W.L recommendation is not obtained. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not developed. • CAT plan are not executed so far.
13	**Singoli Bhatwari***	99.0	Mandakini	34.34	16/1/2009	J-12011/50/ 2007-IA.I, Dt. 24.08.2007	Approximately 6.0 Km from Kedarnath Wild Life Sanctuary	• Damaged in 2013 devastation. • CA land is not mutated and notified within six month of the forest clearance. • Forest clearance stands cancel by 15.07.2009 due to non mutation of non forest land. • Permission not taken from NBWL. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not developed.

								• CAT plan are not executed so far.
14	Bhyundar ganga	24.0	Bhyundar ganga	4.89	19/2/2009	NA	Approximately 7.0 Km from Valley of Flower NP	• Forest clearance stands cancel on the 18.8.2009 due to non mutation of civil-soyam land. Work continued in violation of FCA (1980). • Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
15	**Lata Tapovan***	171.0	Dhauli ganga/ Alaknanda	70.83	30/4/2007	J-12011/57/ 2006-IA.I dt 21.02.2007	Approximately 4.5 Km from Nandadevi NP	• Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
16	**Tapovan Vishnugarh***	520	Dhauli Ganga	76.00	13/3/2000	J-12011/36/ 2004-IA.I dt 08.02.2005	Approximately 7.0 Km from Nandadevi NP	• Permission not taken from NBWL. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site.
17	**Vishnugarh Pipal Kothi***	444.0	Alaknanda	80.507	28/5/2013	J-12011/29/2007-IA.I dt. 22.08.2007	Approximately 1.0 Km from Kedarnath Wild Life Sanctuary	• The Forest land is not mutated in favour of Forest Department and notified as PF/RF • Permission obtained from NBWL.
18	**Srinagar HEP***	330.0	Alaknanda	338.06	15/4/87	J-11016/8/ 1982-Env, 5 dt 03.05.1985	_	• The CA land is provided in Lalitpur, Jhansi district of UP. • Muck disposal management need to be review and constructed above 1 m. of HFL and maintained proper sloping of the muck, sausage-gabion walls and plantation on muck disposal site. • Fish nurseries not develop. • CAT plan are not executed so far.

The Regional Office MoEF has taken appropriate action in conformity/compliances of guidelines of Forest (Conservation) Act, 1980, Environmental (Protection) Act, 1986 and Direction of Hon'ble Supreme Court. Action taken report has also been enclosed with monitoring report.*As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects ≥ 50 MW hydroelectric power generation; and ≥ 10,000 ha. of culturable command area come under category A and below < 50 MW ≥ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs ≥ 25 MW required Environmental Clearance from the MoEF and respective SEIAA. ** Distance from boundary of National Park/Wildlife Sanctuary mention on the basis of information provided by concerned Divisional Forest Officers/ measurement from the scaled map.

ToR 3.3 Status as on March, 2014 of Forest Clearance and Environment Clearance of 24 HEPs given by WII in Bhagirathi and Alaknanda River Basins

On the basis of the available records up to March, 2014 in the Regional Office, Ministry of Environment and Forests, Lucknow, the present status of the above project are as follows:

SN	Contents	No.	Name of tHEPs
Under Forest (Conservation) Act, 1980			
xvii.	Number of HEPs required Forest Clearance	24	Jhala Koti, Bhairon Ghati, Lata Tapovan, Bhyundar Ganga, Kotlibhel-1A, Alaknanda Badrinath, Khirao Ganga, Bal Ganga-II, Jalandrigad, Siyangad, Kakorgad, Karmoli, Jadganga, Rambara, Kotlibhel-1B, Urgam-II, Malari Jhelam, Jhelam Tamak, Tamak Lata, Rishi Ganga-I, Rishi Ganga-II, Birahi Ganga, Kotlibhel-II, Gohana Tal.
xviii.	Number of HEPs applied for Forest Clearance	08	Jhala Koti, Lata Tapovan, Bhyudar Ganga, Kotlibhel-1A, Alaknanda Badrinath, Khirao Ganga, Kotlibhel-1B, Kotlibhel-II.
xix.	Number of HEPs accorded final Forest Clearance	05	Jhala Koti, Lata Tapovan, Bhyudar Ganga, Alaknanda Badrinath, Khirao Ganga.
xx.	Number of HEPs accorded in principle approval for Forest Clearance	01	Kotlibhel-1A
xxi.	Number of HEPs in which Forest Clearance stands canceled due to non compliance of condition.	01	Bhyudar Ganga
xxii.	Number of HEPs in which Forest Clearance was rejected	02	Kotlibhel-1B, Kotlibhel-II
xxiii.	Number of HEPs in which forest proposals have not submitted to the Ministry	16	Bhairon Ghati, Bal Ganga-II, Jalandrigad, Siyangad, Kakorgad, Karmoli, Jadganga, Rambara, Urgam-II, Malari Jhelam, Jhelam Tamak, Tamak Lata, Rishi Ganga-I, Rishi Ganga-II, Birahi Ganga, Gohana Tal.
xxiv.	Number of HEPs which are closed by NGBRA/GOM	Nil	--
Under Environment (Protection) Act, 1986 (EIA Notification, 2006)			
xxii.	Number of HEPs requires Environmental Clearance*	15	Bhairon Ghati, Lata Tapovan, Kotlibhel-1A, Alaknanda Badrinath, Karmoli, Jad Ganga, Rambara, Kotlibhel-1B, Malari Jhelam, Jhelam Tamak, Tamak Lata, Rishi Ganga-I, Rishi Ganga-II,

			Kotlibhel-II, Gohana Tal.
xxiii.	Number of HEPs have applied Environmental Clearance	09	Lata-Tapovan, Kotlibhel-1A, Alaknanda-Badrinath, Rambara, Kotlibhel-1B, Malari Jhelam, Jhelam Tamak, Tamak Lata, Kotlibhel-II.
xxiv.	Number of HEPs accorded Environmental Clearance	05	Lata Tapovan, Kotlibhel-1A, Alaknanda-Badrinath, Kotlibhel-1B, Kotlibhel-II.
xxv.	Number of HEPs rejected/withdrawn Environmental Clearance	01	Kotlibhel-1B.
xxvi.	Number of HEPs in which. Env Clearance in TOR/clearance stage.	04	Rambara, Malari Jhelam, Jhelam Tamak, Tamak Lata
xxvii.	Number of HEPs in which proposal for Environmental Clearance is not submitted	06	Bhairon Ghati, Karmoli, Jadganga, Rishi Ganga-I, Rishi Ganga-II, Gohana Tal.
xviii.	Number of HEPs which are within National Park/Wildlife Sanctuaries	02	Rishi Ganga-I, Rishi Ganga-II.
xxix.	Number of HEPs which falls within 10 Km of National Park/Wildlife Sanctuary.	08	Lata Tapovan, Bhyudar Ganga, Alaknanda Badrinath, Khirao Ganga, Rambara, Urgam-II, Jhelam Tamak, Tamak Lata.
xxx.	Number of HEPs which falls within 10 Km from boundary of National Park/Wildlife Sanctuary and requires permission from National Board for Wild Life.	06	Lata Tapovan, Alaknanda Badrinath, Rambara, Urgam-II, Jhelam Tamak, Tamak Lata.
xxxi.	Number of HEPs which have taken permission from National Board of Wild Life.	Nil	--
xxxii.	Number of HEPs which are coming in Gangotri Eco-Sensitive Zone	06	Bairon Ghati, Jalandrigad, Siyalgad, Kakorgad, Karmoli, Jadganga.

***** As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects $\geq$ 50 MW hydroelectric power generation; and $\geq$ 10,000 ha. of culturable command area come under category A and below < 50 MW $\geq$ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs $\geq$ 25 MW required Environmental Clearance from the MoEF and respective SEIAA.

Table: 3.3 Status as on March, 2014 of Forest Clearance and Environment Clearance of 24 HEPs given by WII in Bhagirathi and Alakananda River Basins

S.N	Name of HEP	Capacity (MW)	Status	River/ Tributary/ Gad etc.	Forest Area Approved (ha)	Forest Clearance Date	Environment Clearance with date*	Distance from NP/ Sanctuary (within 10 KM)**	Remarks
Under Construction /Work not started									
1.	Jhala Koti	12.5	Work yet not started	Balganga/ Bhagirathi	4.49	10/7/2006	NA	_	• CA on double degraded forest land. It should be on non-forest land. • WII report found significantly impacting the Biodiversity of valley. • Due to agitation by local people the work has not been started.
2.	**Bhairon Ghati***	381.0	Under Construction / Closed	Bhagirathi	PNS	PNS	PNS	It is in Gangotri Eco Sensitive Zone	• N.G.R.B.A meeting under Chairmanship of PM, dated 1/11/2010, the project was discontinued. • WII report found significantly impacting the Biodiversity of valley.
3.	**Lata Tapovan***	171.0	Under construction (Work started in non forest land and only road construction in forest land)	Dhauliganga/Alaknanda	70.83	30/4/2007	J-12011/57/ 2006-IA.I dt 21.02.2007	Approximately 4.5 Km from Nandadevi NP	• Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
4.	Bhyundar ganga	24.0	Under construction (About 25% work accomplishe	Bhyundar Ganga	4.89	19/2/2009	NA	Approximately 7.0 Km from Valley of Flower NP	• Forest clearance stands cancel on the 18.8.2009 due to non mutation of civil-soyam land. Work continued in violation of FC Act (1980). • Permission not taken from NBWL.

			d)						• WII report found significantly impacting the Biodiversity of valley.
5.	**Kotlibhel-IA***	195.0	Under Construction (Initial level of Construction in non forest land)	Bhagirathi	261.047	In principal approval accorded on 13/10/2011	J-12011/5/2007-IA.II Dt. 09.05.2007	_	• Final FC is awaited. • WII report found significantly impacting the Biodiversity of valley.
6.	**Alaknanda Badrinath* (GMR)**	300	Work not started	Alaknanda	30.0	9/11/2012	J-12011/1/2008-IA.I, dt. 3/12/2008	Approximately 4.0 Km from Valley of Flower NP	• CA on double degraded forest land. It should be non forest land. • Permission not taken from NBWL. • WII report found significantly impacting the Biodiversity of valley.
7.	Khirao ganga	4.5	Work not started	Khirao Ganga	3.58	22/12/10	NA	Approximately 4.5 Km from Valley of Flower NP	• Whole valley is damaged in 2013 devastation. • WII report found significantly impacting the Biodiversity of valley.
Proposed HEPs									
8.	Bal Ganga II	7.0	Proposed	Balganga/ Bhagirathi	PNS	PNS	NA	_	• User agency has not submitted proposal for FC. • WII report found significantly impacting the Biodiversity of valley.
9.	Jalandrigad	24.0	Proposed	Jalandrigad	PNS (13.21)	PNS	NA	It is in Gangotri Eco Sensitive Zone	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
10.	Siyangad	11.5	Proposed	Siyangad/ Bhagirathi	PNS (4.99)	PNS	NA	It is in Gangotri Eco Sensitive Zone	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
11.	Kakoragad	12.5	Proposed	Kakoragad/ Bhagirathi	PNS (4.96)	PNS	NA	It is in Gangotri Eco Sensitive Zone	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
12.	**Karmoli***	140.0	Proposed	Jadganga/	9.9	PNS	PNS	It is in Gangotri	• FC and EC proposal not submitted.

				Bhagirathi				Eco Sensitive Zone	• WII report found significantly impacting the Biodiversity of valley.
13.	**Jadganga***	50.0	Proposed	Bhagirathi/ Jadganga	8.35	PNS	PNS	It is in Gangotri Eco Sensitive Zone	• FC and EC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
14.	**Rambara***	76.0	Proposed	Mandakini	PNS	PNS	TOR	Within 10 km of the Kedarnath Wild life Sanctuary	• FC proposal not submitted. • In June, 2013 devastation, the entire Rambara town was washed away. • WII report found significantly impacting the Biodiversity of valley.
15.	**Kotlibhel IB***	320.0	Proposed	Alaknanda	496.793	Rejected on 7/7/2011	J-12011/21/2007.IA.I dt 14.08.2007	_	• EC withdrawn on 22/11/2010. • WII report found significantly impacting the Biodiversity of valley.
16.	Urgam-II	5.0	Proposed	Kalp ganga/ Alaknanda	PNS	PNS	NA	Within 10 Km of Kedarnath Wildlife Sanctuary	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
17.	**Malari Jhelum***	114.0	Proposed	Dhauliganga /Alaknanda	PNS	PNS	TOR	_	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
18.	**Jhelam* Tamak**	128.0	Proposed	Dhauliganga /Alaknanda	PNS	PNS	TOR	Approximately 3 Km from Nandadevi NP	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
19.	**Tamak Lata***	280.0	Proposed	Dhauliganga /Alaknanda	PNS	PNS	TOR	Approximately 3 Km from Nandadevi NP	• FC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
20.	**Rishiganga-I***	70.0	Proposed	Rishi ganga/ Dhauliganga	PNS	PNS	PNS	Within Nanda Devi NP	• FC and EC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
21.	**Rishiganga-II***	35.0	Proposed	Rishi ganga/ Dhauliganga	PNS	PNS	PNS	Within Nandadevi NP	• FC and EC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.
22.	Birahi anga I	24.0	Proposed	Birahi	PNS	PNS	NA	_	• WII report found significantly impacting the

				ganga/ Alaknanda					Biodiversity of valley.
23.	**Kotlibhel-II***	530.0	Proposed	Ganga	680.095	Rejected on 5/7/2011	J-12011/49 /2007-IA.I dt 23/08/ 2007	_	• WII report found significantly impacting the mahasheer fish and biodiversity of valley.
24.	**Gohana Tal***	50.0	Proposed	Birahi ganga	PNS	PNS	PNS	_	• FC and EC proposal not submitted. • WII report found significantly impacting the Biodiversity of valley.

Note: PNS, Proposal not submitted; TOR, Term of Reference; NA, not applicable; MW, Mega watt; NP; National Park; NFL, non forest land; CA Compensatory afforestation; FC, Forest Clearance; EC, Environmental Clearance; FCA, Forest Conservation Act.

The Regional Office MoEF has taken appropriate action in conformity/compliances of guidelines of Forest (Conservation) Act, 1980, Environmental (Protection) Act, 1986 and Direction of Hon'ble Supreme Court. Action taken report has also been enclosed with monitoring report.

*As per the EIA Notification, 2006, in point 1-C i.e., River Valley projects ≥ 50 MW hydroelectric power generation; and ≥ 10,000 ha. of culturable command area come under category A and below < 50 MW ≥ 25 MW hydroelectric power and < 10,000 ha. of culturable command area are come under category B. Overall it means that the HEPs ≥ 25 MW required Environmental Clearance from the MoEF and respective SEIAA.
** The distance from boundary of National Park/Wildlife Sanctuary mention on the basis of information provided by concerned Divisional Forest Officers/ measurement from the scaled map.

Chapter 6

TOR 3.1A: Study Current State of Himalayan Glaciers and Impact of HEPs on glaciers, as well as the impact of receding glaciers on HEPS

1. Introduction

Glaciers are naturally regulated reservoirs that reduce the inter-annual runoff variability by increasing flow during summer and by storing water as ice and snow during winter. Changes in the size and volume of glaciers reflect the integrated response of a glacier to changes in precipitation and the surface energy budget that result from climatic fluctuation. Hence changes in glacier mass provide unique information on climate variability with space and time.

A glacier is a large mass of ice formed by the compaction and re-crystallization of snow, moving slowly down slope or outward by creep under the stress of its own weight. It can be differentiated into three zones, viz., the accumulation, ablation and terminus zones (Figure 1). Accumulation is the zone where ice is being continuously accumulated through snowfalls, ablation is the zone where the loss of glacier ice occurs by melting and terminus is the end of a glacier from where the melt water emerges and forms stream.

The accumulation zone is easily identifiable as a clear white snow/ice surface devoid of any surface moraines. The ablation area is wet, dirty and rubble covered. The glacier surface is marked by melt water channels, ponds and occasionally with the presence of supra-glacial lakes. The terminus is also called the snout. It is always moving, either advancing or retreating. Its position is used to determine changes in glacier length over a period of time.

Glaciers and their environment provide essential knowledge of the present, past and future environmental conditions. During the Quaternary period (last 2 million years) waxing and waning of glaciers in response to climatic changes have shaped some of the spectacular landscapes on Earth and deposited glaciogenic sediments far away from the present day glacier limits.[1]

[1] WGMS (1989): *World glacier inventory - Status 1988.* Haeberli, W., Bösch, H., Scherler, K., Østrem, G. and Wallén, C. C. (eds.), IAHS (ICSI) / UNEP / UNESCO, World Glacier Monitoring Service, Zurich, Switzerland: 458 pp.

Figure 1: A valley glacier showing different zones

The most recent glacier advance in the Himalaya corresponds to the Little Ice Age (LIA) 1550-1850 A.D.[2, 3]. Following this there was a gradual retreat with an exception during 1950–1980 when a marginal increase or standstill condition due to global cooling was observed. Since then, the glaciers are receding continuously with varying rates[4]. The temporal coincidence of glacial retreat with the measured increase of greenhouse gases is often cited as evidence of anthropogenic global warming. Mid-latitude mountain ranges such as the Himalaya show some of the largest proportionate glacial loss.

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2 Kamp, U., Byrne, M., and Bolch, T., Glacier fluctuations between 1975and 2008 in the Greater Himalaya Range of Zanskar, southern Ladakh. *Journalof Mountain Science*, 2011, *8,* 374-389. DOI: 10.1007/s11629-011-2007-9

3 Bolch, T.**,* Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, G.,Frey, H., Kargel, J.S., Fujita, K., Scheel, M., Bajracharya, S. andStoffel, M. The State and Fate of Himalayan Glaciers. *Science*, 2012,*336*(6079),310-314. DOI: 10.1126/science.1215828

4 Bhambri, R., Bolch, T., Chaujar, R.K. and Kulshreshtha, S.C. (2011): Glacier changes in the Garhwal Himalayas, India 1968–2006 based on remote sensing. Journal of Glaciology, 2001, 57(203), 543- 556.

2. Glaciers in the Uttarakhand Himalaya

Glaciers occupy about 10% (~ 16 million Km^2) of the Earth's land area but hold about 77% of its fresh water. More than 96% of glacier ice lies in the Polar Regions. The Indian Himalaya has about 9575 glaciers with an estimated area of 37,466 Km^2

Table 1: Distribution of glaciers in different states of Indian Himalaya

State	Glaciers	Area (Km^2)	Average size (Km^2)	Glacier %
Jammu & Kashmir	5262	29163	10.24	55.0
Himachal Pradesh	2736	4516	3.35	28.0
Uttarakhand	968	2857	3.87	10.0
Sikkim	449	706	1.50	5.0
Arunachal Pradesh	161	223	1.40	2.0

Source: Raina and Srivastva, 2008[5]

Uttarakhand has 968 glaciers covering 2,896 $Km^{2.}$. They provide perennial fresh water to the Yamuna, Bhagirathi, Alaknanda and Kali river systems (Figure 2) and play a critical role in hydropower development in Uttarakhand state. These glaciers generally extend between 6500 m (head) and 3800 m (snout). However, the regional snow line fluctuate between 5000 and 5100m asl and the winter snow line descends up to 2200-2500 masl The Uttarakhand Himalaya is climatically dominated by both the monsoon (ISM) and westerly and is fed by summer monsoon and winter snow regimes. However, maximum snowfall occurs in the region between December and March, mostly due to western disturbances[6].

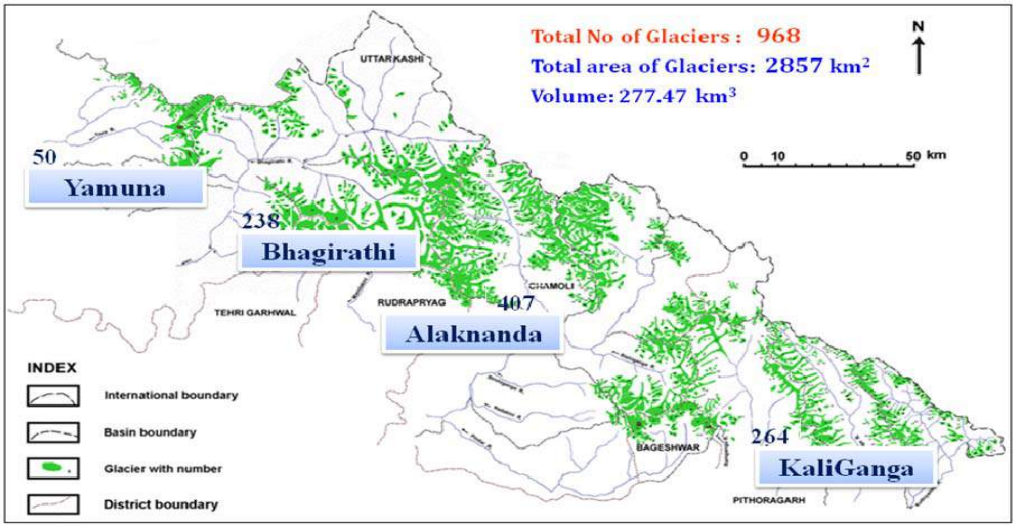

Figure 2: Distribution of glaciers in different river basin of Uttarakhand Himalaya (Raina and Srivastava, 2008)

[5] Raina, V.K. and Srivastava, D. (2008). Glacier atlas of India. Geological Society of India, Bangalore, 316 pp.

[6] Dobhal, D.P., Gergan, J.T. and Thayyen, R.J. (2008). Mass balance studies of the Dokriani Glacier from 1992 to 2000, Garhwal Himalaya, India. Bulletin of Glaciological Research, 25, 9-17.

The Bhagirathi and Alaknanda rivers are major tributaries of the Ganga river. The Bhagirathi originates from the Gangotri Glacier (4000 masl) at Gaumukh. It is the largest valley glacier (~30 km) in the Uttarakhand (Figure 3) with contributions from 238 small and medium glaciers covering an area of ~759 km^2. The headwater of the Alaknanda River originates from the snouts of Bhagirathi Kharak and Satopanth glaciers. The Alaknanda basin has 407 glaciers spread over an area of ~1255 km^2. Some statistics of Uttarakhand glaciers are summarised in table 2.

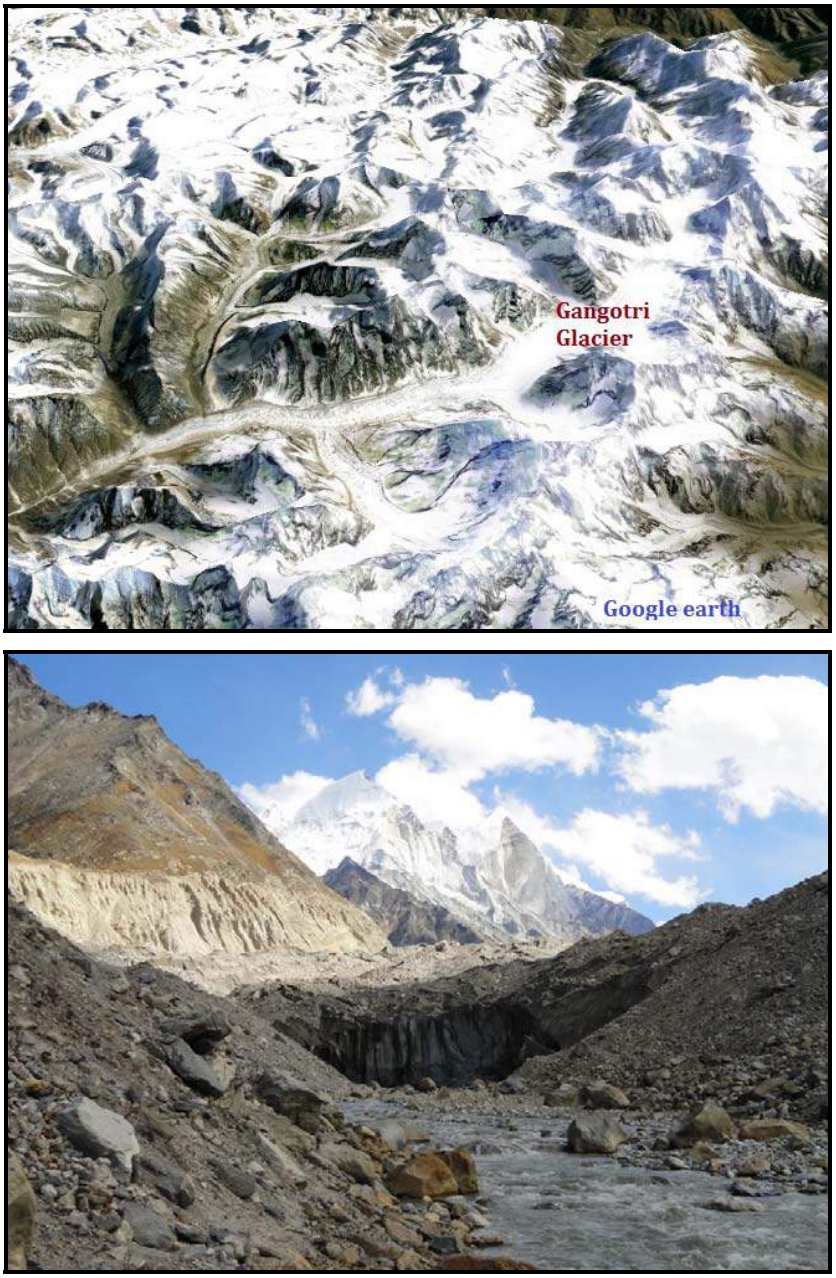

Figure 3: Satellite view (up) and snout (below) of Gangotri Glacier

Table 2: Summarized statistics for the glaciers in river basins of Uttarakhand

Basins/ Parameters	Yamuna	Bhagirathi	Alaknanda	Kali
Basin area (km^2)	10688	7502	11132	8798
Glacierised area (km^2)	205.00	755.00	1204.00	969.00
Glacierised area %	6.5	24.1	38.4	31.0
No of Glaciers	52	238	407	271
Length				
>5km	05	32	49	27
<5km	47	206	358	244
Area				
>5 km^2	08	30	53	26
<5 km^2	44	208	354	245
Types: (%)				
Valley	41	62	48	73
Mountain	59	38	52	27
Orientations (%)				
North facing	35	23	35	80
South facing	46	69	48	07
East &West	19	08	17	13
Largest glacier	Jauloni	Gangotri	Nanda Devi	Milam
a) Length, km	17.0	30.0	19	18.0
b) Area, km^2	143.58	143.58	55.93	54.95
c) Av.Thickness,(m)	60	110	95	80
Elevation (m. asl)				
Maximum	7100	6900	6600	6600
Minimum	4000	4000	4040	4200
Relief Ratio	0.10	0.26	0.26	0.20
Snout Elevation (m. asl)	4040	4150	4130	4240

4. Glacier lakes in Uttarakhand

A glacier lake inventory of Uttarakhand has been created using Landsat images.[7] It shows 127 small and large lakes in its four major river basins. Alaknanda has 57, followed by Bhagirathi 32, Yamuna 20 and Kali 21. They are mainly located in the glacierised and periglacial regions (above 3000m asl). The lakes outline in the area is mainly moraine-dammed, blocked trough lakes, erosion lakes and Supraglacial Lake[8] (WIHG 2013).

In addition a study on glacier lake inventory for Mandakini basin has identified 14 lakes in the Mandakini basin[8]. They are located above 3700 m a.s.l. (Figure 4) and cover an area of 343,478 m^2. Vasuki Tal is the largest lake (74,656 m^2) in the basin.

[7] Sah, M., G. Philip, Mool, P.K., Bhajracharya, S. and Shrestha, B. (2005): Uttaranchal Himalaya India: Inventory of Glaciers and Glacial Lakes and the Identification of Potential Glacial Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of Himalayan Region. International Centre for Integrated Mountain Development, Kathmandu, 176 pp.

[8] WIHG (2013). Technical report on Chorabari Glacier. Submitted to DST New Delhi, 1-65.

Recently, Chorabari lake (Gandhi Sarovar; 25,445 m^2) which breached on June 17th, 2013 and was responsible for the flash flood in the Kedarnath valley. This was not a glacial lake outburst flood (GLOF). It was formed by an obstruction created by the right mountain flank and bordered by lateral moraines of Chorabari Glacier and was rain and snow melting feeded.[9]

It was not genetically related to the glacier meltwater fluctuations. Interpretation of satellite images and field mapping shows that its area fluctuates significantly in different seasons. Extreme rainfall during the 15-16 June, 2013 increased the volume of Chorabari Tal and simultaneously triggering of huge snow avalanche in to the lake (17th June,2013 morning,6.45am) causing it to burst[9]. This suggests growth of Chorabari Tal is an infrequent short-lived event and thus a challenge to monitor the lakes, located in the glaciated terrains.

The lakes which are developed in front and margin of a glacier are more prone to GLOFs. The receding glaciers left behind large debris deposit, dammed in some cases by unstable natural moraines dams. These moraine dams are comparatively weak and can breach suddenly, leading to the sudden discharge of huge volumes of water and debris. The resulting glacial lake outburst can cause catastrophic flooding downstream, with severe damage to life, property, forests, farms, and infrastructure[10].

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[9] Dobhal, D.P., Gupta, A.K., Mehta, M. and Khandelwal, D.D. (2013a). Kedarnath disaster: facts and plausible causes. Current Science, 105(2), 171-174.

[10] ICIMOD (2011). Glacial lakes and glacial lake outburst floods in Nepal. Kathmandu, Nepal, 64 pp.

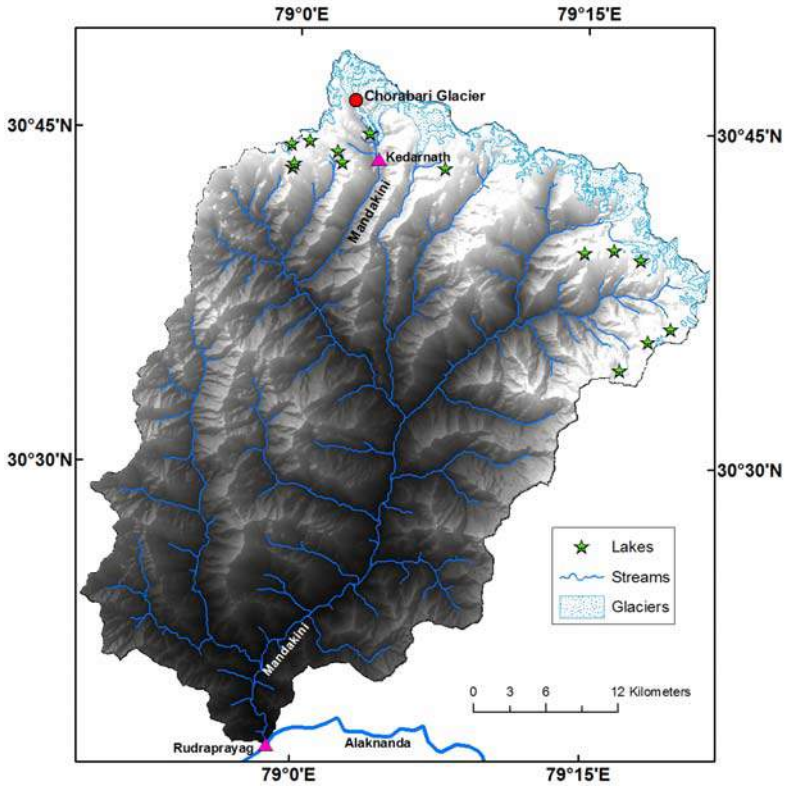

Figure 4: Lakes in Mandakini valley, Garhwal Himalaya. Glacier outlines are based on Global Land Ice Measurements from Space (GLIMS) database. The black and white coded elevation is based on SRTM3 data.

Supra glacial lakes are very common and mainly developed within the ice mass (glacier) with dimensions from <5 to 15m. They are temporary, unstable and the size and numbers may be different year to year depend on the surface and melting of ice. The characteristic feature of these lakes is quick draining and do not make threats.

5. Glacier melts -water contribution and storage

The water discharges from the glacier area in mountain river system pay vital role in the mountain hydrology. The water discharge contribution from glacier area comprise of sow, glacier ice melt runoff and monsoon rain. In terms of snow and glacier melt contribution, November to March is the lean season whereas at the contribution peak during the summer months month of July and August (Figure 5). Maximum discharge takes place between mid July and August.

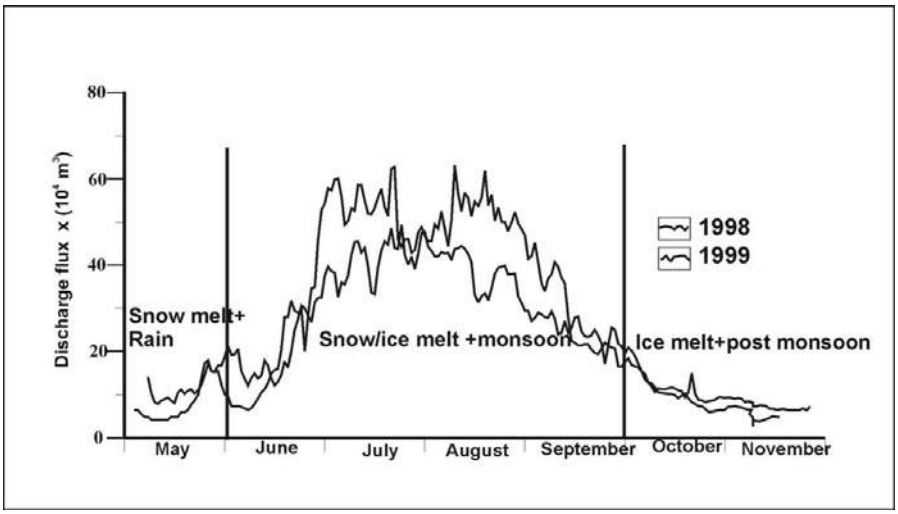

Figure 5: Contribution of discharge from glacierised area - an example from Dokriani Glacier, Bhagirathi river basin, Uttarakhand.

Study has been made to quantify the snow and glacier melt contribution reveals that glacial melt from Gangotri Glacier (147km^2) during 1999 and 2000 (May to October) calculated was 565x10^{6}m^3 and 479 x10^{6}m respectively[11]. Similarly the measurements made during 1998, 1999 and 2000 for Dokriani Glacier(7km^2) which significantly small glacier in the Bhagirathi valley contributed 52.3x10^6 m^3, 42.7x10^6 m^3 and 56.1 x 10^6 m^3 respectively. Recent study based on isotope hydrology (at Rishikesh) show the contribution of glacial ice-melt to the stream discharge peaks during summer and monsoon reaches a maximum value ~40% with an average of 32%[13]

Melt water storage characteristics of the glacier are much stronger in the early part of the melt season which weakens as the melt season progresses. Diurnal variations in the discharge are clearly observed with advancement of the melt season providing variations in the timing of peak flow. A strong seasonal trend towards increasing diurnal amplitude in discharge until August and thereafter a decreasing trend were observed (Figure 5)**.**

Suspended Sediment Transfer

The Himalayan river carry 1.79 Gt year^{-1} of suspended sediments[14], nearly 9% of total annual load carried from continent to the ocean worldwide. High rate of surface erosion is attributed to the continuing tectonic activity in the region.

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[11] Kumar, K., Joshi, V., Miral, M.S. and Joshi, L.M. (2003). Hydrology and suspended sediment of Gangotri Glacier, Garhwal Himalaya. Proce. Workshop on Gangotri Glacier, March 2003. Geological Survey of India, Special volume, 80, 195-203.

[12] Thayyen, RJ, Gergan, J.T and Dobhal, D.P. (2007). Role of glaciers and snow covered on Headwater River Hydrology in Monsoon region-Micro scale study of Din Gad catchment (Dokriani Glacier) Garhwal, Current Science, 92 (3), 376-382.

[13] Maurya, A.S., Shah M., Deshpande, R.D., Bhardwaj, R.M., Prasad, A., Gupta, S.K. (2011). Hydrograph separation and precipitation source identification using stable water isotopes and conductivity: River Ganga at Himalayan foothills. Hydrological Processes, 25 (10), 1521-1530.

[14] Meybeck, M. (1976). Total mineral transport by World Rivers. Hydrological Science Bulletin, 21, 265–284.

Presence of strong monsoonal rain in July August and September months contribute to the acceleration of erosion processes. The influence of the glaciers high up in the head water of the Himalayan rivers contributed substantial amount of sediments.

Melt water streams, originating from a glacier, carry sediment load partly in suspension and partly as bed load. In general glacier melt stream, from even a small glaciers (5km²), can transport as much as 4,000-5,000 tonnes of suspended sediment during the high discharge period of the melt season. On an average, sediment load producing capacity of the glacier ice in the Himalayas has been found to be of the order of 30 tonnes per day per km² of ice during the melt season in a granite / gneissic terrain, which is rather very low when one compared with those of the glaciers in Alps[15].

6. Recession trend of Uttarakhand Glaciers

The glaciers in Uttarakhand are well known for their recession on various time scales and have fluctuated between the wide limits. Pindari Glacier was the first glacier that was monitored in 1845[16] and has retreated by about 2840m during the period from 1845 to 1966. Systematic glacier snout observation was initiated during the International Hydrological Decade (1965-74). Since then a continuous observation of glacier snout has been carried out in different parts of the Uttarakhand Himalaya. Table 3 shows the fluctuation records and patterns of recession with time scale of few monitored glacier in the Uttarakhand region considering rate of recession of theses glaciers, it has been reported that they are generally in state of recession and the rate of retreat is ranges between 05 to 20m/yrs (Milam, Shankulpa and Poting glaciers in Kaili ganga; Dunagiri, Pindari, in Alaknadanda and Gangotri glacier in Bhagirathi river basin has largest record of their recession'[17,18,19,20,21,22,23].

[15] Raina, V.K. (2009); Himalayan Glaciers: A state-of-Art review of glacier studies, Glacier Retreat and Climate change. Submitted to Ministry of Environment and Forest, Government of India, New Delhi, 56 pp.

[16] Madden, E (1847). Notes on an excursion to the Pindaree Glacier in September 1846. Journal of the Asiatic Society of Bengal, 17, 340–450.

[17] Puri V.M.K. and Shukla S.P. (1995). Tongue fluctuation studies on Gangotri Glacier, Uttarkashi District, Uttar Pradesh, Geological Survey of India, Special Publication 21, 289–291.

[18] Shukla, S.P. and Siddqui, N.M.A (2001). Recession of snout front of Millam Glaciers, Goriganga valley, Pithoragarh District, Uttar Pradesh. In: Proceeding of symposium on Snow Ice and Glacier: A Himalayan Perspective, Lucknow, 9-11 March 1999 Geological Survey of India, Special Publication 5.

[19] Srivastava, D. and Swaroop, S. (2001). Oscillations of snout of Dunagiri Glacier. Geological Survey of India, Special Publication 53, 83-85.

[20] Niathani, A.K., Nainwal, H.C, Sati, K.K. and Prasad, C. (2001). Geomorphological evidence of retreat of the Gangotri glacier and its characteristics. Current Science, 80, 87-94.

[21] Dobhal, D.P., Gergan, J.T. and Thayyen, R.J. (2004). Recession and Morpho geometrical changes of Dokriani Glacier (1962-1995), Garhwal Himalaya, India. Current Science, 86 (5), 101-107.

[22] Kulkarni A.V., Bahuguna, I.M, Rathore, B.P., Singh, S.K., Randhawa, S.S., Sood, R.K. and Dhar, S. (2007). Glacial retreat in Himalaya using Indian remote sensing satellite data. Current Science, 92 (1), 69-74.

[23] Nainwal, H.C., Negi, B.D.S., Chaudhary, M., Sajwan, K.S., Gaurav, A. (2008). Temporal change in rate of recession: Evidence from Satopanth and Bhagirathi Khark Glacier, Uttarakhand using Total station survey. Current Science, 94 (5), 653-660.

Table 4: Snout recession of the Himalayan glaciers (modified after Vohra, 1981)

Name of Glacier	River basin	Length (Km)	Period	Recession (in m)	Average rate (m/yr.)
Milam glacier	Goriganga	16.0	1849-1957 1954-2006	1350 1328	12.5 25.0
Pindari glacier	Pindar river	3.5	1845-1966 1966-2010	2840 379	23.4 8.6
Gangotri glacier	Bhagirathi	30.0	1935-1996 1971-2004	1220 565	20.0 17.0
Tipra glacier	Alaknanda	6.0	1962-2002 2002-2008	535 128	13.4 21.0
Dokriani glacier	Bhagirathi	5.5	1962-1991 1991-2000 2000-2010	480 161 170	16.5 17.8 17.0
Chorabari glacier	Alaknanda	7.0	1962-2003 2003-2007	196 41	4.8 10.2
Shankulpa glacier	Goriganga	10.0	1881-1957	518	6.8
Poting glacier	Goriganga	--	1906-1957	262	5.13
Glacier No-3	Alaknanda	--	1932-56	198	8.25
Sathopanth	Alaknanda	14.0	1962-2005 2005-06	1157 6.5	26.9 6.5
Bhagirathi Kharak	Alaknanda	17.0	1962-2005 2005-2006	319 1.5	7.4 1.5
Dunagiri	Dhauli	5.5	1956-1963	219	31.28
Joundhar	Yamuna	19.0	1962-2010	1709	34.8
Jhajju	Yamuna	4.9	1962-2010	800	15.4
Tilku	Yamuna	4.1	1962-2010	700	13.5

Besides the above field based observation recession of glaciers in Uttarakhand, few satellite based studies have also been carried out in the area. Bhambri *et al*. (2011) reported 82 glaciers in Alaknanda and Bhagirathi River basin using remote sensing data. The archival record for the period 1968 -2006 indicates that there has been 4.2% reduction in the glacierised area. The study also indicates around 6% reduction associated with Alaknanda basin and around 3% in Bhagirathi basin[4]. Similar observation were made in Chenab, Parbati and Baspa Basin (466 glaciers) which show overall 21% de-glaciation from 1962 to 2001[24]. Other studies carried out in Goriganga basin, Milam glaciers between 1954 and 2006, showed that glacier receded 1328 m with an average of ~25 m /yr[25].

7. Monitoring of Glaciers in Uttarakhand

In Uttarakhand, out of 968 glaciers only 10-12% glaciers have been monitored for changes in their length and area. Gangotri Glacier (30 km long) is one of the best documented glaciers in the Indian Himalaya as far as its snout position demarcation is concerned. The glacier has been under the state of continuous recession since 1935[26]. Geological Survey of

India (GSI) has monitored the glacier since 1935 till 1996. The data reveal that the glacier has retreated by 1147 m, with an average rate of 19 m/year between 1935 and 1996. The total area vacated by the glacier during 1935 to 1996 is estimated to be 5, 78,100 m^2.

Length fluctuation and area changes of Gangotri Glacier based on remote sensing have been carried out for the period between 1965 and 2006 and observed that glacier retreated 819 m with an average rate of 6 m/y from 1965 to 1968 and 27 m/y from 1968 to 1980. Further, between 1980 and 2001 it retreated 21 m/y (Figure 6). During the period 1965-2006 the glacier has lost 0.41 km^2 (~ 0.01 km^2 y^{-1}). The recession rate declined during 2001-2006 and it receded at a rate of 7 m/y[4].

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[24] Kulkarni, A.V., Rathore B.P., Mahajan, S. and Mathur, P. (2005). Alarming retreat of Parbati Glacier, Beas basin, Himachal Pradesh. Current Science, 88 (11), 1844–1850.

[25] Babu, K.B.G. (2011). Recession and reconstruction of Milam Glacier, Kumaun Himalaya, observed with satellite imagery, 100 (9), 1420-1425.

[26] Srivastava, D. (2004). Recession of Gangotri glacier. Geological Survey of India, Special Publication 80, 21–32.

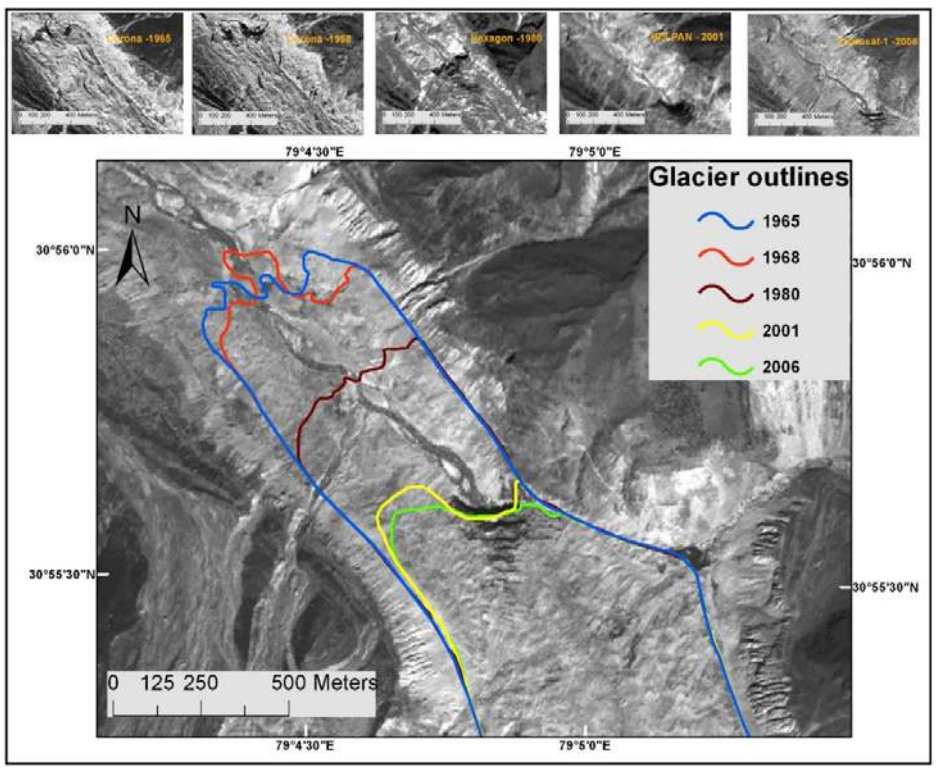

Figure 6: Glacier snout outlines derived from satellite data shows the different position of Gangotri snout (Bhambri, 2011)

Dokriani Glacier (5.5 km), located in the Bhagirathi river basin is another long term monitored glacier since 1991. The glacier has retreated about 751.5m with an average annual rate of 15.7m during the period 1962-2012[2] (Figure 7). The frontal area vacated by the glacier during the period 1991-2007 was 14323.8m^2 with an average of 895.23m^2/yr[28].

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[27] Dobhal, D.P., Gergan, J.T. and Thayyen, R.J. (2007). Recession and Mass balance fluctuations of Dokriani Glacier from 1991 to 2000, Garhwal Himalaya, India. In: International seminar "Climatic and Anthropogenic impacts on water resources variability", International Hydrological Programme (IHP) -VI, UNESCO, Technical Document No. 80, 53-63.

[28] Dobhal, D.P. and Mehta M. (2010). Surface morphology, elevation changes and terminus retreat of Dokriani Glacier, Garhwal Himalaya: Implication for climate change. Himalayan Geology, 31 (1), 71–78.

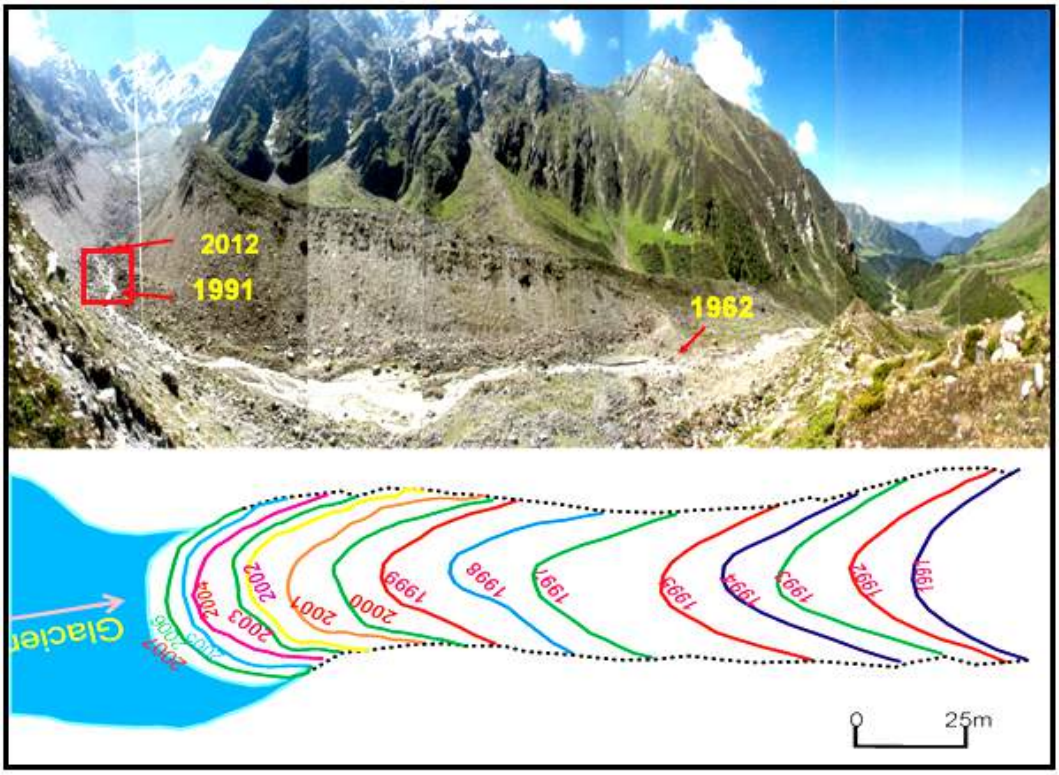

Figure 7: Dokriani Glacier snout fluctuation and data shows the different position of snout (Modified after Dobhal et al., 2007)

The Chorabari Glacier (6.5km) lies in Mandakini valley. The total 327 m cumulative reduction of glacier length reveals that the Chorabari Glacier has ~ 4% total length during the last 48 year (Figure 8). Similarly frontal area vacated by the glacier for the period between 1962 and 2010 was ~ 74621 m^2 with an average rate of 1554.6 m^2 a^{-1}, A total of ~ 9.6% of glacier area has been lost during the last forty eight years[29]. Conversely, another adjoining glacier (Companion glacier, 3.5km), which was a part of the Chorabari Glacier during the period of its advancing stage, is receding at a very slower rate. Figure 9 is clearly indicates that the snout of this glacier is almost in a stationary stage while the Chorabari Glacier has receded more than 400 m since 1882.

[29]Dobhal D.P, Mehta. M. and Srivastava, D. (2013 b). Influence of debris cover on terminus retreat and mass changes of Chorabari Glacier, Garhwal region, central Himalaya, India. Journal of Glaciology, 59 (217), 961-971.

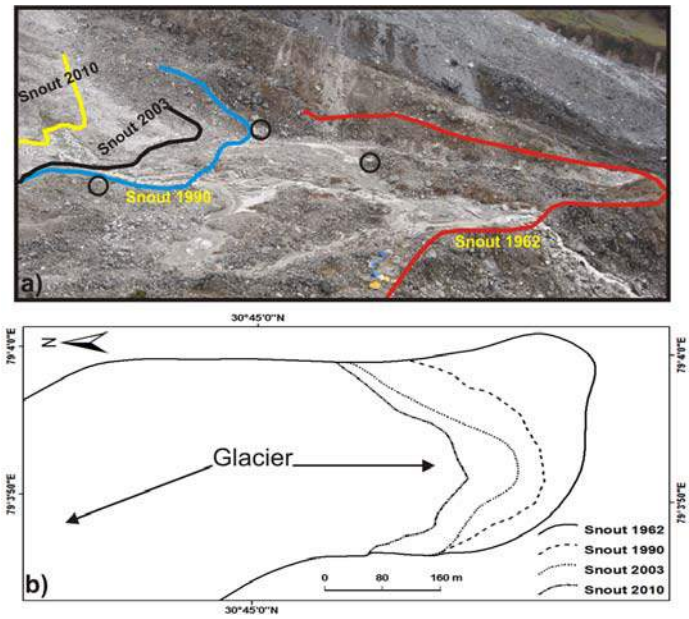

Figure 8: Frontal recession trend of Chorabari Glacier (1962-2010) in Mandakini valley

Figure 9: The terminal position of Chorabari and Companion glaciers in 1882 and 2010 indicating no changes in termini of Companion glacier (Discussed in the text)

Tipra Glacier (4.5km) in the Dhauli Ganga (Alaknanda river basin) has receded ~ 535 m with an average rate of 13.4 m a^{-1} during the period 1962-2008. It has also observed that a large part of the glacier has been detached from the main trunk and separated into the Tipra (7.5 km^2) and Rataban (7.4 km^2). Total frontal area vacated during this period was calculated to be 0.084 km^2 for Tipra and 0.028 km^2 for Rataban glaciers. The Tipra Glacier lost ~10% of total length (663 m) and vacated an area by ~ 18%.during the last 46 years [30].

[30] Mehta M, Dobhal D.P. and Bisht M.P.S (2011). Change of Tipra Glacier in the Garhwal Himalaya, India, between 1962 and 2008, Progress in Physical Geography, 36 (6), 721-738

The Jaundhar (19km), Jhajju (5.5km) and Tilku (4.5km) glaciers occupied in Tons basin (Yamuan river basin). They are also in state of recession and retreated ~1709 m, ~800 m and

~700 m with an average of 34.18, 15.38 and 13.46 m a^{-1} respectively during the period from 1962-2010. In addition these glaciers have lost ~3.6 km^2 area (5.4% of total area) during the same period[31].

The Satopanth (14km) and Bhagirathi-Kharak (18km) glaciers in Alaknada have also undergone continuous recession. A study carried out for the period from 1962 to 2006 shows that the Satopanth glacier registered a net area lost ~313.93x10^3 sq m (7.13x10^3 sq m/yr), while the Bhagirathi Kharak lost 129.40x10^3 sq m (2.94x10^3 sq m/yr)[22]. The Dunagiri Glacier (6.5 km) long and area 2.56 sq km) lies in the Dhauliganaga river basin. The glacier snout was monitored during the years 1984 to 1990 and in 1992 show the gradual retreat. The observations indicated that during 1992-1997, the frontal area lost by 2525 m^2.

Milam (18km) is second largest glacier after Gangotri Glacier in the Uttarakhand and it lies in the Gori ganga (Kali Ganga river basin). The first snout monitoring study was carried out in 1906. Since then the glacier have been monitoring on regular basis. The recent studies suggest that the glacier is in continuous state of recession and it have retreated by ~ 1740m (with an average rate of 19.0 m/yr) and vacated an area of 0,893Km^2 (0.9922 m^2/yr) during the period between 1906 and 1997. Similarly, the Burphu Glacier in the same river basin has been found to be retreat. During the period 1966 to 1997 the rate of snout retreat calculated was 150 m (4.48 m/yr) and vacated an area of 29150 sq m. with an average of 940 sq m/year[18].

The Kafni Glacier (4.2 km) is located in the Pindar river (a tributary of Alaknada river). The study carried out so far shows a variation in the retreat rate during different time period. During the period 1976-1999 it has receded ~ 394.4m (17.2m/yr). Similarly during the period between 1999 and 2009 it has retreat ~ 131.84m with an average rate of 13m/yr which shows a reducing trend. It is important to note that Kafni is a small glacier and the retreat rate come down from 17 to 13m/yr during the last one decade which may be significant on the mass balance of the glacier.

It is to be noted that out of 968 glaciers in the Uttarakhand only few glaciers has been monitored for their length and area change for long period and indicates that all are in the state of receding with varying rates (Table 5 and Figure 10).

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[31]Mehta M, Dobhal D.P., Pratap, B., Verma A., Kumar, A. and Srivastava, D. (2012). Glacier changes in Upper Tons River basin, Garhwal Himalaya, Uttarakhand, India. Zeitschrift für Geomorphologie, 57 (2), 225-244.

Table 5: Frontal area loss of the glaciers in Uttarakhand Himalaya

Name of Glacier	Area Km^2	Year	Area vacated (10^3 m^2)	Rate ($10^3 m^2$ a^{-1})	Total loss (%)
Gangotri	147.0	1968-2006	418.5	10.2	0.28
Dokriani	7.02	1962-2007	87.9	1.9	4.0
Satopanth	21.17	1962-2006	313.9	7.1	1.5
Bhagirath Kharak	31.10	1962-2006	129.3	2.9	0.48
Tipra	7.5	1962-2008	512.1	11.1	3.6
Chorabari	6.20	1962-2010	72	1.5	1.0
Joundhar	14.0	1962-2010	1776	36	3.0
Jhajju	05.9	1962-2010	280	5.8	4.5

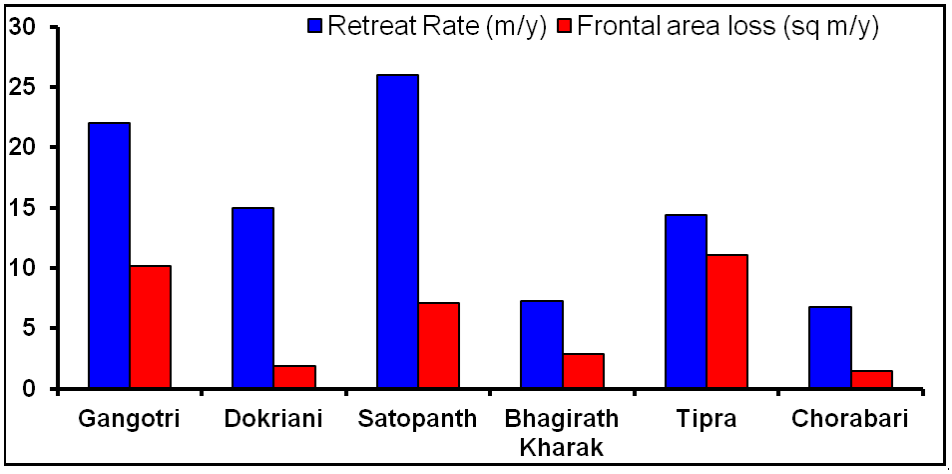

Fig 10: Frontal retreat and area vacated of selected Garhwal Himalayan glaciers (1962-2010).

As discussed earlier, the size of theses glacier ranges from <0.5 to 147 sq km and consequently the rate of recessions are different to different glaciers. The majority of small glaciers are higher than the large glaciers and it has also been observed that the recession rates for both small glaciers (<5 km) and large (>10 km) glaciers are more or less same (Table 6; based on data Glacier inventory data, Raina and Srivastava, 2008). The Alaknada is the largest glacier system of Uttarakhand having 407 glacier and out of them 351 glacier are less than $5km^2$. Likewise, the Bhagirathi basin occupied by a total of 238 glaciers, out of them 208 glaciers is less than $5km^2$ and again out of 208 glaciers 147 are less than $1km^2$. The figures are not encouraging for the state of health of the glaciers in the region.

Table-6. Distribution of small and larger glaciers in Uttarakhand Himalaya

Glacier Basin	No of Glaciers	Area wise (km^2)		Length wise (km)		Volume (km^3)
		<5	>5	<5	>5	
Yamuna	52	46	06	49	03	12.20
Bhagirathi	238	207	31	206	32	67.02
Alaknanda	407	351	56	357	50	90.75
Kali (Ghanda)	271	230	41	234	37	43.77
Total	**968**	834	134	846	122	213.74

8. Impact of glacier retreat (*An Environmental appraisal*)

Snow ice and glaciers are perennial resource of fresh water and lifeline of the millions of people leaving in the down valley. They are not only important for drinking and agricultures use but have a vast potential for hydro power generation. Shrinking of glaciers especially retreat and thinning may give rise to catastrophic hazards, like debris collection and landslides. Excessive melt waters, often in combination with liquid precipitation, may trigger flash floods or debris flows. Glacial surges are another hazard in the north-west Himalaya. In the eastern and central Himalayas, where the glaciers surface are thickly debris covers, glacial melt associated with climate change has led to the formation of glacial lakes in open areas behind exposed end moraines, causing great concern.. The receding glaciers left behind large pro-glacial lakes dammed, in some cases unstable natural dams (moraines). Theses moraine dams are comparatively weak and can breach suddenly, leading to the sudden discharge of huge volumes of water and debris. The resulting glacial lake outburst can cause catastrophic flooding downstream, with serious damage to life, property, forests, farms, and infrastructure. The example of such event is June, 2013 the Chorabari lake (moraine-dammed) outburst, which was located near the Chorabari Glacier snout (3860m asl) about 1.5 km upstream the town of Shri Kedarnath, breached and hit the Kedarnath town and deposited millions of cubic meter unconsolidated moraine debris in and around the temple and downstream (Figure 11).

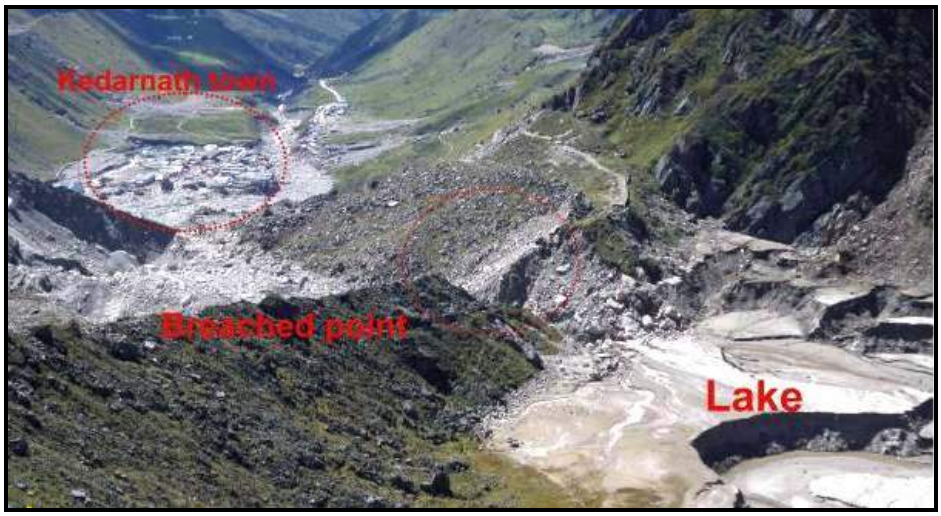

Fig. 11: View of Chorabari lake (Moraine dam lake) breached on 17 June,2013 in Mandakini river basin, (Photo: Dobhal, 2013)

The lakes are generally located in the High Mountain glacierised and periglacial region (above 3000m asl). There are few evidence of glacial lake flood were reported in the region, for examples in 1930, a glacial lake outburst in the Arwa valley (north of Mana village) raised the Alaknanda water level to around 9 m near Holy shrine of Badrinath and destroyed many houses. Similarly, during 1983, an area between Pandukeshwar and Hanuman Chatti was riddled with snow avalanches that not only caused the destruction to the villages but temporarily blocked the Alaknanda river (Sah et al., 2005). Similarly Glacier Lake burst that occurred on 12th August 2007 in Alkapuri glacier caused huge destruction at Keshav Prayag (confluence of Alaknanda and Saraswati River near Mana Village) also demolished a hanging bridge and a good chunk of agricultural fields got affected. Such flooding has also increases the siltation rate in the hydropower power projects in the downstream valleys.

10. Possible impact of glaciers on Hydropower projects

Hydro-electric projects depend upon water flows, a common pool resource (CPR) which is glacierized area, snow cover area and its water storage. The sustainability and profitability of energy projects and livelihoods of local people are both inextricably linked to this CPR[32, 33]. Taking glaciers as a storage system, it acts as natural reservoirs storing water in a frozen state far behind a dam. Glaciers modify stream flow releasing the most runoff during the warmest, driest periods when all other sources of water are at a minimum[34]. The amount of runoff provided by a glacier is the product of its surface area and ablation rate. Annual glacier runoff is highest in warm, dry summers and lowest during winter. Glacier runoff does not increase or decrease the long term runoff for a basin, total runoff over a period of several years is determined largely by annual precipitation. The loss of a glacier does not necessarily reduce annual runoff, annual precipitation changes are the key for annual runoff changes. Glacier runoff peaks at the heights of the melt season June, July and August in the central Himalaya, greatly enhancing summer runoff. Runoff from non-glacier alpine basins peaks in summer months such as May and June (Kumar et al. 2013). Like non-glacier runoff, glacier runoff correlates better with temperature than precipitation, due to the dominant role of glacier melt compared to precipitation in summer runoff from glacierized basins. This is also the reason for the strong diurnal nature of glacier runoff.

There are two types of changes in glacier runoff that occur as a result of warming and enhanced glacier melt. The initial response is an increase in glacier melt rate enhancing glacier runoff, while the glacier extent is still substantial in comparison to previous size. Eventually the resulting decline in glacier extent reduces the area available for melting causing a decrease in glacier runoff.

- The expected influences of climate change on glaciers and hydrology in high mountain regions pose a new challenge to water resource management, especially to hydropower production and other water uses. The results will make it easier to understand the ongoing processes and it will be possible to deliver recommendations for adaptation strategies.
- Changes in annual river discharge, seasonal and temporal offsets of hydrological patterns, extreme precipitation events and increased glacial melt are the most pertinent climate change effects that can impact hydroelectric generation. It is necessary to remember that these impacts all affect each other and cannot solely be viewed in isolation. Some of these changes will cause an increase of hydropower generation, while others have the potential to decrease generation. Amidst these many impacts, increased instability and variability in water supply will increase with climate change.

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[32] Chopra, K. and Dasgupta, P. (2002). Common Pool Resources in India: Evidence, Significance and New Management Initiatives. Mimeo under the UK DFID Project R7973.

[33] Naidu, S.C. (2005). Heterogeneity and common pool resources: collective management of forests in Himachal Pradesh, India. University of Massachusetts Amherst-Working papers (Working paper No. 2005-8).

[34] Fountain, A.G. and Tangborn, W.V. (1985). The effect of glaciers on streamflow variations. Water Resources Research, 21 (4), 579–586.

- The receding glaciers left behind large amount of unconsolidated loose material of rock debris and sediment, which would be a source of slit to hydro-power reservoir in the down valley due to the re-erosion and mass movement of unconsolidated paraglacial deposits.

11. Effect of hydropower projects on glaciers and glacial environment

The hydroelectric power stations are mostly situated downstream valleys (<2000 m asl), and the glaciers are located above the 3800 m asl. Although, there is no such study has been carried out on impact assessments of hydro project on the glaciers regime. However, the construction and operational activities regarding hydropower projects will hardly impact the behavior of glaciers (whether they are retreating or advancing), yet it is very important to understand the process, assessment and implication of impact of hydropower station on the glacier regime.

Broadly the main impacts imposed by Hydropower plants are on the existing physical environment, biological and social environment. Hydropower dams associated with the problems of deforestation, submergence, or rehabilitation, impact on flora and fauna (aquatic and terrestrial) and bio-diversity and also on impinge on carrying capacity of modular ecosystems.

Summery and conclusions

In the present scenario the Himalaya is covered ~10% glacier ice of its total area and additional nearly 30-40% area is seasonal snow covered. The glaciers are dynamic and fragile in nature and are most sensitive to the temperature and precipitation changes that accompany climate change. The changes in their size and volume with time and space, serve as an indicator of regional and global climate change and also vulnerable to environments.

A large area above >2500 m is occupied by glaciogenic sediments which are unconsolidated and fragile in nature and prone to remobilization under unusual weather events. In addition, the area is highly influence by monsoon and snow/ glaciers melt processes as winter snow line descends down an elevation between 2200 and 2500m in Uttarakhand. The stream emanating from glaciers and snow cover area facilitate snow avalanches, debris flows, landslides and particularly along the fast cascading juvenile streams. The direct consequences of such processes will also be exaggerated by a variety of direct/indirect effects in mountain ecology. In such case, particularly in fragile nature of landscape and continuous deposition of sediments by glacier retreat, the construction of large numbers of hydro-power dams should not be planned. And there is an urgent need to study the planning and managements for sustainable development of hydropower projects in the mountain areas.

In summary, it can be suggested that current inferences on the health of glaciers in the face of global warming remain uncertain. However, noting the broad consequences of glacier variability on the agriculture production, hydro-power generation, drinking water supply and ecological system ultimately have implications on the livelihood, human health and resource development.

Chapter 7

ToR 31.B

ToR 3.1Bb: Cumulative impacts of proposed and existing bumper-to-bumper and run of river schemes and on the basis review existing Cumulative Impact Assessment Reports

The increasing demand for power and the consequent increasing exploitation of the Himalayan river ecosystems is a major concern today. This is particularly true of those rivers where multiple projects are proposed with very little distance of free flow between the tail race channel of one project and the reservoir/pond's tip of the next one downstream.

Table 7.1: Some cases of Bumper-to-bumper dams in Uttarakhand

S. No.	River	Total river stretch (Km)	Number of projects	Percentage of river length affected
1.	Bhagirathi	217	4 commissioned, 1 under construction and 1 proposed	70.7
2.	Alaknanda			
3.	Dhauli ganga (W)	92	1 under construction, 4 proposed	51.08
4.	Tons		2 commissioned, 7 proposed	
5.	Gori ganga		7 proposed	
6.	Asi ganga	20.5	2 under construction, 1 proposed	53.4
7.	Bal ganga	37	2 proposed	39.8

The cumulative impacts of multiple hydropower projects along the same river basin and the threat of a cascading chain of catastrophes in case of structural failures or even from purely natural causes such as the Uttarakhand floods of June 2013, suggest that there is an urgent need for a region or entire basin based Strategic Environmental Assessment (SEA) rather than individual project oriented environmental impact assessments (EIA) that neglect the summation effect.[1]

In the Alaknanda and Bhagirathi basins, the impact on rivers due to submergence and/or diversion into tunnels by the 70 HEPs (commissioned, under construction and proposed) range from 29% to 71% per river.[2] For instance, the cascading effect of four HEPs on the Bhagirathi has already affected 71% of the river. Similarly, five proposed in Dhauliganga (W) river would affect 52% of the river. In the Alaknanda catchment (up to Karnaprayag), 10 HEPs would affect a 75 km stretch

[1] The Report of the Task Force Report To look into problems of hill states and hill areas and to suggest ways to ensure that these states and areas do not suffer in any way because of their peculiarities, Planning Commission of India & GB Pant Institute for Himalayan Environment and Development, Government of India, 112 pp.

[2] WII Report Rajvanshi et al. 2012

of the river.[3] Rivers such as Bhagirathi, Alaknanda, Birahi, Tons, Gori Ganga, Asi Ganga, Bhilangana, Balganga, all with multiple projects within short distances would be impacted substantially due to HEPs.

It has been realised that project-specific Environmental Impact Assessment studies are insufficient to tackle the synergistic environmental impacts that are likely to result due to the HEPs.[3] In realisation of this fact, the MoEF has now made it mandatory to conduct basin-level Carrying Capacity studies while considering the grant of environmental clearances to HEPs. Such basin-level studies have been carried out in the Teesta Basin in Sikkim[1], Alaknanda and Bhagirathi basins[2] and currently being conducted in Siang and other basins in Arunachal Pradesh.[4]

The EB endorsed the MoEF's current practice of initiating basin level studies for assessing the carrying capacity of HEPs in a river basin and **recommends that such SEA should be carried out for all the other river basins such as the Yamuna and Kali Basins in Uttarakhand**. The EB acknowledged the fact that there are no comprehensive studies on the impacts of bumper-to-bumper dams on Indian river systems till now. Therefore, the EB faced limitations due to lack of information on the guiding principles for maintaining minimum distances between two HEPs. Fortunately, at the international level, a few studies are available. Two research papers reviewed for South Africa suggest that (i) the factor modified by upstream impoundment has to be returned to normal levels before reaching the next reservoir in case of cumulative multiple impoundments; [5] and (ii) recovery of the river chemistry was achieved at a distance of 3 to 18 km downstream of a dam depending upon the river flows.[6]

During the deliberations, the EB members unanimously agreed that the guiding principle(s) for determining the minimum distance between consecutive dams should include concerns for (i) maintenance of river ecology and its functions, (ii) conservation of biodiversity and wildlife habitats, (iii) ensuring adequate free stretches of the river for use by terrestrial wildlife as movement corridors, (iv) fulfilling the requirements of human societies for cultural, religious, domestic use and (v) preservation of natural beauty, aesthetic and wilderness values.

Taking into consideration the above concerns, the EB deliberated upon the notification/ proposals of the committees constituted for such purposes. The guiding principle on retaining some stretches of a river in its natural form or retaining some proportion of the river basin free from hydropower development as proposed by different committees are listed below.

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3 Agarwal et al. 2010. Are EIA studies sufficient for projected hydropower development in the Indian Himalayan Region? Current Science, Vol. 98: No2: 154-161.

4 Minutes of the Meeting of the Environmental Appraisal Committee???

5 Ward and Stanford. 1983. The Serial Discontinuity Concept of of lotic ecosystems, In T. D. Fontaine & S. M. Bartell (eds), Dynamics of lotic ecosystems. Ann Arbor Science Publishers. Pp 29-42.

6 Palmer and O'keeffe 1990. Downstream effects of impoundments on the water chemistry of the Buffalo river (Eastern Cape), Southern Africa. Hydrobiologia. 202: 71-83

(a) The Task Force on the Himalaya had recommended that '*All natural water zones (glaciers, rivers, lakes, and springs) must be strictly protected. Activities in any of the zones that, in any way, adversely impact on water resources should be barred. Areas that harboured natural springs must be converted to "Spring Sanctuaries" and this concept should be incorporated in all planning*.' [1] The Task Force also mentioned that it is '*logical and essential to demarcate zones in the higher Himalayan region that are naturally unstable. In these areas, no hydropower projects should be allowed to be developed*. Areas above 3500 m should be considered to be particularly vulnerable on account of their natural fragility'.

(b) The National Ganga River Basin Authority (NGRBA) declared an Eco-sensitive Zone (ESZ) to ensure free flow of River Ganga from its origin to Uttarkashi and placed a ban on all new HEPs in this stretch except for the construction of micro ($\leq$ 2 MW) and mini projects (1 MW) and that too only after consultation with Gram Sabhas. [7]

(c) The Inter-Ministerial Group (IMG) on Cumulative Impacts of Hydropower projects in Alaknanda and Bhagirathi Basins in Uttarakhand, had proposed that at least six rivers *viz*., Balganga, Bhyundar Ganga, Birahi Ganga, Dhauli Ganga (upper reaches), Rishiganga, and Nayar river should be maintained in their pristine conditions.[8]

(d) The High Level Working Group on the Western Ghats (HLWG) recommended that at least 50% of a river basin should not be exploited for hydropower. [9]

The EB deliberated upon the above proposals and makes some recommendations with further justification. The strong recommendation to leave some rivers in a pristine form by the Task force and IMG or retaining at least 50% of the river basin in the natural state by HLWG were endorsed by the EB. This also complements with the proposal of not building developmental projects in areas above certain elevations in the Himalaya. The EB realizes that the high altitude areas above 2,500m in the Uttarakhand encompass critical wildlife habitats and corridors for several RET terrestrial wildlife species. This is also a zone of high seismicity and has experienced extensive glaciations in the past. As a result the terrain is not sediment limited and prone to unusual sediment mobilization during unusual weather events like the June 2013. Therefore, hydropower projects and other developmental activities above 2,500m in Uttarakhand State should not be permitted.

The EB deliberated upon the guiding principles for maintaining minimum distances between two HEPs and observed that in the Indian context there has been

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[7] Notification on the declaration of Eco-sensitive Zone for Ganges River by the National Ganga River Basin Authority on Ecosensitive Zone

[8] Report of the Inter-Ministerial Group on the hydropower projects in the Himalaya

[9] Report of the High Level Working Group on the Western Ghats. 2013. Ministry of Environment and Forests, Government of India. 143 pp.

only one case where, an attempt was made to propose a minimum distance between two HEPs. For the Western Ghats, the HLWG recommended 3 km as the minimum distance between consecutive HEPs. The shorter distance was considered keeping the shorter river lengths in Western Ghats. However, in the case of the Himalaya, the scales and aspects to be considered are different and diverse as this region encompass large complex geographical area with wide ranging elevation, aspect, slope, unique geology and hydrology, biodiversity, wildlife habitats, and most importantly religious and socio-cultural aspects. The IMG recommended 3-5 km as a minimum distance between two HEPs while deliberating this issue with regard to HEPs in Alaknanda and Bhagirathi Basins.[8]

In the Himalaya, rivers flow at substantial speed due to steep gradient carrying sediments oxygenating the system and ensuring all parameters in optimal conditions for sustaining river flora and fauna. When the river flow is altered by a storage and run-of-the river HEPs, the river loses its optimal conditions to sustain populations of flora or faunal species in carrying capacity levels. This is indicated by reduction in the status of river biota (reduction in diversity, density). Macro-invertebrates which play a significant role in sustaining the food chain in a river are also excellent indicators of river health. The populations of macro-invertebrates are very much reduced in the river downstream of a reservoir or after they leave the Tail Race Tunnel of a HEP.

The EB realized that a river downstream of an HEP has to rejuvenate itself and regain all its qualities as like the original natural river before it is held up again in a reservoir or barrage of another downstream HEP. Therefore, the EB strongly recommends that the guiding principle for minimum distance between HEPs could be that distance at which the river rejuvenates itself downstream of a HEP wherein the status of the biota is similar to the status under normal conditions of the natural free flowing river at a given elevation zone. But at present there are not studies on this subject for Himalayan rivers are certainly none for Uttarakhand's river. The EB believes that MoEF should initiate a strong research programme on this subject and good research institutions and other bodies should be encourage to generate data of practical utility.

The EB proposes that the existing, under-construction and proposed HEPs in the Himalaya should be considered on the basis of following principles

(a) Six rivers in Alaknanda and Bhagirathi basins, *viz*., Bal Ganga, Bhyundar Ganga, Birahi Ganga, Dhauli Ganga (upper reaches), Rishiganga, and Nayar river should be maintained in their pristine condition. The EB endorses this recommendation of the IMG and proposes that other similar rivers or river stretches (eco-sensitive zones) should be identified in other river basins of Uttarakhand by a group of subject experts.

(b) The EB also recommends that at least 50% of a basin should be left in natural conditions and no developmental project be permitted.

(c) The EB strongly recommends that the guiding principle for minimum distance between HEPs could be that distance downstream of a HEP which enables its biota to regain its normal condition of the natural free flowing river at a given elevation zone.

Conclusion:

There are no scientific studies on this aspect and therefore proposes that the guiding principle for minimum distance between HEPs could be that distance at which the river rejuvenates itself downstream of a HEP. Rejuvenation point of a river is defined as that stretch of river downstream of a HEP where the status of biota is comparable to the baseline status of river biota in a natural free flowing river at a given elevation zone.

Recommendation:

The Expert Body recommends that Strategic Environmental Assessment (SEA) should be carried out in other river basins such as the Yamuna and Kali Basins in Uttarakhand.

The Expert Body strongly recommends that 'scientific studies by subject experts should be conducted for establishing baseline data on river parameters, diversity and populations of floral and faunal species in different rivers of Uttarakhand at different elevation zones. This could be used for deciding upon the minimum distances between two HEPs.' Until such scientific studies are completed, no new or proposed HEPs should be allowed to be constructed in the rivers of Uttarakhand, particularly those proposed HEPs that are likely to be located within the minimum distance between two HEPs and may have to be cancelled.

Chapter 8

ToR 3.4

ToR 3.4: Assess Projects where impacts cannot be mitigated to preserve biodiversity

The impacts of HEPs in Uttarakhand on biodiversity and wildlife habitats have been presented in detail in the preceding sections of this report (ToRs 2.1a, 2.2, & 3.1B). It is well established that HEPs alter the natural flow of rivers due to submergence, drying up of rivers downstream of HEPs during the non-monsoon months due to diversion of river waters into tunnels for substantial distances and fragmentation of rivers due to cascading effects of multiple HEPs on a river.[1,2]

A recent study[3] has mapped the distribution of 292 dams (under construction and proposed) in the Indian Himalayan region and projected the effects of these dams on terrestrial ecosystems under different scenarios of land cover loss. Land-cover data analysis and a species-area relation (SAR) model of dam sites in the Himalaya predicted short- and long-term species extinctions driven by deforestation.

The study reported that almost 90% of Indian Himalayan valleys would be affected by dam building and 27% of these dams would affect dense forests. Their modelling analysis projected that 54,117 ha of forests would be submerged and 114,361 ha would be damaged in the Indian Himalaya by dams-related activities. The Indian Himalayan region with an average of 1 dam for every 32 km of river, and with most of them located in species-rich areas, would lead to substantial impacts on the biodiversity of the Himalaya. The SAR model analysis projected that by 2025, deforestation due to dam building would likely result in extinction of 22 angiosperm and 7 vertebrate taxa. Disturbance due to dam building would very likely reduce tree species richness by 35%, tree density by 42%, and the tree basal cover by 30% in dense forests. It is estimated that 87% of 76 fish species found in Alaknanda and Bhagirtahi basins would be impacted if all HEPs planned in these basins are eventually constructed.[4]

A few dams such as the Tehri-I, the proposed Pancheshwar and RoR projects such as Vishnuprayag, Maneri Bhali-I & II have led to irreversible impacts on biodiversity due to habitat loss (both aquatic and terrestrial), habitat degradation and consequently impact on species by reducing their numbers, sometimes leading to local

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1 McAllister, D.E., John F. Craig, Nick Davidson, Simon Delany and Mary Seddon, (2001): Biodiversity Impacts of Large Dams, Prepared for IUCN / UNEP / WCD.

2 Smith, L. 2009. Flaming Gorge Dam Effects on Amphibian, Reptile, and Mammal Populations, A report. 23 pp

3 Pandit, M.K. and Grumbine, R.E. (2012): "Potential Effects of Ongoing and Proposed Hydropower Development on Terrestrial Biological Diversity in the Indian Himalaya", *Conservation Biology*, v 26, No. 6, pp 1061–1071

4 WII Report Rajvanshi et al. 2012

extinctions.[5] These HEPs have also altered the distribution range, behaviour, movement and ranging patterns of species. Other impacts of HEP include disturbances to wildlife species during construction phase, accidental introduction of invasive species, local changes in climate, and wildlife-human conflicts.[6]

In the Tehri dam submergence area, during an assessment of the vegetation structure and community patterns it was reported that 'although the animals are in low density, the loss of their habitat after impoundment of water is likely to cause impact on surrounding areas. The scrub vegetation forms a typical habitat for Partridges, which will be lost permanently after the impoundment'. [7]

An assessment of projects where impacts on biodiversity cannot be mitigated is presented below.

3.4.1 Irreversible impacts of HEPs on aquatic and terrestrial habitats and species

Due to reservoir-based HEPs, river ecosystems are changed from free flowing to stagnant waters. HEPs also lead to changes in flow patterns and river morphology.[8] Loss of river ecosystem and fragmentation of rivers prevent fish migration and lead to decline in fish and other fauna populations. River dependent species such as otters have become extinct from most stretches of the rivers in Uttarakhand due to habitat loss/degradation due to HEPs, anthropogenic pressures as well as poaching.

The ritualistic implementation of poorly developed fisheries management plans, have led to introduction of exotic fish species in river systems which have led to reduction in the populations of native fishes. The construction of a reservoir at Kalagarh across Ramganga created a barrier for upstream migration of gold mahseer from the Ganga. For allowing migration of fish from and into its reservoir, a fish passage has been constructed. However, this fish passage is functional only during the surplusing of the reservoir and the reservoir very seldom got surplus flows, i.e., once in 10 to 15 years.[9] Impacts on migration of fishes and on fish habitats cannot be mitigated by methods such as fish ladders which have largely failed in Indian

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5 Sarkar U.K., Pathak, A.K> Sinha, R.K., Sivakumar, K., Pandian, A.K., Pandey, A., Dubey V.K., and Lakra, W.S. et al. (2011): "Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives", Rev Fish Biol Fisheries DOI 10.1007/s11160-011-9218-6

6 Sharma, R.C. (2003): "Protection of an endangered fish Tor tor and Tor putitora population impacted by transportation network in the area of Tehri Dam Project, Garhwal Himalaya, India", Proceedings of the 2003 International Conference on Ecology and Transportation, (Eds.) Irwin CL, Garrett P, McDermott KP, Center for Transportation and the Environment, North Carolina State University, Raleigh, NC: pp. 83-90.

7 Adhikari, B.S., Uniyal, S.K., Rawat, G.S., and Rajvanshi, A. (2009): "Vegetation structure and community patterns of Tehri Dam Submergence Zone, Uttarakhand, India", EurAsian Journal of Biosciences, Issue 3, p40.

8 Ward J.V., and Standord, J.A. (1995): "The serial discontinuity concept: extending the model to flood plain river", Regulated Rivers: Research & Management, 10: pp 159-168

9 Report on Environmental Evaluation Study of Ram Ganga Major Irrigation Project, Volume I: Main Report 2012 - Prepared by Agriculture Finance Corporation Limited, Hyderabad. Pages 167 to 188

conditions. Fish ladders in reservoirs and barrages that are less than 12 m height are known to facilitate fish migration upstream provided there are no other anthropogenic pressures such as poaching. Similarly, restocking fishes from hatcheries have largely benefitted exotic fishes at the cost of native fishes.

Tropical reservoirs have been identified as being potentially significant greenhouse gas (GHG) producers (gross emissions), producing mainly carbon dioxide and methane.[10]

Altering river flow patterns can lead to loss or decrease in populations of planktons and macro-invertebrates that form important food for fish.[11,12] Drying up of rivers downstream of RoR HEPs in the non-monsoon months due to no or minimum flows have led to decline and subsequent loss of several macro-invertebrates.[13]

Riverine habitats generally occupy a small proportion in the total landscape. But they play a critical role as corridors and migration pathways for several faunal and floral species. They serve as 'edge habitats', facilitate river courses and also assist in prevention of soil erosion. The loss of 68 km riverine habitat from Chinyalisaur to Koteshwar due to Tehri and Koteshwar HEPs constitute an irreversible loss. Similarly, substantial riverine forests have been lost in Bhilangana due to submergence by Tehri HEP.

Such losses of riparian vegetation and habitat cannot be mitigated by current practices such as compensatory afforestation (CA) where areas that are not riverine and not located in mountains have been used. In chapter 5 of this report evidence has been presented to show that the performance record of CA. In the case of the Ramganga project, the area under forests decreased 9.87 thousand ha between 1970 and 1979. Similarly the decrease in forest cover between 1990 and 2008 was 663.15 ha.[8]

Such habitat losses influence the movement and ranging patterns of faunal species leading to reduced occupancy, use of suboptimal or unfamiliar habitats resulting in mortalities due to poaching or exploitation, human-wildlife conflicts, reduction in population and consequently local extinctions. Even small barriers alter the movement of wide ranging endangered large mammals such as elephants and tigers in the terai-bhabhar regions of Uttarkhand.[14] Similarly effects on species such as snow leopard, brown bear, black bear, Tibetan wolf and other high Himalayan species have serious implications on their breeding, migration and other activities. Impacts due to loss of migratory routes or corridors and consequent failures in

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10 Giles, J. (2006). "Methane quashes green credentials of hydropower", Nature, v.444, pp524-525

11 CPCB (2007, 2012):

12 Singh et al. (2008):

13 Semwal, N & Akolkar,P. (2011): "Bio-mapping, a biological classification of River Bhagirathi in Himalaya Basin", CIBTECH vol 1(4), pp 32-44 accessed at http://www.cibtech.org/jls.htm

14 Johnsingh et al. 1990.

8 WII Report. Rajvanshi et al. 2012

breeding cannot be mitigated by any methods. Adopting the precautionary principle is the best option available in the absence of science based knowledge.

In the Alaknanda and Bhagirathi basins, 17 HEPs have been commissioned with total installed capacity of 1851 MW; 14 projects of 2538 MW capacity are in the advanced stage of construction and 39 projects with installed capacity of 4644 MW are in different stages of planning. WII in its Cumulative Environmental Impact Assessment study[9] had mentioned that five scenarios can be used to improve upfront the process of decision making and forward planning of the hydropower sector. These scenarios distinctly present options to decision makers in respect of approval or relocation of HEPs based on potential risk to biodiversity values and reflection, if required. The scenarios also provide adequate basis to make decisions with respect to applying 'exclusion approach' across the two basins for securing key biodiversity values in key biodiversity sites, critically important habitats and designated protected areas. WII's report excluded the 17 commissioned and 14 under construction HEPs considering huge investments already made in hydropower development. For acceptable outcomes from hydropower development for biodiversity conservation and societal well-being, WII recommended that 24 out of the 39 proposed projects may be reviewed for combined benefits of reducing impacts on both, aquatic and terrestrial biodiversity.

The proposed 24 HEPs in Alaknanda and Bhagirathi Basins which are likely to cause irreversible impacts that cannot be mitigated are given below.

Sub-basin	**Proposed HEPs to be excluded**	**River/ Stream (*gad*)**	**Remarks**
Bhagirathi I	Karmoli (140 MW)	Jadh ganga	Irreversible impacts on terrestrial species (flora & fauna) and habitats that are inside the Gangotri NP and the Gangotri Eco-sensitive Zone.
	Jadh ganga (50 MW)	Jadh ganga	
Bhagirathi II	Bharonghati (381 MW)	Bhagirathi	Irreversible impacts on terrestrial species (flora & fauna) and habitats that are inside the Gangotri NP and the Gangotri Eco-sensitive Zone. The NGRBA decided to discontinue Bharonghati HEP
	Jhalandarigad (24 MW)	Jhalandarigad	
	Siyangad (11.5 MW)	Siyangad	
	Kakoragad (12.50 MW)	Kakoragad	
Bhagirathi IV	Kotlibhel 1A # (195 MW)	Bhagirathi	Already impacted due to river fragmentation
Bal ganga	Bal ganga II (7MW)	Bal ganga	Irreversible impact on the aquatic ecosystem, riverine habitats and aquatic species. Bal ganga identified as critical aquatic habitat for fish and hence proposed as 'Fish Conservation Reserve'. The IMG has recommended this river to be declared as a pristine river
	Jhalakoti (12.5 MW)	Bal ganga	

Mandakini	Rambara (76 MW)	Mandakini	Irreversible impacts on terrestrial species (flora & fauna) and habitats in and near Kedarnath WS
Alaknanda I	Kotlibhel 1B (320 MW)	Alaknanda	Irreversible impact on the aquatic ecosystem, riverine habitats and aquatic species.
Alaknanda II	Urgam (5 MW)	Kalpganga	Irreversible impacts on terrestrial species (flora & fauna) and habitats near Kedarnath WS that are important wildlife habitats connecting Protected Areas
Alaknanda III	Alaknanda (300 MW)	Alaknanda	Irreversible impacts on terrestrial species (flora & fauna) and habitats in the buffer zone of Nanda Devi Biosphere Reserve that are important wildlife corridors connecting Kedarnath WS and Valley of Flowers Protected Areas
	Khiron ganga (4.5 MW)	Khironganga	
Bhyundar ganga	Bhyundar ganga (24.0 MW)	Bhyundar ganga	Irreversible impacts on terrestrial species (flora & fauna) and habitats in the buffer of Nanda Devi Biosphere Reserve that are important wildlife corridors connecting Kedarnath WS and Valley of Flowers NP. This HEP is also located within 10 km from the Valley of Flowers NP - UNESCO Natural World Heritage Site. The IMG has recommended this river to be declared as a pristine river.
Dhauli ganga	Malari-Jhelum (114.00 MW)	Dhauli ganga	Irreversible impacts on terrestrial species (flora & fauna) and habitats in the buffer zone of Nanda Devi Biosphere Reserve that are important wildlife corridors connecting Valley of Flowers and Nanda Devi National Parks. Four HEPs fall within 10 km from the boundary of Nanda Devi NP. The IMG has recommended that the upper stretches of this river to be declared as a pristine river.
	Jhelum-Tamak (128.00 MW)	Dhauli ganga	
	Tamak-Lata (280 MW)	Dhauli ganga	
	Lata-Tapovan (171 MW)	Dhauli ganga	
Rishi ganga	Rishi ganga I (70 MW)	Rishi ganga	Irreversible impacts on terrestrial species (flora & fauna) and habitats within Nanda Devi National Park – UNESCO Natural World Heritage Site. IMG has recommended this river to be declared as a pristine river.
	Rishi ganga II (35 MW)	Rishi ganga	
Birahi ganga	Birahiganga I (124 MW)	Birahi ganga	Irreversible impacts on terrestrial and aquatic species (flora & fauna) and habitats within important wildlife habitats connecting Protected Areas. The IMG has recommended this river to be declared as a pristine river.
	Gohana Tal (50 MW)	Birahi ganga	
Ganga	Kotlibhel II	Ganga	Irreversible impact on the aquatic

	(530 MW)		ecosystem, riverine habitats and aquatic species. The Nayar River a rain-fed tributary located upstream of this HEP is the last natural habitat where mahseer breeding occurs. This has been identified as critical aquatic habitat for fish and hence proposed as 'Fish Conservation Reserve'. The IMG has recommended this river to be declared as a pristine river.

Comprehensive research studies of other basins in Uttarakhand are lacking at this stage. The loss of a riverine ecosystem, 7 however around the Tehri dam reservoir cannot be mitigated as discussed elsewhere (Chapter 3) in this report. Otters appear to be nearing extinction in the Ganga, Alaknanda sub-basins.

Conclusion: The EB concluded that on the basis of currently available evidence 23 out of the 24 HEPs would have irreversible impacts on the biodiversity of Alaknanda and Bhagirathi basins.

Recommendations:

The EB recommends that of the 23 HEPs that would have irreversible impacts on the biodiversity of Alaknanda and Bhagirathi Basins, the HEPs that fall is any of the following conditions should not be allowed to be constructed.

(a) Proposed HEPs that fall inside wildlife Protected Areas such National Parks and Wildlife Sancturies

(b) Proposed HEPs that fall within the Gangotri Eco-sensitive Zone

(c) Proposed HEPs that fall above 2,500m that encompass critical wildlife habitats, high biological diversity, movement corridors, and fragile in nature due to unpredictable glacial and paraglacial activities.

(d) Proposed HEPs that fall within 10 km from the boundary of Protected Areas and have not obtained clearance from the National Board for Wildlife.

Chapter 9

Himalayan Policy (for Uttarakhand)

By: Shekhar Pathak & Hemant Dhyani

" स्थावराणां हिमालयः " Among the mountains- I am the Himalaya.

- (Sri Krishna, Bhagvadgita-10.25)

"तत्र धन्यं महाभाग भारतं वर्षमीरितं।

तत्र धन्यो महाभाग हिमवद्देश संज्ञकः ।।

तत्रापि धन्या ते देशा यत्र गङ्गा सरिद्वरा ।

हरेः सानिध्यकं स्थानं तत्रापि हि मुनीश्वर" ।।

Preface

The Himalaya, known as *'Dev-Aatma'* (The divine soul) and revered by millions, the abode of snow, is home to a geological, geographical, biological diversity and multitude of human concerns - from hunting-gathering communities to pastoral-agrarian-trading societies to the economies of modern trade, industry and services sector. This mountain system has evolved a distinctive ecology that has become the basis for the existence of the natural as well as cultural systems of South Asia. It surprisingly connects the tropical rain forests of Myanmar, Arunachal and Bhutan with the sparse and semi cold deserts of the Ladakh-Karakoram and the Indus-Ganga-Brahmputra plains with the Tibetan plateau. This contrast makes Himalaya different from other mountain systems.

The dynamic and active Himalaya stands like a sub-continental arc. The lives and cultures of South Asia are deeply connected with it. Its geology teaches us about the continental drift, the disappearing of Tethys Sea, or its own rising height, about its own peculiar nature, which hides within itself dynamism and seismicity- the seeds of all earthquakes. With its peaks, passes, glaciers, moraines, rivers, confluences, gorges and pastures, its geography is akin to the myriad faces of nature. Its lofty peaks make a formidable barrier for the monsoons, resulting in heavy rainfall on the southern side. Himalaya, indeed produce and control the climate of South Asia. If it is changing it is related with the change in Himalaya itself.

The vegetation and the forests are like green lungs that absorb the rising atmospheric carbon. Its wilderness has given natural expression and embodiment to a plethora of floral-faunal species- from medicinal-aromatic plants to bushes and trees, and from birds, fish and

butterflies to Yarsha Gumba or Keeda Jadi (*Cordyceps sinensis*). These Himalayan forests are part of physical/ material as well as visual and aesthetic resources.

The wilderness and sacredness has been a confluence for natural and spiritual energies and within a broader cultural context it is the main attraction for the pilgrims and tourists.[1] The Himalaya and these rivers are revered by millions of Indians and are of immense cultural and historical significance. These rivers form the most fertile basins in the country, the Ganga river basin alone is the lifeline of more than 500 million people and their food and water security is directly related to these rivers.

Today this mountain, the rivers and the communities living here are in a crisis. Himalaya is being rapidly encroached upon in so many ways. Its resources are being exploited at an unsustainable rate, much beyond what can be regenerated. Further, the challenges of the global climatic change and the rampant 'developmental activities', pose a grave threat to the very existence of the Himalaya, survival of its rivers and the people leaving there.

As far as a Himalayan Policy in the context of Uttarakhand is concerned, we suggest a few points, which have been discussed time and again by social movements, experts/committees and the communities.[2] At the same time it is to be noted that for a detailed Himalayan Policy we need a large group of specialists and experts from different institutions, disciplines and regions. We have to discuss things with tribes, scheduled castes, minorities, youth, women and children. A spark of new ideas may come from any corner. When we are aspiring for a Himalayan Authority or Ministry for Himalaya/ Mountains, this kind of deep homework is needed.

First we should evolve a Himalayan policy in Asian perspective, as this will look at the Himalayan resources and communities in a holistic way. It will look at all Himalayan countries/regions and their inter dependence. Then consider the case of the Indian Himalaya as hundreds of communities upstream and down-stream are dependent on the resources of this mountain and the interdependence of these communities and their cultures is also to be understood. After this, we should formulate policy for different regions/states of the Indian Himalaya.

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1. Bernbaum, Edwin, 1992 (1990), *Sacred Mountains of the World*, San Francisco, 2-23, 206-248; Pathak, Shekhar, *Himalaya Hai To Hum Hai*, 2011, 4th Rabindranath Tagore Memorial Lecture, NCERT, 10-22, New Delhi.

2. One can see the demands of Chipko Movement, Himalaya Bachao Andolan, Himalaya Niti Abhiyan and recommendation of so many seminars. ICIMOD have its recommendation for whole HKH region. Planning Commission of India has its own documents regarding different Indian Himalayan States. The following may be the major official documents, which has given policy inputs on one or the other aspects of Himalayan/ Mountain area development:

   1. *Task Force for the Study of Eco Development of the Himalayan Region*, 1982; 2. *Working Group on Hill Area development for VII Five Year Plan*, 1985; 3. *Action Plan for Himalaya*, 1992; 4. *Expert Group on National Policy on Integrated Development of Himalaya*, 1993; 5. *High Level Commission Report on NE Region*, 1997; 6. *Task Force on the Mountain Ecosystems for 11th Five Year Plan*, 2006; 7. *Himalaya Mission under National Action Plan on Climate Change*, 2008; 8. *NE Region Development Vision 2020*, 2008; 9. *Governance for Sustaining Himalayan Eco System*, 2009.

Historical and geographical background:

Before we elaborate on the salient features of the proposed Himalayan Policy in the context of Uttarakhand, it is necessary to dwell briefly on the ecological problems of the area and the historical movements that they gave rise to.

Having studied the region, travelling to remotest parts and witnessing the earthquakes, cloud bursts, land slides, floods, forest fires for last four decades and going through the historical records related with calamities and devastations[3], we want to say in the beginning that all these calamities failed in fully sensitizing the system, administrators, and policy makers. The social protests regarding land, forests, waters and governance were never heeded to by the powers that be. These were termed as 'anti-development' and against the 'wish of the people'. Vested interests who encroached on lands and forests for their `development' projects, created this myth of 'wish of the people' to justify their encroachment (without consulting the local people who were ousted from their lands). This myth was so powerful that not only political leaders and media people, but also some scientists and social activists came out in favour of this model of development. Several MLAs, MPs, Ministers and civil servants supported the construction of big dams and industries, ignoring the need for the conservation of forests, progress in agriculture and horticulture in the state. Most of the industries were developed in the foothills - Doon, Bhabar and Tarai region- and HEPs in inner Himalaya. For all these `development' projects, the authorities acquired land at minimum cost.

The plan of `development' through such indiscriminate exploitation of forests and devastation of agricultural land, led to a series of inevitable disasters, the latest being the massive and intense devastation of June 2013. This led the judiciary to take step towards the formation of an expert committee to assess the environmental degradation, factors responsible for the disasters, and to suggest an appropriate Himalayan Policy. The judiciary, however, was not properly informed about the kind of devastation in Yamuna, Pindar (Alaknanda tributary), Saryu, Ram Ganga East, Gori Ganga, Aila Gad, Kali and Dhauli East river valleys. The media was not able to see beyond Mandakini-Kedarnath valley, where bigger tragedies happened. The calamity in Yamuna, Aglad, Jalandharigad, Pinder, Saryu, Ram Ganga East, Gori Ganga, Aila Gad, Kali and Dhauli East valleys has not yet been fully reported and documented. The warnings given many years back were not even recalled/

[3] Some of the post 1970 are listed here: Tawaghat landslide (1977, killed 44 people), Bhagirathi valley landslide and flood (1978, killed 25), Kuntha landslide (1979, killed 40+), Gyansu landslide (1980, killed 45), Karmi landslide and flood(1983, killed 37), Neelkanth Mahadev near Laxman Jhula landslide (1990, killed 100), Uttarkashi earthquake (1991, killed 737+), Forest Fires of 1996, Mad Maheshari-Kali Ganga flood (1998, killed 100+), Malpa landslide (1998, killed 250+), Chamoli earthquake (1999, killed 100+), Varunavat landslide (1998, damaging houses), Kosi flood (2010), Forest Fires of 1996, 2006, 2008, La-Jhakla cloud burst (2009, killed 33), Assi Ganga cloudburst (2010-12), landslide and flood (2012, killed 29+), Ukhimath landslide (2012, killed 69) and many other disasters. For more information on earthquakes see: K.N. Khatri, 1987, *Great Earthquakes, Seismicity Gaps and Potential for Earthquake Disaster along the Himalayan Plate Boundry*, Tectophysics 138; V.K. Gaur (Ed.),1993, *Earthquake Hazard and Large Dams in the Himalaya*, Delhi.

reported by any agency.[4] The administration and leadership failed to go to the much damaged remote areas and know the extent of the damage. They also failed in establishing a functional and credible coordination mechanism to interlink the relief effort. As proper relief work was not done, it was not followed by serious rehabilitation measures. Nine months after the disaster the new Chief Minister is now doing the work which should have been initiated long back.

It is also clear from the demands of the victims, discussions in the media and decisions taken by the state or central government, judiciary and even learned members of National River Ganga Basin Authority (NRGBA) that river Ganga is not being taken in its totality and whole Uttarakhand is not being considered as the north-western most catchment of river Ganga. It is exclusively in the Indian Himalaya as no river flowing in this state originates in Tibet. Though it is true that the Yamun-Tons and Kali-Sharda system meet the main Ganga respectively in Allahabad and Chhapra (Bihar) taking all the waters bringing from the right side catchment in Uttarakhand, Himachal and Haryana and left side catchment in Tibet-Nepal. The outer Himalayan non glacial rivers independently flow and meet Ganga in the plains. Therefore, entire Uttarakhand should be considered as a part of the Ganga system. Traditionally also each river in its own way is considered as Ganga or her sacred sister in India.

Previous reports

In 2010 WII was given the task of making an assessment on 'cumulative impacts' of 'HEPs on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins' and AHEC, IIT Roorkee was given the task of assessing the 'cumulative impact' of HEPs on the same basins (the Hon. Supreme Court has said in para 46, page 64, 'prima facie, we are of the view that the AHEC Report has not made any in-depth study on the 'cumulative impact' of all project components like construction of dam, tunnels, blasting, power house, muck disposal, mining, deforestation etc by the various projects in question and its consequences on Alaknanda as well as Bhagirathi river basins so also on Ganga, which is pristine river')[5]. Both the reports are in public domain now. Both the reports have their short comings.

The AHEC, IIT-Roorkee report is already questioned by SC and the WII report did not consider many projects for serious scrutiny on the basis of a poor logic that in these projects much work has already been done. But at the same time WII suggested for abandoning 24 out of 70 (13 commissioned, 14 under construction and 43 under other stage of development) projects after doing an in-depth study of 'cumulative impacts' on Aquatic and Terrestrial Biodiversity. If biodiversity has compelled them for these recommendations than the other aspects like geology and tectonics of the region, seismic behavior (Uttarakhand being considered as ‘seismic gap area’), glaciological and geo-hydrological aspects, volume of the silt in the rivers, socio-cultural disturbances, dislocation of the communities and finally loss of the land and soil raises serious questions about the overall feasibility of these projects.

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4 Kimothi, M.M., Juyal, Navin and Bhatt, Omprakash, 2003, *Landslide Induced Flooods in the Upper Alaknanda Basin* (Report Prepared for Ministry of Agriculture, GoI), SAC (ISRO), PRL Ahmedabad and DGSM, Gopeshwar.

5 See: Judgement by Justice K.S. Radhakrishnan, dated August 13, 2013.

The idea and endeavor for alternatives and other ways of getting energy was never aptly explored in this Himalayan state. The solar and wind energy became the victim of state apathy. Many people may recall that the Micro Hydel Corporation in UP was established when Chipko Movement started *bijli satyagrah* by generating power from the locally developed small hydro enterprise in Balkhila river (tributary of Alaknanda) near Gopeshwar in early seventies.[6] The *bijli satyagrahees* were not allowed to take the light inside homes.

Since last few years river Ganga has become the centre of public debate and the Government of India has been compelled for some new and bold official decisions. In August 2009, Government of India re-launched the Ganga Action Plan with reconstituted National Ganga River Basin Authority (NGRBA). Ganga was given the status of 'National River', though casually. However, with the notification of 20th February 2009 the status of National River seems to have been fossilized into a mere label as no concrete steps towards the conservation and protection of the national river has been taken so far. Earlier also the Ganga Authority spent millions of rupees in the Ganga cleaning but it was a futile exercise. It was like giving a medication without a proper diagnosis and as a result, the remedy didn't have the effect.

The Governemnt of India also formed an Inter Ministerial Group (IMG) under the Chairmanship of Mr. B.K. Chaturvedi (Member, Planning Commission of India) in June 2012 for looking at various aspects of Ganga and to make available the information and material on 'Ganga River Basin Management Plan Study' being carried out by the consortium of IITs. This was supposed to be the beginning of an in depth study of the whole Ganga basin, at-least its Indian part. There was debate and disagreement within IMG members also, as the report was more concerned about the generation of power than taking care of the environment, biodiversity and communities along and in the catchments of the Uttarakhand Rivers. The report casually recommends about keeping six rivers in pristine stage and also discussed the idea of 'environmental flows' (E-Flows).

Three decades back Vishnuprayag HEP was cancelled after getting a scientific challenge from Chipko Movement. Mr. Chandi Prasad Bhatt submitted the ecological, hydro-geological and human aspects of the project and Prime then Minister Smt. Indira Gandhi decided to scrap this project. Only under the compulsions of new economic policy with privatization as its salient feature the project restarted in 1995 with benefit for the developer and loss for the local ecology and the villagers. This may be the case with many other projects.[7]

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6 See: Dinman, 13-19 November 1977, New Delhi.

7 Sunil Sethi, *Vishnu Prayag Project: Blue Print for Disaster*, India Today, 30 Novemeber 1983: 42-43, New Delhi; Bhatt, Chandi Prasad, Juyal, N., Kunwar, M., 1985, *Vishnuprayag Project : A Risky Venture in Higher Himalaya*, in J.S. Singh (Ed.), Environmental Regeneration in Himalaya: Concepts and Stratagies, Nainital: 410-418; Bhatt , Chandi Prasad, 1997, *Future of Large Projects in the Himalaya*, Nainital; K.S. Valdiya, 1993, *High Dams in Himalaya*, Nainital.

A few other decisions with reference to the Ganga and Himalaya have been taken. Three under-construction HEPs were scrapped in the upper Bhagirathi valley (Bhaironghati, Loharinag-Pala, Pala-Maneri and Bhairon-ghati HEPs) and with a special notification dated 18th December 2012 the Ministry of Environment and Forests has declared entire water shed of about 100 Kilometre stretch of Bhagirathi river from the snout (Gaumukh) to Uttarkashi town covering an area of 4179.59 square Kilometres as the 'Eco sensitive Zone' under the Environment (Protection) Act 1986 and Environment (Protection) Rules 1986.

Even though this is welcome decision and a good beginning but is surely incomplete for all the other regions/belts of the entire Himalaya ecosystem are equally fragile and sensitive and need to be declared so. This decision was something close to the 'Wild and Scenic River Act of USA' but introduced with out much debate among different stake holders. The seed of this idea was given in a Planning Commission report a few years back in a different form.[8]

The reports/ studies done in the past have all been put under question after the massive devastation of June 2013. This has compelled our society, the executive, the legislative and the judiciary to dwell deep to find out the right reasons for this massive catastrophe. It is pertinent to point out here that the very reason of drafting this Himalayan Policy is to acknowledge and address that the Himalayas and its people are facing the roughest and toughest challenges & the fragile ecology of this place is not to be toyed with.

Recommendations for a Himalayan Policy: (For Uttarakhand)

It is in this background of ecological problems and historical political responses to them, as outlined above, that we propose recommendations for a Himalayan policy under the following heads:

1. **The Resources of the Region**
2. **Complex Demography**
3. **Alternate Energy Sources**
4. **The Wilderness and Socio-Cultural Significance: A unique Resource**
   4.1 Cultural Eco Zones (CEZs)
   4.2 Green Bonus
5. **Planning and Governance**

Elaborated below are salient features of the 'Himalayan Policy' in the context of Uttarakhand and should be implemented over a period of time and then also be used as blueprint for other Himalayan regions.

[8] *Report of the Task Force on the Mountain Eco Systems (Environment and Forest Sector) for Eleventh Five Year Plan*, Chaired by R.S. Tolia, Planning Commission of India, November 2006

1. THE RESOURCES

A. Land
B. Water
C. Forests

The resources made the human life possible in the Himalaya. To look at all the resources- land, forest, water, wilderness, cattle, humans as allied- together and any development model has to be evolved around them. All these resources are very intimately connected. These resources have been developed in millions of years and are the meticulous and magical works of the nature.

For thousand of years, human communities have been living and evolving the ways of survival on these resources. The services sector is only 150 years old. Around these, they have developed all indigenous sciences and arts, which we still find around us. They have been developing the methods of resource use by saving and protecting them. The idea of sacred groves, dedicating forests to deities, worshipping trees and water springs/rivers, not using leather shoes and not making noise in *bugyals* and festivals related to nature, are all expressions of this wisdom of using and conserving the resources.

The colonial regime declared these 'life resources' to be 'goods' and the 'corporate approach' of the open market economy has turned them into 'commodities'. In this way all the resources have become the silent victims to a relentless, institutionalized plunder. Any encroachment in one resource disturbs the other. The fragility of young Himalaya, remoteness, marginality, little agricultural land, high out-migration and increasing number of incoming tourists-pilgrims, the bio mass based energy use, increasing 'developmental' activities and finally the compulsions created by globalisation and climatic change are to be looked at with the resources. It should also be remembered that any wrong deed in the Himalaya may have serious implications in the down stream regions. Any sensible thing done for the Himalaya will have positive impacts on the ecology of North Indian plains and ultimately the whole country.

So inter-relationship of the resources and the regions (upstream and downstream) should be in our minds when we think about doing anything in Himalaya. Long term planning can not be replaced by short term gains. To increase and accelerate the fragility of the already fragile Himalaya by opting for ways, which are against the very existence of this mountain with multi micro eco zones, can not be termed as wise. The relationship of different Himalayan nations / regions on the one hand and trans-Himalaya with higher Himalaya, lower Himalaya, Tarai-Bhabar-Dun area and finally the North Indian plains on the other can be understood only when one looks at the horizontality of the Himalaya with its verticality.

A. LAND – '*Vasundhara*': The Mother Resource

Land is considered to be the mother resource everywhere. In the Himalayan context land is not just an agricultural and horticultural base but is also related with the identity of the communities or individuals. Around the individually owned agricultural / horticultural land they have *panghat-gochar* and *van panchayats* (commons or CPRs), domestic cattle, forests,

wild life and in some places *bugyals* (alpine pastures). The spring or ravine is nearby and so is the small temple of local folk God/Goddess. This makes a true mountain milieu.

The Uttarakhand region has very little agricultural land and there is tremendous pressure on it. Only 13 % land is under agriculture and individually owned (may be less than this, in U.P. it is around 70%). Only Hardwar and Udhamsinghnagar districts have more than 50% agricultural land. In the 88 % mountainous region –(districts of Almora, Pithoragarh, Bageshwar, Chamoli, Rudraprayag, Uttarkashi and Tehri fully and Champawat, Nainital, Pauri and Dehradun partially)- around 6% agricultural land is available and it is around 3 % in the border blocks like Dharchula, Munsiari, Kapkot, Deval, Joshimath, Ukhimath, Bhilangana, Bhatwari and Mori, which were heavily devastated in June 2013 landslides-floods.

If we look at the size of land, the scenario will be clear to us. 71 % people in Uttarakhand have less than 1 hector (28 % of tal-total agricultural land), 17 % people have 1 to 2 hectors of land (25% of tal), 9 % have 2 to 4 hectors (25% of tal), 2.8 % have 4 to 10 hectors (16 % of tal) and only 0.2 % have more than 10 hectors (5 % of tal) of land[9] (the whole Hindukush-Himalaya region have only 5% agricultural land as per ICIMOD studies).[10] Organic agriculture with all its diversity is but a very natural expression of these difficult areas with small land holdings.

Recommendations:

(i) Systematic layout of construction of roads must be ensured because due to unplanned construction of roads, dams and growth in urban and semi urban centres the land is shrinking. Loss of agricultural diversity will have serious consequences.[11] The encroachment in commons and reserve forests must be stopped.

(ii) 'The new land settlement', which was due for the year 2000-2004 should be conducted immediately.

(iii) No change of land use from green uses such as horticulture, agriculture, parks etc to non green uses should be permitted. There is need of strict rules regarding the sale and conversion of the land like in other Himalayan states and also land consolidation is urgently to be done. In Tarai-Dun and Bhabar areas much of the agricultural land is taken for non agricultural purposes and similarly in other parts of Uttarakhand the individually owned agricultural land is now being used for community housing, government buildings, institutions and industries. Some method should be evolved to stop or minimize this process.

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9. *Agricultural Statistics of Uttarakhand 200-01 to 2002-03*, Agriculture Directorate, Dehradun: 224-27.

10. In whole Hindukush-Himalaya area the pasture land is 39%, the forest area is 21%, protected areis 11% and agricultural land is 5% (Sharma, Eklabya., 2004, *ICIMOD News Letter 45*, Kathmandu). In Indian Himalaya per capita agricultural land is 0.29 Hector (Ya, Tang and Tulachan, Pradeep M. (Eds), 2003, *Mountain Agriculture in the HKH Region*, ICIMOD, Kathmandu: 7)

11. Maikhuri, R.K. & others, 1997, *Eroding Traditional Crop Diversity Imperils the Sustainability of Agricultural Systems in Central Himalaya*, Current Science, 10 November: 777-781, Bangalore; कुँवर प्रसून, 1995, *बीजों की विरासत*, जाजल (टिहरी); जरधारी, विजय, 2007, *बारहनाजा–समृद्धशाली पारम्परिक कृषि विज्ञान*, रायगढ़।

(iv) A policy to introduce 'Special Agriculture Zones' (SAZs) in Uttarakhand has been approved long back but little has been implemented. Steps to ensure implementation of this policy are much needed. This will encourage cash crops as well as crops of medicinal value.

(v) Permanent exchange of ownership of land amongst villagers so that each one owns all of his land in one place. Farmers in Uttarakhand own very small patches of land. If a farmer owns more than one patch of land then most of the times it is at different locations in the village. Due to this, the effort to grow crops on different sites has always been a challenge. Also, lot of land was just left unused. The introduction of SAZ's in the area allows sharing/ renting the land beside the farmer's productive land, which not only increases the productivity due to the usage of the barren land but also reduces the effort on the part of the farmer.

(vi) Organic farming is the method followed for generations. Now use of chemicals and fertilizers started even in un-irrigated land. Natural farming should be encouraged as there is a huge demand in the market for organic grains and such produce. Further all chemicals and fertilizers should be discouraged as these pollute the earth and by percolation pollute the ground water, streams and eventually the rivers.

(vii) To develop orchards the region is well-suited. Several fruits such as different citrus fruits, plums, apricots, apples, figs, walnuts and wild berries. Large scale orchards can be encouraged throughout the region besides herbal, floral and vegetable farms.

(viii) The region is best suited to cultivate a variety of medicinal and aromatic plants. Their farming should be encouraged. Trees like Chulu (wild Apricot), Cheura (butter tree or *Diploknema butyracea*), Kafal (*Myrica sapida*), Thuner (*Texax beccata*), and Aonla (*Emblica officinalis*) should be given priority. Wild fruit trees should also be increased in the forest .

B. WATER

Uttarakhand is a land of snow and water and part of larger Himalayan 'water tower'.[12] This water is associated with monsoon, glaciers and the forests and without them one cannot understand the Himalayan hydrology. The behavior of a Himalayan river is associated with glaciers, forests and geo-morphology of the catchment areas. The movements along Main Central Thrust (MCT) and associated thrusts and faults also impact the behavior of the river. All these elements and forces make the river a living entity. The Himalayan rivers provide pristine water, fertile silt and are home to diverse kind of life forms. Since the last century, these Himalayan rivers have also become a rich source of hydro-power.

Hundred years back first time the small (micro) hydro-projects were introduced in Himalaya near the hill stations by the colonial rulers with European technology. This process continued for half a century. After the independence Bhakra-Nangal became the symbol of the first 'hydro temple' of the country. In seventies the process got a speed, which was accelerated after the beginning of open economy and privatization. Instead of Public Sector Undertakings (PSUs) the private parties, most of the time new to 'hydro activity', became the dominant players in power sector. Generally the Himalayan region and particularly

12. *The State of the Mountains*, UNCED, 1992.

Uttarakhand became the victim of this process of abuse of the water resources. It was never understood and analysed that how deforestation, mining, road construction, tunneling, use of explosives in HEP construction etc. increased the volume of loose mass (silt, muck, debris, boulders, and tree trunks/roots) in and around rivers and how this has changed their behavior drastically. The loss of the soil and vegetation, drying up and shifting of natural springs and decline in the agricultural production is very much evident in most of the areas. Even some of the best agricultural valleys were destroyed due to the landslides and floods. One can take the cases of Someshwar and Baitalghat areas in Kosi valley (districts of Almora and Nainital) and many places in Kamal river (Uttarkashi), Aglad (Dehradun), Balganga (Tehri), Nayar (Pauri), Saryu (Bageswar), Binu, Nayar, Ramganga East and Gori (both Pithoragarh) etc. in recent decades. The best irrigated agricultural land lies in the valleys of smaller rivers.

. The rivers are not simply mechanical flows for HEP exploitation; they play a crucial life sustaining, ecological and cultural role. The ecological role is the scheme of the nature but the cultural role is human induced. In this situation the rivers have been failing to sustain themselves and in playing their natural role properly. Today the ecological services of a river are considered very important. In Himalayan and Indian context the cultural, and to some extent recreational, role is of equal importance.

'The Nayabad and Wasteland Grant Rules 1893' indirectly started the process of state control, which further cleared in 'Kumaon Water Rules 1917' (modified in 1930), framed under the 'Scheduled District Act of 1874' in the second decade of last century[13]. At that time Indian freedom struggle was already at its height, so these rules were not implemented. After the independence our own government made the water as state owned and communities don't have the right in this resource.[14]

Recommendations:

(i) Looking at the Himalayan Rivers in a purely ecological way is not enough if we do not relate it with culture. Therefore in addition to 'ecological flows', we recommend the aspect of 'socio– cultural flows', which should be defined and implemented.

(ii) Water as a resource can be used for empowering the locals and for making the villages self-sufficient and the villagers self-reliant. Micro hydel projects should be encouraged where the local communities can be made responsible for running these projects.

(iii) Combination of water milling and hydro power generation can be done together. The traditional *gharats* or *panchakkis* (water mills) can be developed further. These projects can help in satisfying the local energy demands.

(iv) The locals can collectively establish these water mills and the electricity generated can be used locally in the villages and the extra energy can be given to the grid and the benefit would be utilized in making the villages self-reliant.

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13. Kumaon Water Rules 1917; Asthana, Rohit, 2000, *Empowered State and Eroded Water Rights in Uttarakhand- A Study of Water Disputes in Almora District, UP, Hills, India*, Development Centre for Alternative Policies, New Delhi.

14. See: *Kumaon and Garhwal Water (Collection, Retention and Distribution) Act of 1975 and UP Water Supply and Sewerage Act of 1975.*

(v) It is still to be learnt the use of water judiciously and priority wise for drinking, cultural use (the sacred bath, purifier and part of religious-cultural rituals, so much attraction for *Gangajal*), irrigation, water milling, hydro-power generation, industrial use and packaging purposes.[15] The priorities should not be altered and whereever possible the hydro-power generation and packaging of water should also be done under community ownership.

(vi) Even though Himalaya is the 'water tower' but rain water harvesting is need of the hour. It will recharge ground water and contribute in the flow of non-glacial rivers. A dying river cannot sustain life and if a river is dying due to human induced causes then rain water conservation, judicious use of it and harvesting is the only way for making rivers living. Linking and diverting the rivers is still a controversial issue.

C. FORESTS

Uttarakhand constitute 1.63 % (53483 Sq. Km.) of India's total area. The recorded forest area of the state is 34651 Sq. Km., which constitutes 64.79 % of total geographical area of Uttarakhand. But the 'forest cover' in the state is 24496 Sq. Km. (45.80%) as per satellite data of October-December 2008. It may be less than that as there are doubts about the actual forests in India and Himalaya.[16] Out of this only 18 % (civil *soyam* land is 4768.70 Sq. Km. or 8.93 % and village *panchayat* land is 4961.85 sq. km. or 9.28 %) can be termed as 'commons'.[17]

Uttarakhand has 6 national parks, 6 wild life sanctuaries and 2 conservation reserves covering an area of 7376 sq. km, which is 13.79 % of state's geographical area. As per a Forest Department document prior to the creation of MoEF (in 1983) 50% of total land diversion was for HEPs and after the promulgation of Forest Conservation Act of 1980 a total of 808.26 sq. km. (2.34%) forest land was diverted for non forestry purposes in Uttarakhand.

The forests are as much an integral and distinctive feature of Himalaya as the snow/ice and water are. The 'water towers' lie not just in the glaciers their roots go deep into the forests. Gathering and collecting, livestock and agriculture, crafts and cottage industries, traditional medicines and trade are all supported by the forests. Forests are critical to the formation and retention of soil. Forests fill the lives of people with song, music, journeys and a range of arts and implements. They are home to animals and birds. They make possible the extent of biological diversity.[18]

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15. PSI Report on Water; Alter, Stephen, 2001, *Sacred Waters: A Pilgrimage to the Many Sources of Ganga*, Penguin, Delhi.
16. Gilbert, Natasha, 2012, *India's Forest Area in Doubt : Reliance on Satellite Data is Blamed for Over-Optimistic Estimates of the Nation's Forest Cover*, Nature, 4 September.
    Satellite data don't give us information about the under growth and non timber species of the forest. So this method must be associated with manual survey of the forest. Working Plans should also be associated with this method.
17. *India- State of the Forest Report 2011*, FSI, Dehradun: 236-38.
18. Brandis, Dietrich, 1994 (1897), *Forestry in India*, Dehradun; Ribbentrop, Berthold, 1989 (1900), *Forestry in British India*, New Delhi; Pant, Govind Ballabh, 1922, *The Forest Problem in Kumaon*, Allahabad; Guha, Ramachandra, 1989, *The Unquiet Woods - Economic Change and Peasent Resistance in the*

Anthropogenic activities including HEPs have created further threats to biodiversity (including aquatic, terrestrial, avian etc). Even in the areas close to Protected Areas, the HEPs were allowed to enter, which is against the very acts enacted by our Parliament. It has not only increased the threat to the biodiversity, but also reduced the space for the carbon sink. Eco System Services is another important aspect related with forests. If we can not discuss the complex, complicated and not fully known aspects of the climatic changes, we can at-least try to visualise its possible implications in the near future.[19]

Recommendations:

1. Empowering '*Van-Panchayats'* is the very first task. The *van panchayats* are the traditional institutions for managing the forests in a participatory way. Earlier these were known as '*lath panchayats'* and during *jungle satyagraha* in the early decades of 20th century after a aggressive movement the communities were able to get back their forests from colonial take over and reinvented the *van panchayats*[20], which are the best known community forest institutions in India.[21]

Growth of *Van Panchayats*

Years	Number of Van Panchayats
1925	First VP
1931	VP Act
Up to 1947	429
1947-1993	3635
2001	6777
Up to 2006	12089

Compiled from UP and UA Forest Statistics, Forest Department Lucknow and Nainital

After independence the *van panchayats* have become the victim of departmental apathy as the autonomy of the *van panchayats* was diluted during World Bank sponsored Joint Forest Management (JFM). Due to the pressure on forests the biodiversity is in peril. Many flora and fauna are in RET status as per IUCN

Himalaya, Delhi; Grove, Richard H.; Damodaran, Vinita and Sangwan, Satpal (Eds.), 2000 (1998), *Nature and the Orient: The Environmental History of South and and Southeast Asia*, Delhi; Pouchepadass, Jacques, 1995, *Colonialism and Environment in India: Comparative Perspective*, Economic and Political Weekly, 19 August, Bombay; Shiva, V. and Bandyopadhyay, 1986, *India's Civilisational Response to the Forest Crisis*, New Delhi; Singh, J.S.and Singh, S.P., 1994, *The Forests of Himalaya*, Nainital; Pathak, Shekhar, 2001, *Jungle Satyagraha* in Rawat, Ajay S. (Ed.), Forest History of the Mountain Regions of the World: 222-241, Nainital.

19. Malone, Elizabeth L., 2010, *Changing Glaciers and Hydrology in Asia- Addressing Vulnerabilities to Glacier Melt Impacts*, 2010, USAID.
20. Guha, Ramachandra, 1989, *The Unquiet Woods*, OUP; Mishra, Anupam, 1979, *Chipko Andolan*, GPF, Delhi.
21. Agrawal, Arun, 2007, *Environmentality*, Duke University, Durham.

classification. It is therefore extremely important to reinvent and restructure the institution of *van-panchayats and to* encourage their protection.

2. *Van Panchayats* have to be made independent of the Forest Department. Every village will have its own 'village forest', for the fulfillment of grass, leaves and wood for domestic use. The forest will be distributed among the villagers, who have no forest or forest land on priority basis. The forest department should be in a role to help communities to conserve their *gram van/ panchayati* forests.

3. The idea of sacred groves, dedicating forests to deities, worshipping trees and water springs/rivers, not using leather shoes and not making noise in *bugyals* and festivals related to nature, are all expressions of the traditional wisdom of using and conserving the resources. One of the most interesting traditions is that of '*dev van'* meaning God's land/ forest. A certain area or forest is dedicated to a God/Goddess after which cutting of trees, encroachment in the forest land is not at all practiced. This practice having great traditional wisdom should be encouraged, which are very helpful in land/forest conservation and prevent the ruthless cutting of trees.

4. Himalayan forests are home to some of the most exquisite species of animals (Snow leopards, Himalayan black and brown bears, chital, goral, bharal, otters, Indian grey mongooses etc.) and birds (red Helen, the great eggfly, pale wanderer, great slaty woodpecker, orange breasted pigeon etc). Conservation of these Himalayan animals and birds is important in order to maintain the balance of this delicate ecosystem. Due to the road construction, construction of HEPs, buildings and structures, mining etc., the forest and agricultural land is being compromised. At many places there is encroachment into commons *(panghat, gauchar* and *van panchayats*) and even into Reserve Forests and Protected Areas (PAs). These practices need strict regulation and checks.

5. The tragedy of the commons have many other aspects in Uttarakhand as even after 1980 Forest Conservation Act many forest areas were used and are being used for non forest purposes. Mining is going on in river beds and elsewhere. Compensatory afforestation works (related with developmental projects) is almost nothing in comparison of diverted forest. Catchment Area Treatment (CAT) programmes have been most of the time ritualistic and casual. Under the scheme of 'Corporate Social Responsibility' (CSR) very little amount have been spent for conservation purposes. Private interests are now penetrating into commons, reserve forests and protected areas and it must be checked.

6. Today resources are being captured by the corporate world without having a widely acceptable state policies thus compromising with the interests of commons. It is high time to return all the resources to communities. This will open the way for a participatory green democracy. The state may retain large areas of reserve forests and Protected Areas (PAs), though these areas also need community based initiatives for long term sustainability.

2. COMPLEX DEMOGRAPHY AND OUT-MIGRATION:

Uttarakhand is a state with much difficult demography. Out-migration has not only drastically changed the rural mountain scenario it has also challenged the very justification of Uttarakhand state. First time in the history of census operations since 1872 the two districts- Almora and Pauri- have shown the negative population growth in 2011 census. As per 2011 census the population of the state is 10116752[22] and as per our projection around 4 million people of Uttarakhand origin live out side of the state and the country.[23] The demographic profile of the state within itself has changed. Now in 88 % mountainous region (7 district fully and 4 districts partly) less than 47 % population live and in 12 % Bhabar, Dun and Tarai area (2 districts fully and 4 very partly) more than 53 % population lives with industrial growth and high seasonal influx. The economic growth and rise in GSDP index is centred in the districts of Dehradun, Hardwar and Udhamsingh Nagar and agricultural growth has come down all over the state.[24]

Though complete stoppage to the out-migration seems to be a far-fetched idea but some next positive steps can certainly put a check on the intensity of it. Slowing migrations is linked to skill development through education, motivation and training. All innovative schemes need perfect planning, committed leadership, hard work and communities also need to dream and aspire for them. Government should come in only as the facilitator. Most of the corporations can only destroy the mountains. The schemes should come from the communities and their organisations. They can also learn from other mountain states of India and other mountain countries too. Keeping this in mind, we recommend the following:

Recommendations:

1. Planning and developing educational, vocational and training institutes around pilgrimage, tourism, cultures and languages of the region is the first work in this regard. Trained mountain / nature guides (for pilgrimage, trekking, landscape studies, mountaineering and tours in PAs etc), sports, museums, handicrafts, horticulture, floriculture, medicinal and aromatic plants can pave the way for alternative livelihoods.[25]

In this connection, Community based tourism (CBT) can lead to all round development of the countryside as well as employment opportunities. A village or a cluster up of villages can be developed as an eco-friendly village/ villages with green

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22. Anonymous, 2001. *Census of India 2001*, Population Totals, Registrar General of India, New Delhi (In C.D.); Anonymous, 2011.*Census of India 2011*, Provisional Population Totals, Registrar General of India, New Delhi; Anonymous, 2011.*Census of India 2011*, Provisional Population Totals, Paper -1 of 2011 and Paper -2 Volume-1 Rural and Urban Distribution, Registrar General of India, New Delhi.

23. Askot Arakot Abhiyan 1974-84-94 and 2004, 2007, Pahar 14-15, Nainital.

24. See for Uttarakhand's changing demography: Chand, Raghubir and others, Pahar-1, 1983; Pahar-2, 1986; Pahar-18, 2013.

25. Some of these ideas are part of Government reports. See, *Governance for Sustaining Himalayan Ecosystems: Guidelines and Best Practices*, 2011, MoEF and GBPIHED, Kosi Katarmal.

electricity alternatives and involving green practices like garbage recycling, organic farming, animal husbandry and use of gobar gas etc. Home stays for pilgrims / tourists can be organized in these eco-villages thereby providing entrepreneurship opportunities to the locals literally at their doorstep. Local youth can be employed as guides for walking tours of the vicinity.

2. Local resource based cottage industries like jam-making, herbs, handmade soaps, incense making, woolens, handicrafts, different folk arts etc. can provide employment to both men and women. Proper organization of the dairy sector will be a help in promoting dairy products like milk-cheese-chocolate-butter-ghee and allied products etc can be a good source of income for the locals.

3. Dairy sector is not aptly organized in the hill states. Organizing this sector will be a help in promoting dairy products like milk-cheese-chocolate-butter-ghee and allied products etc can be a good source of income for the locals.

4. Sheep rearing for wool, shawl making and other traditional arts and craft like baskets etc. should be encouraged and promoted via small local eco-craft shops can be set up by the locals where organic agricultural produce or products made out of them (soya crackers, potato, burans products, local oils, soaps etc) can be sold.

5. Creating jobs for the youth in the hills will really help in mitigating the problem of out-migration. Most of the tourism related jobs are seasonal and the other jobs are project oriented ones which are temporary and limited to construction phase only (like HEP construction etc) but we should provide a consistent and sufficiently paying engagement to the youth. One such activity could be construction of green structures.

- The youth in the hills can be engaged in building green structures by providing them required material on a subsidy and the required technical education about this preferred form of architecture that is earthquake proof, eco-friendly and aesthetical.
- These wooden structures are perfectly appropriate for a high seismic zone as they help in mitigating the impact of earthquakes and must be preferred over cement buildings that are not safe and not preferred for the hill climate as it remains cold in winter and warm during summers thereby consuming a lot of electricity unnecessarily.
- A vocational training to the youngsters about this kind of traditional architecture can be carried out for a large scale implementation. Town planning can be done keeping these structures in the centre of it, where new innovations of right kind of sewage disposal (with small STPs) must be included.
- These kind of green structures have been an age old practice. An example is that of the *Kath khuni* buildings of Himachal Pradesh and Koti Banal in Uttarakhand, which are made up of locally available material - deodar wood and slate stone.

- *Kashta kala* (wood carving) is the other type of construction pattern in the Jaunsar and Bhabar region of Uttarakhand, where wooden structures are made which are not just earthquake prone but also economical and airy.

6. The IT, fruit, milk-cheese-chocolate, toy making and mountain music, map and literature related community based small enterprises can make good alternatives for the village women and youth.

7. Micro hydro-projects, solar and bio mass (including pine needles) based projects can also be run by communities. High standards are to be created and maintained.

8. We have to encourage the animal husbandry with much more clarity and conviction. Organic composting should also be encouraged. The different roles played by domestic animals are to be studied more properly.

3. ALTERNATE ENERGY SOURCES

This is unfortunate that no energy policy has been extensively discussed after the formation of the state in a view of its fragile environmental, socio-cultural aspects. As a result the rivers, mountains and therefore the society is continuously being the victim of unplanned policies. Even this concern has earlier been raised by planning commission's recent task force report in 2010 headed by G B Mukherjee, emphasizes that- '…***There is every reason to suggest that the standard pattern for hydro power generation, distribution and consumption within the IHR should be decentralized and networked through small projects only. The task force strongly seconds the views of the state governments that for exporting power, mega projects rarely; and a few medium projects are the logical recommendations for the IHR…'***

In different parts of the world, wind, solar, gober gas, biomass-perul based energy and solar-thermal powers are now being harnessed with more sophisticated technologies. In Spain the Terre sol's 19.9 MW Gemasolar Thermosolar Power Plant is supplying power to national grid.[26] The new technology can be used here as well. Experts say that in most areas of Uttarakhand, more than 250 sunny days are available in a year. Geo-thermal energy resources are not being studied and taped in a proper way[27]. Apart from wind energy (it is to be researched whether wind mill affect avian life) it is necessary to find out whether water can play the role of energy in some of the cottage industries (this kind of use was traditionally done in water milling, wood carving, wool cleaning, saw milling, wood shaping etc.).

Though we have a Ministry for New and Renewable Energy (MNRE), its budget and commitment are meagre, since the bias in favour of nuclear and hydro power is high and strong.[28] Water is the strongest resource of the Himalayan state and is also the most

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26. Prem Shanker Jha's article in *Brahmputra: Towards Unity*, Part I, pages 25-26, The Third Pole Net.

27. See for some information on geo-thermal energy resources in Uttarakhand: Bharadwaj, Kailash N. and Tiwari, S.C., 2008, *Geothermal Energy Resource Utilization: Perspective of the Uttarakhand Himalaya*, Current Science 10 October: 846-850.

28. Some new facts emerged in the recently concluded *4th Anil Agrawal Dialogue on Energy Access and Renewable Energy*, New Delhi on 27-28 February 2014 organised by CSE. The Union Minister for New

exploited resource. The ecological balance gets disturbed with much exploitation of this precious source especially in HEPs. In order to prevent this exploitation of water, it is strongly recommended to move towards decentralized alternate sources of energy generation on the following lines:

a. Solar power: The government's initiative to move towards greener sources of power generation is a much applauded step. For the same Dehraduun, Rishikesh & Gopeshwar have been proposed as sites of solar power generation. In the hills, solar panels and solar street lights can be used.

b. Pirul electricity: Pine needles are found everywhere on the forest ground during its shedding season. Pine is a major native and hardy species, which after the impregnation during the British raj became the major timber. The pine needles form a carpet on the forest grass and make it impossible for any other plant to grow. Collection of these pine needles by the locals is done and used to make bricks, which is used as bio-fuel. These needles can also be used for generating electricity and an initiative has been introduced in the state for the same. This will suffice the local requirements and provide employment to the locals. Avani is already doing this work.

c. Gobar gas plants: This is another kind of initiative towards production of green electricity. In the state, UREDA has taken steps towards implementing these and such practices must be actively encouraged and replicated elsewhere in the state as well.

d. Combination power projects: Dual medium of alternative energy sources can be put together and this is a novel idea to ensure electricity supply by a project through out the year. For example a combination of solar panels and micro hydel can be made, where during monsoons micro-hydel can be used to generate electricity and during winters when the flow of water is less, sunlight can be harnessed to generate electricity.

4. THE WILDERNESS (WITH SPIRITUAL AMBIENCE): A UNIQUE RESOURCE

The most special, 'niche' resource of the Himalaya is its 'wilderness', its natural beauty and tranquility. This beauty isn't just the peaks, glaciers, confluences, springs, lakes,

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and Renewable Energy (MNRE) told that in 2012-13 electricity produced by renewables met the electricity requirements of 60 million people. But India still reels under immense energy poverty. Renewable energy projects can have major ecological impacts if we don't have environmental safeguards. The growth of renewable energy has changed the energy business in India. In the past ten years, installation of renewable energy for electricity has grown at an annual rate of 25%, as of January 2014, it has reached 30000 megawats. But unfortunately when the total plan outlay for the energy sector during 2012-17 (11th Five Year Plan) was Rs. 10,94,938 crore, the outlay for MNRE was Rs. 33,033 crore only, which is about 3 percent of the total plan outlay (See Press release of CSE dated, New Delhi, 28 February 2014).

valleys of flowers, green and blue forests and perennial rivers considered by themselves, but a combined and juxtaposed whole, much greater than the sum of its parts. This immeasurable beauty cannot be manufactured by nation-states or multinational companies. This wilderness is the perpetual possession of the Himalaya. Pilgrimage and tourism are very much dependent on these assets.[29] A major part of these assets is aesthetic and cutting or digging is not involved. This is the wilderness, which can be the basis for the dust and smoke-free industry of the twenty first century, i.e. people's tourism. And there is tremendous pressure on this resource today.

The wilderness-natural beauty- and sacredness of the region should be used as a rare and composite resource with community based institutions. People (including NRIs) do come to Uttarakhand and Himalaya from all over world for pilgrimage, *shradhh, Gangasnan* and many other rituals. Being the home of Ganga, the region of 6 dhams (4 dhams-Jamunotri, Gangotri, Kedarnath and Badrinath + Hemkunt Sahib+ Kailas Mansarovar-as the only route to this destination in Western Tibet goes through Kali valley) and hundreds of sacred places, it is can be developed into a unique cultural zone.

A Cultural Area

Indian culture never separated the environment from the spiritualism. Spiritual texts-Upanishads and 'Aranyakas' were created in the forest.

Hence due respect to this factor should be made in all developmental activities. Himalaya and Ganga- these two names develop and articulate such attraction that people from different socio-cultural and religious backgrounds have same kind of feeling to visit its different destinations and to touch its waters. Uttarakhand, the origin of the rivers like Yamuna, Ganga and tributaries and the chardhams, is a vibrant and culturally rich area. Pilgrims from all over the world come here for spiritual upliftment. Not only Hindus (Chardhams etc), Muslims (Piran Kaliar), Sikhs (Nanakmatta, Meetha Reetha and Hemkunt Saheb) but also Jains (as the Adinath went to Kailas from this region) and Buddhists (due to Buddhist art and Huen Tsang trail) also come to this region. This spiritual/ cultural significance has a deep relationship with the wilderness of the region. This aspect must be understood that here culture, ecology and economy have been interdependent and disturbing the fine balance means destroying everything.

Also the pilgrimage/ tourism is a very important source of earning for this hill state. The massive no. of pilgrims/tourist during the season certainly brings about a lot of pressure on the ecology and natural resources of the state. Excessive road widening and road building are damaging the Himalayan slopes in an irreversible manner. Massive landslides, entire roads collapsing and destroyed forests can be seen all along the road side in Alaknanda, Mandakini, Bhagirathi and other valleys of Ganga Basin. The captive and ugly big tourism will ruin the region in a short time (as per official statements the total visitors to Uttarakhand

29. Pathak, Shekhar and Ghildiyal, Sanjay, 2007, *Biodiversity: A Basic Tourism Resource*, in Tourism and Himalayan Biodiversity, (Eds) Bisht, Harshvanti and Rajwar, Govind, Srinagar: 1-14.

are more than 13 million per annum). Steps to curb the pressure are essential to implement so as to ensure that the sanctity and the ecology of the area is also maintained.

The wilderness-natural beauty- and sacredness of the region should be used as a rare and combined resource with community based institutions. The communities in coherence with government institutions can formulate a joint program that can be facilitated and implemented.

Recommendations:

1. **Maintaining the spiritual ambience of the valleys:**

These valleys are primarily a highly spiritually charged destination of pilgrimage. It is the place where the Ganga Herself, worshipped by millions, originates and flows. Thus all the banks, confluences (*prayags/sangams*) and the mountains are sacred and spots of pilgrimage. The pilgrimage itself should be conducted on lines that are eco-friendly such as –

- Walking instead of taking recourse to vehicles; disposing of garbage before entering the valleys; banning plastic containers; banning loud music that disturbs the silence of the hills, animals and causes noise pollution, water pollution of streams.
- Silent zones can be identified and meditation groves at different points can be established as well.
- Solar lighting should be encouraged. Ostentatious and excessive lighting should be discouraged through out the zone. There have been recommendations by certain vested interests, like to have light and sound shows in Gangotri, which would greatly disturb the wild life, environment, the ambience and destroy the meditative sanctity of the place. These should be completely banned. For street-lights rather if at all required low non-glaring mild solar path lights could be used.

3. Walking paths *(Aastha path)* for *chardhams*: Traditionally the pilgrims to the *char dhams* used to walk up to the temple site. A walking path for the pilgrims can be made along the mountain side of about 5-6ft wide all along the mountains and where is possible old paths can be rebuild or restored. This path can also be used by the locals and by shepherds that migrate with their cattle. Thus instead of the destructive process of building excessive roads let us encourage walking as mode of tourism with the following initiatives:

(i) Encourage and advertise the sites and places of cultural / historical importance on the map of this walking path. This will engage and decentralise the pilgrims/tourists inflow always in different places and will also serve as an alternate route on the time of disaster. Further it will encourage a new brand of green tourism, which is very much in demand, wherein one can walk the entire distance, stopping and staying at villages, interacting with local culture and enjoying nature. This will also help the local economy as small campsites can be made along the way. The survey of these tourist places will be done with the help of village panchayats and locals can be employed in these projects. This can also reduce vehicular traffic.

(ii) Excessive widening of the roads must be avoided as road widening creates huge muck and debris, leads to speedy traffic and has been seen to cause accidents. Also road widening de-stabilizes the mountain slopes and leads to more frequent and intense landslides. Villages situated at higher elevation having fragile ecology or geology should be connected through ropeways to prevent the excessive road building and therefore irreparable losses caused by this.

4. **Regulation of vehicular traffic**:

Increasing vehicular traffic is one of the matter of serious concern, not only do large trucks and buses blare music and horns but they drive at killing speeds. Thus pollution and risk to life has greatly increased. Further it is dangerous for wild animals that are used to crossing and may want to approach river bank. As one have witnessed deaths of wildlife like jungle cats and porcupines etc on the road. In winter it is common to see leopards on the main road at night. Hence night traffic is also disturbing to them. Therefore, besides to encourage walking paths, we need to reduce and regulate:

(i) Type of vehicles: Large tourist buses and trucks should be banned except Army or Police vehicles. For piligrim/tourism in eco zone only small commercial vehicles with pollution control certificate should be allowed to protect environment as well as to serve local employments.

(ii) Number of vehicles (reduce daily inflow).

(iii) Time of movement (restrictive night travels).

(iv) The final distance of 15 to 30 kms to holy shrines could be encouraged to be made on foot, mules, cycles or small sized solar/electric/bio-fuel powered vehicles. This would provide direct local employment on one hand and preserve the matchless beauty and sanctity of the Himalayan highs, the glaciers and the forests. The 'Mountaineering Policy' prepared by Uttarakhand government is to be implemented.

5. A trail tracking/ tracing the path of many historical figures that tread through the mountains and forests of Uttarakhand must be laid out for the tourists to know about it and appreciate the historical connections here. From the point of view of architecture, art, handicraft, languages, forts, archaeological sites also Uttarakhand is very important. Apart from Chardham, Hemkunt Sahib and Kailas-Manasarovar routes, the trails in which Adinath, Huen Tsang, Adi Shankara, Jesuit Fathers, William Moorcroft, Nain Singh, Kishan Singh, Dayanand Saraswati, Vivekanand, Lord Curzon, Gandhi, Jim Corbett and so many others traveled can still be traced in Uttarakahnd. These can be reinvented and recharged.

6. Kumbh, Nanda Devi Rajjat, Chhipla Jat, Mahasu movement and many other Jats are part of the cultural landscape of the region. In different valleys different festivals, fairs, ballads and dances are associated with this cultural landscape. A 365 day cultural calendar can be made for different cultural expressions of Uttarakhand. Their place and date can be shown with precise distance from the last rail or motor heads. With these events can be associated arts, handicrafts, clay-metal-fiber-wood-stone-slate-woolen works / products.

7. Cultural festivals, fairs and *jaats* are unique and colourful expressions. These should be encouraged and informed about so that inquisitive tourists can come and appreciate this uniqueness of the state.

4.1 Cultural Eco Zones (CEZs):

The state of Uttarakhand is bountiful with unique flora, fauna and culture. The Ganga-Himalaya is of special significance to pilgrims from all over the world who come every year to this pious land to perform obeisance. It is much needed in India especially in the context of Himalayan Rivers to evolve an act like 'Wild and Scenic River Act of USA', which they have revised and reinvented as per the status of river in the respective provinces of US. The concept of 'Eco Sensitive Zone' (ESZ) may be a small step towards that direction.[30] Conservation of the river Ganga and the Himalaya is of immense significance from-environmental, cultural and social perspectives.

The steps towards implementation of this Himalayan Policy are also just as much needed as the policy itself. We therefore propose the implementation of the Himalayan Policy under the larger umbrella of 'Cultural Eco Zones (CEZs)' in the state of Uttarakhand. Only after due consultations with the locals of the area, one must elaborate on the salient characteristics of the CEZs. Every stake holder should be part of this process and the plan must not seem enforced and rather should be evolved and developed through them. This should be part of community initiative and can be introduced now holistically in the higher Himalayan part of Uttarakhand. It can also be introduced river wise with full community participation. All kind of related literature should be given to them in their languages and experts must tell them all aspect of this idea. Community acceptance is essential for any kind of new beginning.

Throughout the Himalaya the watershed area of all Himalayan river valleys should be developed as a Cultural Eco Zone (CEZ) with the following 6 objectives :

1. Preservation and increase in green cover – thus promoting growth of both flora and fauna and thereby enhancing the bio-diversity.
2. Encouraging and permitting only those activities on a local level, which would help in achieving object 1 and at the same time benefiting the local population economically – thus to achieve development using a 'green' vision.
3. Prohibiting the many incompatible 'developmental' and other activities like obstruction of rivers, excessive tourist inflow, commercial mining / crushing, large concrete structures, which do not adhere with the ecology of the area.
4. To maintain and preserve the wild and pristine Himalayan forests.
5. To maintain and preserve the Himalayan Rivers and adjoining tributaries in the form of wild mountain rivers and streams – pristine, uninterrupted, free flowing and pollution free.
6. To maintain the sanctity of the area as it is a place of spiritual and cultural significance – a place of pilgrimage, meditation and worship.

30. Ministry of Environment and Forests, Notification dated 18 December 2012, New Delhi, The Gazette of India, Extraordinary, New Delhi, 18 December 2012.

Many aspects of Himalayan policy have been discussed and elaborated before as well but the rightful acceptance and implementation of the draft Himalayan policy is essential to ensure the conservation of our invaluable resources. The 2013 tragedy has brought home in unmistakable terms that tampering with the fragile Himalayan eco-system will result in devastation at unprecedented levels, beyond both man's imagination and his ability to cope with it. Therefore it is crucial that any future Himalayan policy takes this extreme scenario into deep consideration.

4.2 Green Bonus for CEZs:

These Cultural Eco Zones (CEZs) deserve adequate payment (green bonus) for the development of local population in a sustainable way and so to provide ecological services to the rest of country. The Green Bonus must directly benefit the people who forego the use of their forests and other environmental resources. This yearly requirement of the funds should also be incorporated separately with the zonal master plan of CEZs. For budgeting the green-development of the valley the following recommendations are given:

a. Adequate subsidy in the price of gas cylinder should be provided to the villagers to conserve the forests.

b. For the employment of locals as a 'van-rakshak-dal' to strengthen *van-panchayats.* Jobs can be provided to enhance forest-cover in each *van-panchayat* area. Suggestions from due consultations with locals should be considered and assessed in this regard.

c. Assessment to improve the agricultural aspect mentioned above.

d. For the restoration of denuded area, groundwater management, revival of water springs etc. with the help of *vanpanchayats, grampanchayats, mahila and yuvak mangal dals*.

e. To set up a vocational training centres for encouraging the traditional architecture and will also provide building material for the traditional construction as mentioned above.

f. All other required activities mentioned above.

Compliance of Doon Valley Notification and promotion of CNG services :

Doon valley notification of 1st Feb-1989 under 3(2)(v) of Environment (Protection) Act, 1986, and Rule 5(3)(d) of Environment (Protection) Rules, 1986, should be implemented properly. CNG services should be promoted for all big/small cities like Dehradun, Haridwar, kashipur, Udhamsingh nagar etc.

5. PLANNING AND GOVERNANCE

This brings us to the role of the state. Ever since the formation of the state of Uttarakhand, the government's policies and mode of administration have created problems. The short sighted aim for immediate gains, motivated the policy makers to design policies that mostly exploited the natural resources, instead of strengthening these resources so that they could become stronger assets for the future. The topography of the region and its socio-cultural composition requires de-centralized planning. A state with 15000+ settlements from foot hills to 12000 + feet above sea level should think about the totality of effect whatever developmental activity they propose or implement.

- Recommendations:
- Any development policy for the hill states must be based on a watershed approach, considering the catchment area of the river.
- Well defined policies around disaster mitigation measures, preparedness for a possible disaster, disaster management planning, active response during the time of disaster are much needed.
- Safest ways of road construction, Micro HEPs, ecology conservation plans, afforestation, irrigation and water requirements – all must be addressed with good policies in hand. Alternative and less destructive ways for different activities should always be searched and invented.
- The Constitutional Amendments Acts 73 and 74 and schedule 11th and 12th are very crucial for developing a local self village / municipal government with all rights and duties in Uttarakhand. All power should go to village and nagar *panchayats.* This act also gives the chance for local participatory planning and implementation by the people.
- The real *panchayat raj* can reach to villages if we decide that these local institutions should grow and work with local planning and management. Decentralization with the implementation of *panchayati raj* will give the villagers dignity and prosperity together.
- Policies where the locals can be engaged as much as possible have to be planned and implemented. Local generation of energy with alternative energy methods like that of micro-hydel, pine needles, bio-mass etc can be a very good step forward.
- Policies encouraging entrepreneurship in the communities must be planned and implemented. Small scale cottage industries of different kind can be a beginning. Water sources can be used to set up various units (eg: water milling, wood carving, wool cleaning, saw milling, wood shaping etc), which will make them owners of their land and give tremendous job opportunities.
- Policies to train the locals for eco-tourism and adventure guides etc will also help increase the aspect of service industry. The local training centres can be formed with representations from civil members in order to enroll more and more trainees and ensure smooth functioning.

6. <u>Urbanization:</u>

The pace and nature of urbanization of Uttarakhand since its statehood is posing a serious threat to its inhabitants. Poor town planning, and violation by realtors and contractors of the legal norms of building, have made the urban space over- crowded and unhealthy. In Uttarakhand, which lies in IV and V earthquake prone zones, the concentration of large populations within an urban conglomeration may have unforeseen consequences – if there are natural disasters.

Some policy changes to curb this centralization of population / unplanned urbanization are being listed below:

a. Villages can be improved by developing basic infrastructure, establishing good hospitals and making schools better, developing communications and good green road network. Public transport should be improved and CNG in the urban transport should be introduced.
b. Creating small economic avenues through *mahila mangal dals, yuvak mangal dals, village panchayats* and *van panchayats* will be very helpful in the long run.
c. A small state capital in the vicinity of the mountains at Gairsain will be helpful in dispersing the urban population.

7. Education:

Education should have been the first priority of the state. But today it is the most neglected issue. School education is especially in a very bad state. Some policy changes to improve the education system in the hill state are being listed below:

a. Natural resources, local geography, disasters, history, culture should be part of the school curriculum.
b. The students and young people should know their local milieu through knowledge of their own village, rivers, forests, wildlife, local languages and folklore studies. This understanding will cultivate in them the idea of ecological sustainability.
c. At the same time, GBPUAT, VPKAS, GBPIHED, IVRI, Chaubatia Garden, ICWFI, DRDO and other institutions including regional universities have to work to develop critical studies on different aspects of Uttarakhand issues, which can also be included in the curriculum.
d. A Planning Commission Report has already suggested integration among national institutions, Himalayan universities and the establishment of new institutions which may work on EIA Procedures, Green Road Engineering, Technology for Management of Hazardous Waste, Mountain Hydrology, Water Harvesting Technology, Risk Engineering, Community Forestry, Mountain Farming Research Centre and Centre for Mountain Studies.[31] But we have to start from the elementary education with all above new and creative ideas.

8. Health of Communities:

In Uttarakhand, the health-care and hospital facilities are very poor. As we go to inner valleys and villages there is virtually no medical facility available. Food and nutrition issues also need to be addressed. The use of junk food, alcohol and loss of the local agricultural products is posing a threat to the health of young people. The minerals, vitamins and vital elements which the communities used to get from domestic and wild fruits, roots, stems and flowers has changed now as most of these species are lost or not available.

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[31] *Report of the Task Force on the Mountain Eco Systems (Environment and Forest Sector) for Eleventh Five Year Plan,* Chaired by R.S. Tolia, Planning Commission of India, November 2006

a. The modern, well- equipped (with doctors, technical, para-medical staff, machines and medicines) hospitals are the need of the hour. The patients taken by vehicle 108 should get that kind of hospitals near by.

b. Traditional medicine should also be revived. This will help in regulating the out migration. Some work is also to be done in traditional medicines and *ayurveda* as this region have a variety of medicinal and aromatic plants.

Women in Uttarakhand are very hard working & possess the real know-how about their area. Policy for their upliftment is absolutely essential. Since agriculture is the main work area for the Uttarakhandi women, it is suggested that strong policies towards protection of forests, soil and rivers must be taken in order to ensure these women their livelihoods. Initiatives to curb trafficking and eliminate alcoholism must also be planned and implemented.

CONCLUSION

Considering the guiding principle here that:

(i) The Himalayas are the Water Tower of Asia and that the water and food security for billions of people is dependent on these mountains and the rivers that originate from here. The ecological balance maintained by the Himalayas, the spiritual tradition and ambience they nurture, the socio-cultural significance of the Himalayas and the Himalayan Rivers is certainly far greater than any gain we can possibly receive through their exploitation.

(ii) The exploitation has been carried out to such an extent that the fragile ecology of these mountains has been immensely disturbed. The ecological, environmental, social and cultural losses due to rampant and massive anthropogenic activities (such as building of large HEPs etc) have lead to an irreparable loss in a large part of the Himalayan ecosystem and therefore the cost-benefit from the generation of hydro-power cannot be justified. The condition of Himalaya has been consistently deteriorating and perhaps that is why the intensity and frequency of disasters is also increasing.

It is therefore only logical to point out that before applying the policies elaborated in this document some immediate next steps will have to be taken:

1- Review all the under-construction and proposed hydro power projects which entail tunneling, formation of a barrage or a reservoir.

2- Release 50 % of water in lean season from the already existing hydro projects like Maneri Bhali -1 and 2, Vishnuprayag, Dhauli-Ganga etc.

3- Care should be taken of the villages which are located in the vicinity of these projects and reservoirs. The existing risky projects must be moved towards a phase of systematic decommissioning in a set time frame.

4- Cultural Eco-Sensitive Zones (CEZs) need to be demarcated and established throughout the Himalaya to ensure the conservation of the rich bio-diversity that the Himalaya are endowed with. The entire area throughout the Himalaya descending down 100 kms from snout of glacier should be declared as an eco zone, similar to as declared from Gaumukh to Uttarkashi. The model and parameters that have been defined for the Gangotri Eco-zone should be implemented and replicated in the other valleys.

5- It is important that we take the matter of conservation of Himalaya with utmost sincerity by demarcating a designated department/ ministry in the central government. Since Himalaya is our vital source of growth and abundance – assigning a focused task force towards implementation of Himalayan policy will be a very good initiative.

It is important that we realize that the Himalayas provide us protection and enrich our lives with natural resources and spiritual ambience and we must see this potential and wake up to the reality of the situation here. We must take steps therefore towards the protection of the Divine-Souled, magnanimous, mighty yet fragile Himalayas before it gets too late for all of us.

अस्युत्तरस्यां दिशि देवतात्मा हिमालयो नाम नगाधिराजः

पूर्वापरौ तोयनिधी वगाह्य स्थितः पृथिव्या इव मानदंडः

There is to the north, a mountain named
Himalaya, divine-Souled deity

with his pers reaching into the Eastern and Western oceans and who stands as the measuring road of the earth.

- (Kumarsambhavam; Kalidas)

Chapter 10

Recommendations

The Uttarakhand Himalaya are well recognized for their ecological, hydrological, floral, faunal, socio-cultural and aesthetic values. They are also a life support system for several hundred million people in the plains of northern India. These geologically active mountains are fragile and prone to disasters that can be aggravated by human interventions that do not recognize the region's fragility.

Uttarakhand's Himalayan region has been nurtured by a culture which worshipped the land as 'devbhoomi'. Similarly Himalayan rivers are revered and respected for providing ecological services and a sense of identity. Traditionally the faithful have trod the difficult terrain of the Himalaya to offer their obeisance to the many tirthas here. These traditional beliefs, customs and practices are deeply endowed with a sense of the surrounding environment. Even today forests are preserved as sacrosanct and offered to the divine as sacred groves or 'dev van'. In many places speaking loudly, consuming alcohol or wearing ostentatious colours or leather shoes is traditionally prohibited in such forests. In Badrinath, the abode of Vishnu, daily rituals are carried out without the blowing of a conch as the surrounding are said to be sensitive to loud sounds.

The following recommendations have been made keeping in mind the need for maintaining a fine balance of conservation and development in the region.

ToR 2.1a

Environmental Flows: Till such time as a decision is taken on the E-flows recommendations of the IITs-consortium the EB recommends e flows of 50% during the lean season and 30% during the remaining non-monsoon months. Sustaining the integrity of Uttarakhand's rivers and their eco-systems is not negotiable.

Eco Sensitive Zones: It is recommended that legislation be enacted along the lines of the innovative concepts of (i) protecting small but significant rivers as done in Himachal Pradesh and also recommended by the IMG for Uttarakhand and (ii) designating Eco-Sensitive Zones for all rivers of Uttarakhand.

River Water Quality: The EB recommends that MoEF strengthens its personnel and procedures for post-sanction monitoring of environmental conditionalities. The MoEF should develop a programme for research studies by reputed organizations on the impacts of HEPs on river water quality (and flows). Pre-construction and post operation long term studies are required.

Forests and Biodiversity Conservation: As a rule mitigation programmes for forests and biodiversity conservation have not succeeded so far. Recommendations for community based CAT programmes have to be systemically implemented for ensuring sustenance of

the plantations. This requires training of forest officials to work with the communities through their Van Panchayats.

Geology & Social Issues: Given the massive scale of construction of HEPs in Uttarakhand it may be worthwhile to set up a formal institution or mechanism for investigating and redressing complaints about damages to social infrastructure. The functioning of such an institution can be funded by a small cess imposed on the developers. It is also suggested that to minimize complaints of bias, investigations should be carried out by joint committees of subject experts and the community. Local communities can get educated on the technical issues in the process and the experts may also begin to appreciate the loss and pain felt by the affected people.

ToR 2.1b

Flood Warning Systems: The operation of barrages during extreme events leaves a lot of ambiguity as to when the gates should be fully lifted. Without any real time flood forecasting network or an automated weather station upstream and the possibility of massive landslides, the barrages are likely to face severe blocking. This is particularly a threat in June when the snow melt component is very high. The probability of errant monsoon behavior is only likely to increase with global warming.

For the Tehri dam to safely meet the objective of flood moderation, particularly during the later part of the monsoon, it requires the installation of a Real Time Flow Forecasting Network which would transmit hydrometeorological data to enable forecast of inflow into Tehri reservoir at least 12 to 18 hours in advance.

Such a forecast is also required for advance information on the contribution of Alaknanda at Devprayag and of the basin below Devprayag to Haridwar. This is only possible by analysis of real time data which Tehri dam authorities must get. It will enable decisions on appropriate releases so as to prevent synchronisation of Bhagirathi (Tehri release) and Alaknanda floods. Until such time the Tehri reservoir level should be limited to 825m in mid-September, to be filled up judiciously from the receding monsoon flows.

The river bed profiles at Phata-Byung, Singoli-Bhatwari, Vishnuprayag and Srinagar HEPs have changed significantly. This requires a fresh analysis of the project hydrology and redesigning them if necessary

All projects must undertake river restoration works after prior clearance from MoEF. It was noticed that project developers were engaged in projects' restoration only. MoEF needs to conduct a formal review of the environmental damages at all the HEPs in Uttarakhand and prepare guidelines for restoration. Till then none of the projects should begin power production.

Muck Management: Contribution of the muck excavated and kept along river banks to downstream flooding generated a lot of angry debate after the June 2013 disaster. The

existing practices of muck management are inadequate to protect the terrain and the people from an eventuality like the June 2013 flood. Therefore, a serious revisit is required towards evolving technically better and ecologically sustainable methods for the muck disposal and rehabilitation in Uttarakhand. As mentioned above appropriate monitoring systems have to be put in place.

Disaster Management: The EB did not have an opportunity to examine Disaster Management Plans of any of the projects. But it is doubtful if these were used in June 2013, or if they were, whether they were effective. DMPs need to be an integral part of EIA Reports. The DMP needs to be carefully reviewed and approved by local communities in the probable zone of influence also.

Disaster preparedness is critical because all of Uttarakhand lies either in seismic Zone IV or V. These are the most vulnerable to strong earthquakes.

ToR 2.2

The EB concluded that all the 24 HEPs identified by WII would have significant biodiversity impacts. It also recognized, however, that the Kotli Bhel 1A project might not significantly worsen the condition of the river Bhagirathi between Koteshwar and Devprayag – already part of a highly fragmented zone – if the project was redesigned so that there would be an adequate free flowing stretch between the Koteshwar tail race channel and the tip of the Kotli Bhel 1A reservoir.

The EB recommends that of the 23 HEPs out of the 24 (other than Kotli Bhel 1A) that would have significant impacts on the biodiversity of Alaknanda and Bhagirathi basins, the HEPs that fall in any of the following conditions may be rejected.

(a) Proposed HEPs that fall inside wildlife Protected Areas such National Parks and Wildlife Sanctuaries

(b) Proposed HEPs that fall within the Gangotri Eco-sensitive Zone

(c) Proposed HEPs that (i) Encompass critical wildlife habitats, high biological diversity, movement corridors; (ii) That fall above 2,500m. This zone is fragile in nature due to unpredictable glacial and paraglacial activities.

Proposed HEPs that fall within 10 km from the boundary of Protected Areas and have not obtained clearance from the National Board for Wildlife

ToR 3.1, 3.2, 3.3

1. The EB noted extremely slow pace of execution of the Compensatory Afforestation (CA) and Catchment Area Treatment (CAT) plan by State Forest Department. Its suggests executing the same within the construction period of the project. This is to be monitored by a committee comprising of concerned CCF of Garhwal/Kumaon region, one representative from State Irrigation Department,

two representatives from local communities, Renowned Environmentalist and one member from SBCP and Regional Office of MoEF, Dehradun. The committee should be headed by APCCF, MoEF, RO, Dehradun.

2.(a) All projects $\geq$ 2 MW, which entail tunneling, barrages and construction of reservoir, shall require prior Environmental Clearances (EC) from MoEF and subsequently, such projects falling in the eco-sensitive zones of notified National Park and Wildlife Sanctuaries of Uttarakhand should take prior permission from National Board for Wildlife (NBWL), as per the Hon'ble Supreme Court order on Goa foundation case dated 4.12. 2006.

(b) Similar to MoEF notification dated 18.12.2012 issued for Gangotri eco-sensitive zone, guidelines/notification should also be issued for other Ecological sensitive basins/zones.

(c) As per the EIA notification 14 September, 2006, the validity of approved EC is 10 years. It has been noticed that in a number of cases the validity of EC is 5 years only. The validity should not be extended, unless fresh appraisal is done.

(d) The EB during examination/analysis of the EIA/EMP reports has observed incorrect information provided by project proponent. An appropriate action is required to be taken by MoEF in such cases.

(e) Cumulative Environmental Impact Assessment (CEIA) including Regional Environmental Impact (REI) and Strategic Impact Analysis (SIA) should be done by MoEF for all river basins.

(f) LCA (Life Cycle Assessment) of hydropower projects should be done by MoEF to compile a data base and EC and FC shall be accorded based on above data base.

3. The committee also noticed during site visit that most of the instruments (sediment measurement, flow rate, meteorological data, water quality monitoring etc) installed at site were inadequate.

4. River Regulation Zone (R.R.Z.) guidelines should be issued immediately by the Ministry of Environment & Forests and should be executed accordingly.

5.(a) It is mandatory for all projects should display the all project related information (including Name of the project, EC, FC, consent from PCB, Cost of the project, land uses, forest area, reservoir, muck disposal site information, submergence, etc) on sign boards around the respective project locations.

(b) Hydropower projects should display all necessary data/information (Consent from PCB, E.C., F.C. and its compliance report, details data of inlet flow, outlet flow, power generation etc, except the classified data) on their website.

(c) It is also mandatory for the project to construct the boundary pillars on the diverted forest land.

(d) Online linkage of the all HEPs with MoEF, CEA, CWC, GSI, ISRO, Government of Uttarakhand with regard to disaster management and sharing of data during operation and crises.

The committee noted with concern that none of the project visited has real time telemetry network which comprise of automatic weather stations. The transmission of real time, weather time data, rainfall, discharges etc is important for officials to operate project safely and optimally. This is the reason why committee felt poor quality of data management. Therefore, EB recommends before Monsoon each project (commissioned/construction) should install all required automated instruments and aerial real time telemetry and its online management to share this data for proper operation of the project & warning etc.

ToR 3.1A

Learning form the June 2013 event, the EB felt that the enhanced sediment flux could be a serious problem for the longevity of the proposed and on going river valley projects in Uttarakhand. The reason being that glaciers in Uttarakhand are receding and leaving behind debris in the vacated areas. The debris could eventually contribute to the sediment flux into the river valleys particularly during extreme weather event like June 2013.

In view of this, the EB recommends that terrain above the MCT in general and above the winter snow line in particular (~2200-2500 m) should be kept free from the hydropower intervention in Uttarakhand.

ToR 3.1B

The Expert Body recommends that Strategic Environmental Assessment (SEA) be carried out in other major river basins of Uttarakhand such as the Yamuna and Kali basins.

The Expert Body strongly recommends that scientific studies by subject experts should be conducted for establishing baseline data on river parameters, diversity and populations of floral and faunal species in different rivers of Uttarakhand at different elevation zones. Such studies should be used for deciding upon the minimum distances between two consecutive HEPs. Until such scientific studies are completed, no new HEPs (in S&I stage) should be cleared on the rivers of Uttarakhand within a distance that may later be revoked. Minimum distances for projects in the clearance stage should be revised upward from the current consideration of 1 km.

ToR 3.4

The recommendation for this ToR are similar to those in ToR 2.2. The EB recommends that of the 23 HEPs that would have irreversible impacts on the biodiversity of Alaknanda and Bhagirathi Basins, the HEPs that fall is any of the following conditions should not be allowed to be constructed.

(a) Proposed HEPs that fall inside wildlife Protected Areas such National Parks and Wildlife Sancturies

(b) Proposed HEPs that fall within the Gangotri Eco-sensitive Zone

(c) Proposed HEPs that fall above 2,500m that encompass critical wildlife habitats, high biological diversity, movement corridors, and fragile in nature due to unpredictable glacial and paraglacial activities.

(d) Proposed HEPs that fall within 10 km from the boundary of Protected Areas and have not obtained clearance from the National Board for Wildlife.

ToR 3.4A

1. The Himalayas as a source of life, birth place of our National River Ganga. The problems, challenges, crisis and solutions in the context of Uttarakhand have been described in the draft of Himalayan Policy. We therefore recommend that the Draft Himalayan Policy for Uttarakhand, be submitted for a wider debate. Cultural Eco Zones (CEZs) need to be demarcated and established throughout the Himalaya to ensure the conservation of the rich culture & bio-diversity that the Himalaya are endowed with.

2. It is important that the matter of conservation of Himalaya be addressed with utmost sincerity by a designated department/ ministry in the central government. Since the Himalaya are our vital source of growth and abundance – assigning a focused task force for implementation of a National Himalayan Policy will be a very good initiative.

The EB in its limited time, feels that many other important aspects need to be studied and therefore strongly recommend the following important studies related to this area.

The Himalaya are enriched with spring water sources which are important sources of drinking water & irrigation water for the local community. Many anthropogenic activities (road construction, hydro power projects, etc) require deforestation, blasting and tunneling. They also disrupt river flows in the non monsoon period. Therefore, the EB strongly recommends that a detailed study of the impacts of hydro power projects in terms of deforestation/tunneling/ blasting/reservoir on the hydrogeology of the area should be carried out.

3. A study on the role of large artificial reservoirs on local climate change and precipitation pattern with special reference to the Tehri dam reservoir.

4. Recent studies have highlighted serious concern about the Indian deltas, which are shrinking due to changes in river courses. The Ganga-Brahmaputra delta is also noted in this category. This seems to be a major issue in near future therefore we recommend that the studies should be carried out regarding the impacts on sediment transportation due to projects existing on the way of Himalayan rivers of heavy silt load.