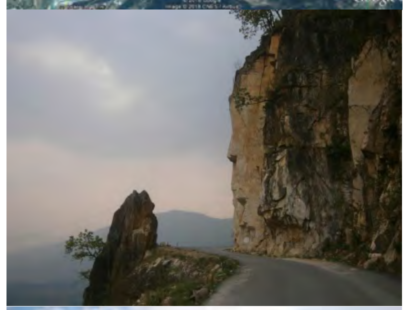
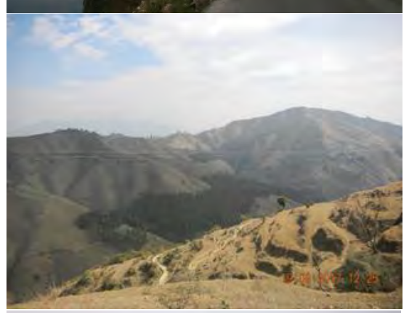
A COMPENDIUM ON

STATE OF MAHAKALI BASIN









2017

Environics Trust

Acknowledgments

No environmental work is an end in itself, it's a process to enhance learnings, building relationships with the communities and organisations for a broader alliance for a common good.

We are thankful to numerous organisations, whom we have come across during this period and shared with them the need of developing river basin level understanding. At the same time we are extremely thankful to all the communities who took time out of their busy schedules for making the confluence conclaves a place to share their issues, thoughts and discuss development of their valleys. Their valuable inputs have really helped us frame issues acorss different valleys which one has to otherwise depend on the secondary sources.

We are also thankful to the officials who gave time to discuss the issues as well as share district level statistics. Due to paucity of time and geographical attributes, we also relied on the RTI – thanks are due to all those officials who kept the communication alive and provided information.

Team Environics

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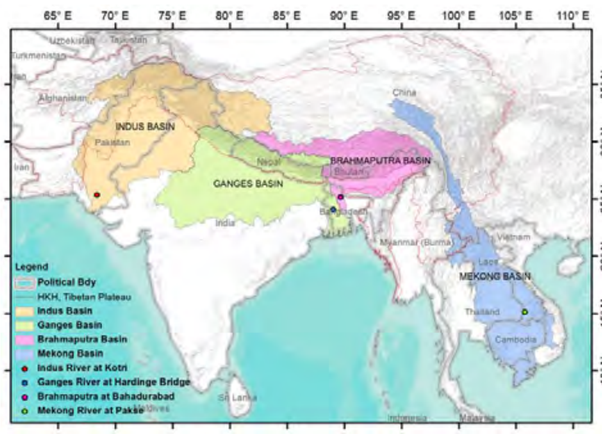
1. BACKGROUND AND INTRODUCTION

Seven countries in the South Asian region share the Ganges, Indus and Barahmaputra river basin. These countries are India, China, Nepal, Pakistan, Afghanistan, Bangladesh and Bhutan with some form of treaties and cooperation on the issue of water management and development.



http://www.mdpi.com/2073-4433/7/10/123

Each of the river basins is characterised by large populations with varying needs for agriculture, drinking water and energy needs. On the same hand the communities also face floods and many a times extreme events thus making them integral to the coping strategy. The involvement of people in presenting their views on river management has been minimal or even negligible, especially along the international boundaries. All these three river basins originate at the top cover the Himalayan range, portray their significance for the downstream communities.

The river Mahakali is called by various names viz. Kali, Mahakali, Sarda along its course falling in India and Nepal. River Mahakali is a Himalayan catchment of Ghagra sub basin of the large Ganga Basin, originating from the Trans Himalayan region (>3600 m) ultimately draining the region through the Tarai-plains of Uttar Pradesh. Almost 1/3rd catchment area of Ganga basin lies in Uttarakhand and Uttar Pradesh. The catchment area of Mahakali is around 15,260 sq km, large part of which (9,943 sq km) lies in Uttarakhand and rest lies in Nepal. Mahakali is a trans-boundary/international river. In whole of South Asia, rivers have played a symbiotic role and also provided tangible benefits to communities dependent on them, became nucleus of socio-cultural-economic relations. With changing times these inter-linkages needs to be strengthen further.

Numerous rivers and streams join the Mahakali from the higher, lesser and outer Himalayas and almost each of such confluence (at least of major rivers) acts as a confluence of socio-cultural beliefs and practices, trading centres and local-regional festivals. Before the river encounters Tanakpur barrage (Sarda Ghat) and later Banbasa Barrage where water of the river is diverted into the Sarda Canal system, the Kali River exhibits a free riverine character. The catchment boundaries of Mahakali/Sarda basin cut across administrative boundaries of 'Far Western' Himalayan region of Nepal comprising four districts of Baitadi, Dadheldhura, Kanchanpur and Darchula through major parts of Pitthoragarh (except the top most NW border), almost whole of Champawat, Bageshwar district (excluding upper part of Kapkot Tehsil) and very small parts of lower Almora and Udham Singh Nagar. In the upper reaches Mahakali/Sarda flows through narrow gorges passing through Garbyang, Tawaghat and Dharchula and spreads as it flows downwards in the lower hills.

The Confluences

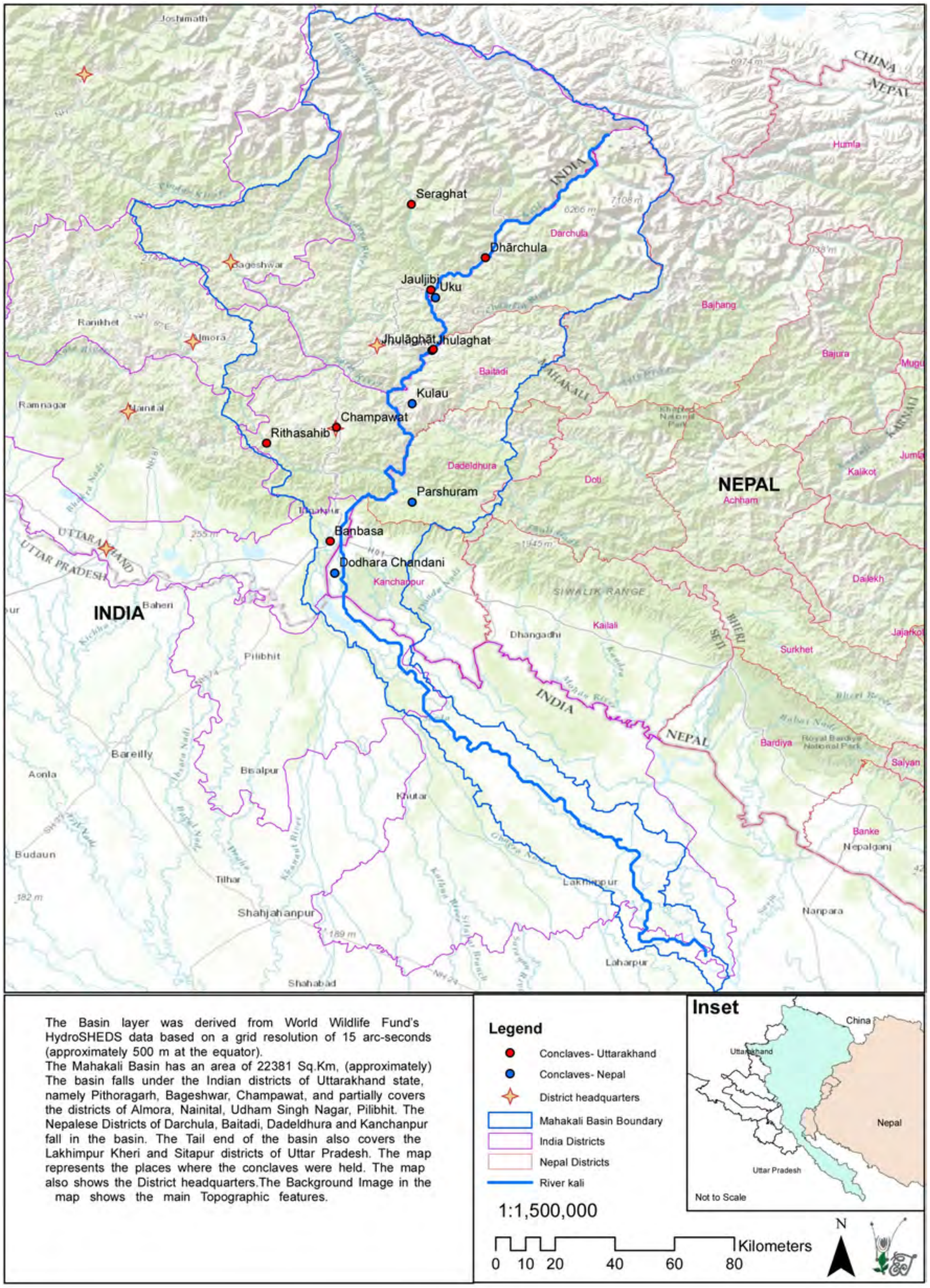
The environmental setting of the region has many facets attached to it like, geographic peculiarities, ecological significance, and limitations of expansion, socio-cultural and economic ties and many other aspects. Tawaghat is the place where Kali receives Dhauliganga and flows towards Dharchula (a little upstream of this confluence, a 280 MW Dhauliganga project of NHPC on Dhauli river is located). Dharchula is a zone affected by recurring landslides and floods. The unprecedented rainfall event in June 2013 in Darchula of Nepal and Dhauli Valley are also not very old incidents. Dharchula in India and Darchula in Nepal may slightly differ in nomenclature but the towns and their inhabitants share similar landscapes, cultures and traditions. Gori Ganga, formed from Milam and Nanda Devi Glacier, flows down and joins Kali at Jauljibi. This is a common social and market place for communities of both sides – *the bagad belt is synonymous to settlers from both sides.* Few kilometres downstream from Jauljibi, River Chamliya of Nepal, flowing from Nepal's Gurans Himal, meets Kali on its left bank – here a 30 MW hydroelectric project on Chamliya is waiting completion. Further down, Saryu is joined by Panar a few kilometres upstream of Saryu-Eastern Ramganga confluence at Rameshwar, afterwards the combined flows of Saryu-Panar-Eastern Ramganga join Kali at Pancheshwar. Lohawati from Lohaghat and Ladhiya from the Mournala hills flow to meet Sharda / Kali in its lower reaches.

Dharchula & Darchula, separated by the Kali River, seem like a continuous settlement draped in the meanders. Khotila a settlement near Dharchula is also seen. Both ends of the river seen above are inflicted by landslides.

Key Components and Purpose

The Indo Nepal Treaty of Peace & Friendship 1950 has enabled ease of cross border movement of people without much formality and also maintained cordial social relations among communities. The ecological and socio-cultural similarities in the basin make it more or less a homogeneous unit. The Mahakali Treaty of 1996 is the key binding instrument between two countries on water sharing, river management and infrastructure development for which the modalities are worked out by the two Governments. While there are debates on the quantum of water releases with reference to establishment of first user right, this has not affected the community relations on both the sides. Also communities are the peripheral observers and have not the slightest role in the formalisation of decisions on trans-boundary river management.

This effort/process is to interact with people and enable interaction among the communities from river valleys within the catchment boundaries of Mahakali/Sarda to increase understanding on social, environmental, cultural, economic, climate change and alike parameters which concern them the most. Given the importance of Sangams or confluences, the idea of confluence conclaves emerged across different locations in Uttarakhand and Nepal (7 in India and 5 in Nepal). Most often the people in adjacent valleys only meet during special occasions and regular interaction is thus restricted in time and space, these confluence conclaves intend to bring people together and initiate cross learning of issues surrounding different smaller valleys and river tributaries.



To connect more people who want to contribute and increase cooperation among the communities on a variety of issues including river management, a voice based server named 'Voices of Sharda' is kept. The system relies completely on the mobile network to establish connection and allow user to use keypad to record or listen to the messages recorded over the platform. The aim of this initiative is to connect those communities which have issues to share, but have no means to share these with the outside world or communities in other valleys/districts.

Last but not the least, the attempt is to develop a baseline understanding about this basin alongwith network of institutions, communities and organisations who work in the basin towards a common objective of community development and participatory research. Indo Nepal Joint Action Forum (INJAF) and partner organisation Nepal National Social Welfare Association based in Mahendranagar took forward the process in Far Western Development Region's Mahakali zone.

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Contents

2. LANDSCAPE, CATCHMENT AND PEOPLE

2.1 The Landscape

The upper Mahakali catchment is a part of the Ghaghra sub-basin of the larger Ganga basin and also a part of the Kailash landscape which extends from the Tibetan Plateau to the upper catchment of Mahakali in Nepal and India. The landscape is atypical to the diverse Himalayan ecology wherein each valley holds some peculiarities and challenges as well.

Ganga basin (8,50,000 Km^2) - Ghaghra Sub basin (58,634 Km^2) – Sharda/Mahakali catchment (15,260 Km^2)

The famous Kailash Mansarovar trek passes through the catchment – with Dharchula being the gateway for this journey. The landscape possesses great wealth and poses challenges for people. Wealth in terms of resources it offers and the restrain it puts due to its inhabitable conditions for several months during which it recuperates, challenges in terms of restricted livelihood options and natural furies which people have to face. In India, the Kailash landscape extends to an area of 7120 km^2 and in Nepal it is almost double, 13,299 km^2. The major river valleys that form part of the landscape are Panar-Saryu-Ramganga; Gori-Dhauli and Kali draining the upper Himalayan regions. The Darma, Byans, Chaudhans valleys are the interior valleys where geomorphology keeps readjusting to the natural processes, these valleys also witness extreme events like landslides, cloudbursts. The cloudburst in the Byans valley (August 2017) during the pilgrim season took several lives and many of them were porters and shopkeepers; porters from Nepal have also been reported missing.

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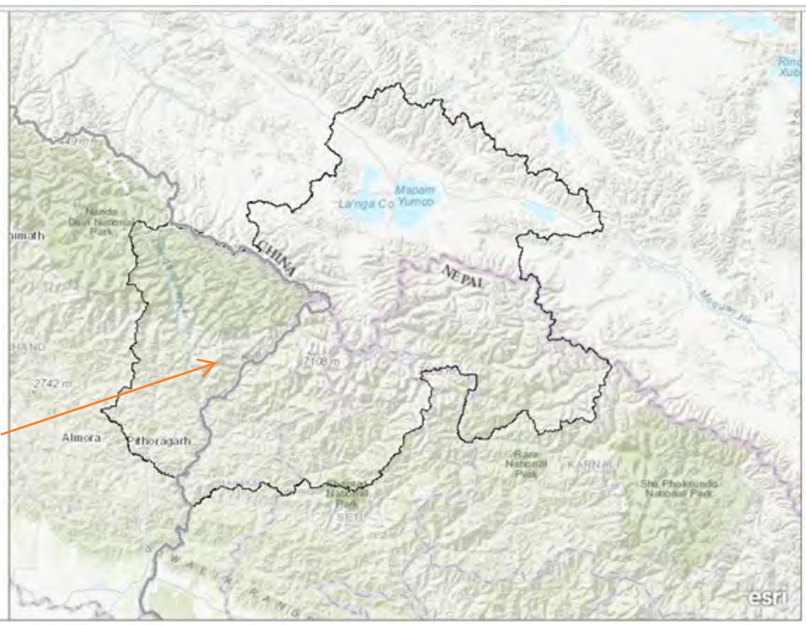
***Figure 1**: Kailash Landscape & Part of Mahakali Catchment*

(Pitthoragarh District in the Indian part)



Kailash sacred landscape boundary

Esri, HERE, Garmin, FAO, USGS | Sources: Esri, MapmyIndia, DeLorme, METI/NASA | Mxd assembled by Corey LaMar

While the top of the catchment is high Himalayan alpine belt with few protected areas, the outflows towards the toe of catchment give shape to widespread terai landscapes. The landscape and the catchment is surrounded by several protected areas which also act as a cushion during floods and also maintain a healthy habitat for the fauna and its survival requirements. Askot musk deer wildlife sanctuary located in Pitthoragarh district along the boundary of River Kali is one of the major protected areas covering around 600 km^2 which has now the abandoned multi metal mining of a Canadian company in its periphery; the upper parts of the sanctuary are also frequented by communities for harvesting of high value 'yarsagumba'. Nanda Devi Biosphere reserve is a fairly large reserve integral to the trans Himalayan landscape with several peaks in its fold. Besides, these are important bird areas, especially along the long valleys and large protected areas.

Figure 1 – Protected Areas in the Mahakali Catchment

The Far western elephant population together with the Indian migrating herds from Dhudwa National Park and adjoining areas, immensely affect mukta kamaya (bonded laborers), sukumbasi (landless), who reside all along forest corridors in Kailali and Kanchanpur Districts. It appears that conflict heightens in elephant forest corridors (Dhudwa – Basanta, Dhudwa - Sukla) where communities have agroforestry practices which is also evident in eastern Nepal (Thapa, 2007)[1].

[1] *Elephant conservation Action plan of Nepal*

The ridge with a mean elevation of 18,000 feet lies along the Tibetan frontier, forming water-parting between the drainage system of Indus and Sutlej on the north and the Kali on the south. The basin or catchment level interaction of Himalayan and terai ecological zones is important to understand both in terms of development approach as well as from the perspective of climate change. River Kali or Sharda flows uninterrupted till Tanakpur when its flows are regulated by the barrage. The Mahakali catchment in the Ghaghra sub-basin is marked with a series of protected areas, especially in its lower part (as soon as it enters terai region). This also gives rise to the wetlands and grassland ecosystems in the terai landscape for the wildlife as well as fulfil water needs of the farming community. Heavy rains in the upper catchments result in sufficient cushioning of water resource in the lower parts, thereby augmenting the water regime of the region. The series of these protected areas provide a critical habitat link for species ranging from elephants, tigers and many others.

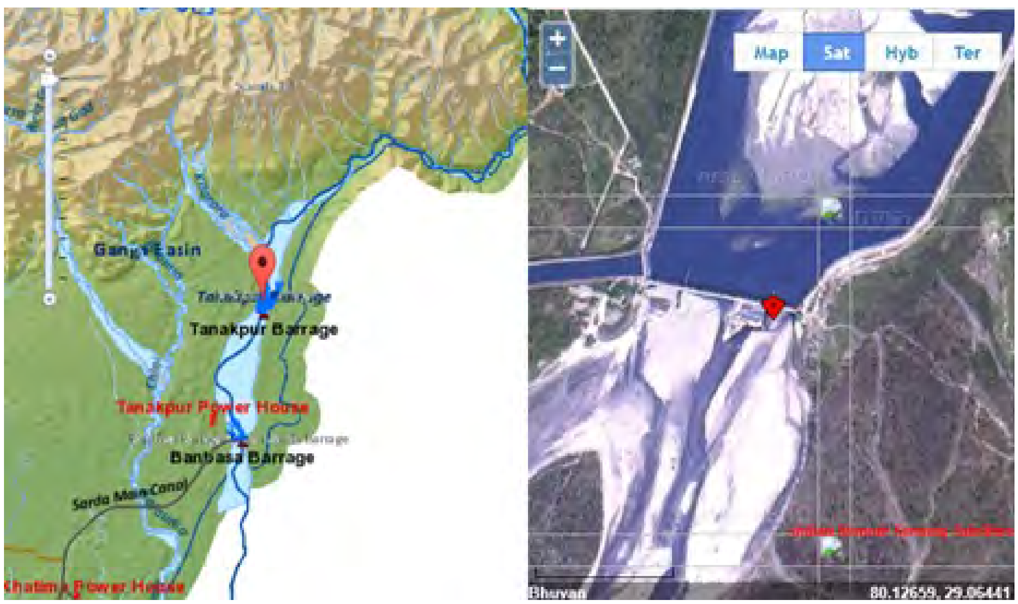


Figure 2 – Tanakapur & Banbasa Barrage downstream of Purnagiri, Canal from the right bank

2.2 The Catchment

The Mahakali catchment is administratively spread in Nepal's Far Western Development Region's Mahakali zone and in Uttarakhand's Kumaon division – these are, four districts in Nepal's Mahakali zone viz. Baitadi, Kanchanpur, Dadeldhura and Darchula and almost the full Districts of Pitthoragarh (excluding the NW part of upper Munsiari), Champawat and large part of Bageshwar (leaving the upper Kapkot Block-Pindari River) and lower Almora (Blocks of Dhaula Devi, Lamgarha and partly Bhaisachana block bordering Bageshwar). Cumulatively, the total population in the Mahakali catchment is 18.58 lakh persons (excluding the tailend of Upper catchment beyond Banbasa barrage and Uttarakhand boundary) including the districts in the catchment of both India (at Census village level and across 11 urban local bodies) and Nepal (VDC level and across urban local bodies). The sex ratio is 1097 for the overall basin. However, the variance in sex ratio is noticed, an average of 1048 is in the Indian portion of the catchment whereas it is 1116 in Nepal. The physiographic characteristics of both the regions in the catchment (Kumaon in Uttarakhand and Far Western Region of Nepal) portray typical landforms of terai-hills-lesser and higher Himalayas. The sex ratio lessens in the terai plains.

Darma and Mandakini catchments are largely covering the alpine regions of Pitthoragarh[2] viz. Dhauliganga and Goriganga. The population density is the lowest in these two catchments i.e. average of 23 persons per km^2. The other catchments have an average population density of 135 persons per km^2

Table 1 - Demographic Characteristics in the Mahakali Catchment

Districts in Uttarakhand	**Villages**	**Households**	**Population**	**Sex Ratio**
Pitthoragarh	1675	84688	402181	1066
Bageshwar	920	47408	227223	1125
Champawat	715	32640	166962	1073
Almora	340	15926	80703	1130
Nainital	113	8087	46507	957
Udhamsingh Nagar	11	1863	12056	938
Sub Total (India)	3774	190612	935632	1048 (avg.)
Districts in FWDR	**VDC**	**Households**	**Population**	**Sex Ratio**
Baitadi	57	41206	227317	1150
Darchula	42	24604	127779	1107
Kanchanpur	20	79483	434076	1100
Dadeldhura	13	19821	105954	1104
Kailali	3	5184	27907	1119
Sub Total (Nepal)	135	170298	923033	1116 (avg.)
Mahakali Catchment	**3909**	**360910**	**1858665**	**1097 (avg.)**

Source: Derived from Maps and Census Data 2011

Note: Due to incorporation of layers from external sources, any error is thus beyond control. Efforts have been made to reduce the errors but errors cannot be ruled out. The villages were overlayed over the sub-basin layers from Bhuvan Portal and the population in a particular sub-basin is derived.

As per Statistical report of Nepal, female headed households are 25.2% in rural areas showing an increase of 10.7% from 2001.

Table 2 - Mahakali Catchment Characteristics

S.No.	**Sub Basins**	**Area of Sub Basin**	**Watersheds**	**Villages**	**Households**	**Population**	**Sex Ratio**
1	Mandakini	2263	177	176	9251	43209	1045
2	Gomti	4067	570	2560	121288	585058	1111
3	Kali	2383	66	403	62432	321882	1107
4	Darma Ganga	3738	262	89	18048	92056	1048
5	Lohaghat	4902	257	664	103999	556188	1082
6	Sharda	1646	-	15	45892	260272	1112
	Total	18999*	1332	3907	360910	1858665	1084 (Avg.)

Source: Derived from Maps and Census Data 2011

Notes: i) No. of watersheds for the Indian portion in the respective sub basin (accessed from Bhuvan portal of GoI). (ii) * The area of Mahakali/Sharda catchment of Ghaghra Basin upto Banbasa barrage is 15,260 km^2 whereas its area is 18999 sq. km. if the entire sub catchment of Lohaghat and Sharda is taken into account. Some portions of Lohaghat and Sharda sub catchment lies in Pilibhit and Lakhimpur Kheri Districts of UP whereas the Dahawa-Barauncha catchment lies entirely in UP and has been just shown for representation purposes only.

Ghaghra basin's 58,000 sq. km. area is spread in Kumaon region of Uttarakhand and terai of Uttar Pradesh and rest of its catchment area lies in Mahakali zone of Nepal. The Sharda catchment in the Ghaghra sub basin is roughly 15,260 sq. kms (upto Banbasa barrage) and is wholly a Himalayan catchment; almost 72% of its catchment in the Indian portion (10,785 sq. kms) and rest in Nepal. As

[2] *Around 35% of geographical area is snow bound (Soil Resource Mapping, Soil and Land Use Survey of India)*

per one study[3], the annual mean discharge of Mahakali at Pancheshwar is 582 cumec whereas another study[4] puts it at 728 cumec (Upto Tanakpur Barrage). The period of observation of former study was done in the year 1984-92 whereas the latter's observation period is between 2006-2010. The specific sediment yield of Kali at Pancheswar is estimated at 4365 t^{-1} km^{-2} yr^{-1} from June to November 1990.

Tributaries of Kali flow from the valleys between the lower ranges of hills – the Dhauliganga and the Goriganga rising in glaciers, the Saryu and Poorvi Ramganga just below the snow-line, and Lohawati and Ladhiya in the outer hills. The basin has elevation range from 250m to 7000 m. River Kali rises in the Trans Himalayan region and makes its way through narrow gorges and traverses

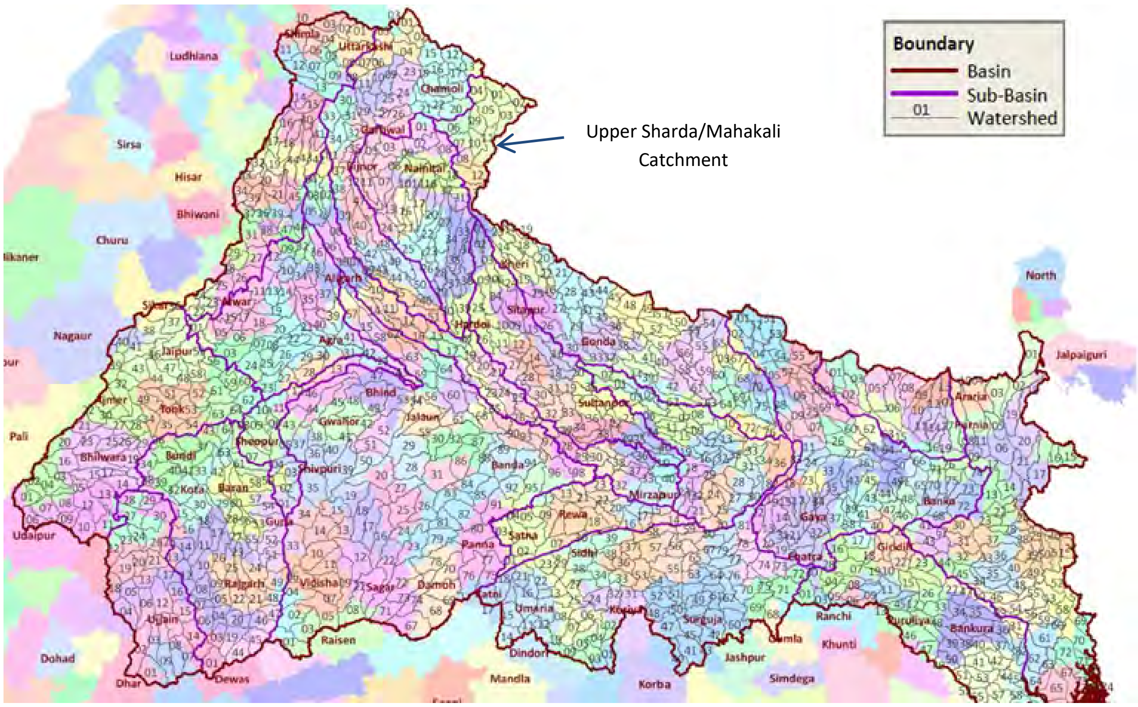


Figure 3 – The Ganga Basin

Source: WRIS, 2017

through high, middle and outer Himalayas and continues its journey in the terai plains of Uttar Pradesh. It flows as Mahakali in the upper reaches and is known as Saryu/Sharda[5] in the lower reaches. The river system is made up from numerous large and small tributaries of the Mahakali catchment (Ghaghra sub basin of the larger Ganges system). The river is not constricted in the upper reaches, Tanakpur Barrage is the first structure encountered by it, from where the Sharda Canal System network supplies water to the terai plains of Uttar Pradesh. The river floodplains expand from here onwards.

Almost whole of Uttarakhand state is drained by the Ganga Basin (6.15% of total drainage area). The Kumaon region is partly drained by the Mahakali catchment of Ghagra sub basin and rest by

[3] *http://lib.icimod.org/record/21985/files/c_attachment_131_1068.pdf*

[4] *https://cest.gnest.org/sites/default/files/presentation_file_list/cest2017_00841_oral_paper.pdf*

[5] *Sarju, a considerable affluent of the Kali River, to which it often gives its name. From the confluence at Pancheshwar in Kali Kumaon, the united stream is known as the Saryu or Kali as far as Brahmdeo, and as the Sarda or Ghaghra to its confluence with the Ganges in District Ballia at the extreme southern point of the NW provinces. [The Himalayan Districts of the NW Provinces of India]*

the Ramganga-Pindar Rivers. Hydrological cycle in the Ganga and its Himalayan sub basins is governed by the SW monsoons during the four months of June-July-August-September.

Hydro Observation Sites in Mahakali Catchment of Ghaghra Sub Basin are few, and these are shown in the table below;

Table 2a - Existing Hydrological Stations in Sharda Basin

Name	Type	Regional office	Division	Drainage area (sq.km.)	Zero of Gauge	Station bank
Tawaghat	GD		M Ganga Div, I, Lucknow	1225	1080	Right
Dharchula	G	YBO, N Delhi	Plng & Invest, Faridabad			
Jauljibi	GD		M Ganga Div, I, Lucknow	2150	600	Left
Jhulaghat	G	YBO, N Delhi	Plng & Invest, Faridabad			
Ghat	GDQ[6]		M Ganga Div, I, Lucknow	3900	450	Right
Pancheshwar	GDS	YBO, N Delhi	Plng & Invest, Faridabad			
Pancheshwar	G	UGBO, Lucknow				
Poornagiri	GDS	YBO, N Delhi	Plng & Invest, Faridabad			
Banbasa	G		M Ganga Div, I, Lucknow	15820	214	Right

Source: www. india-wris.nrsc.gov.in & Other web sources
Note: Blanks indicate no information available from sources

[6] *G-Gauge, D-Discharge, Q-Water Quality, S-Silt*

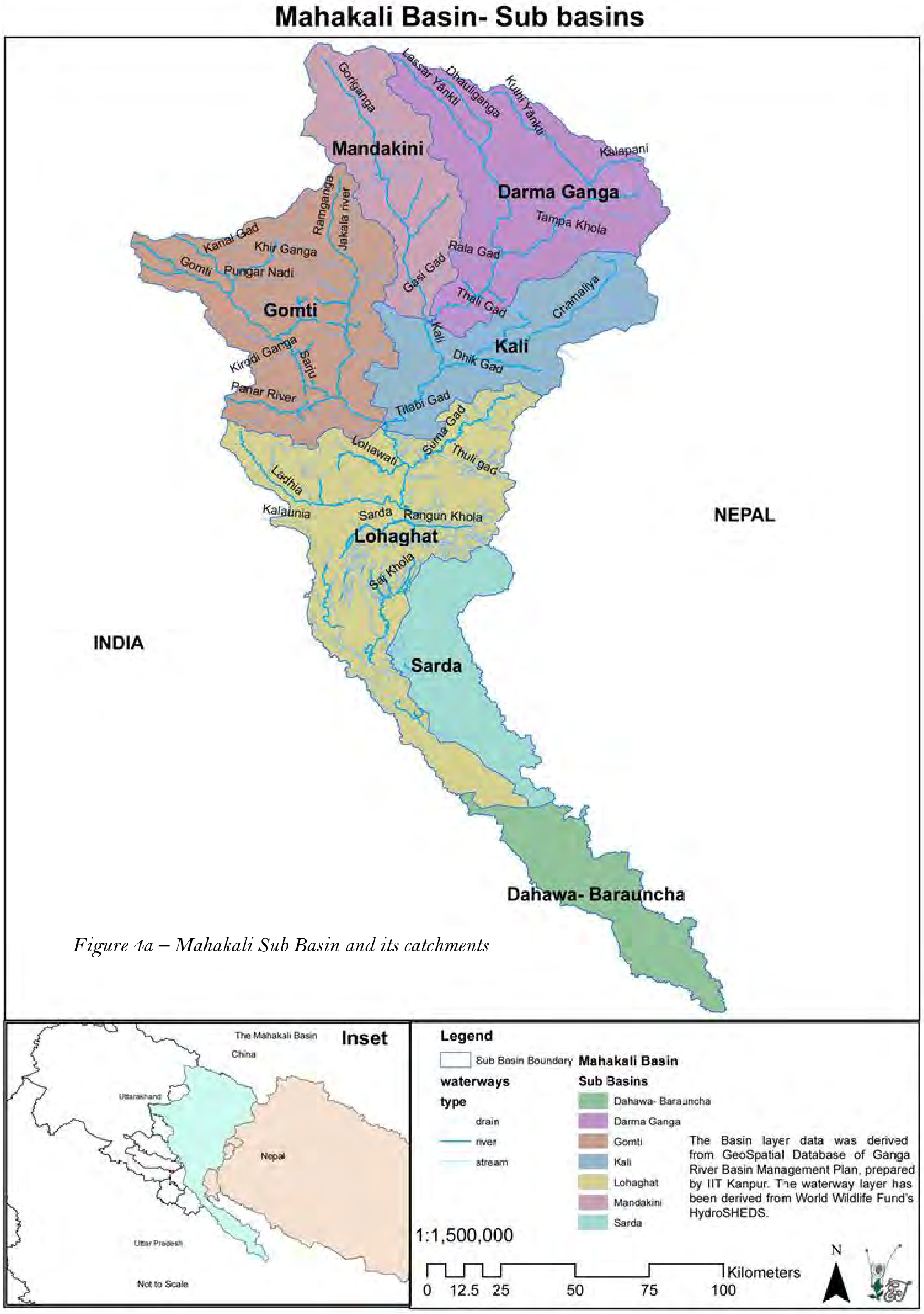
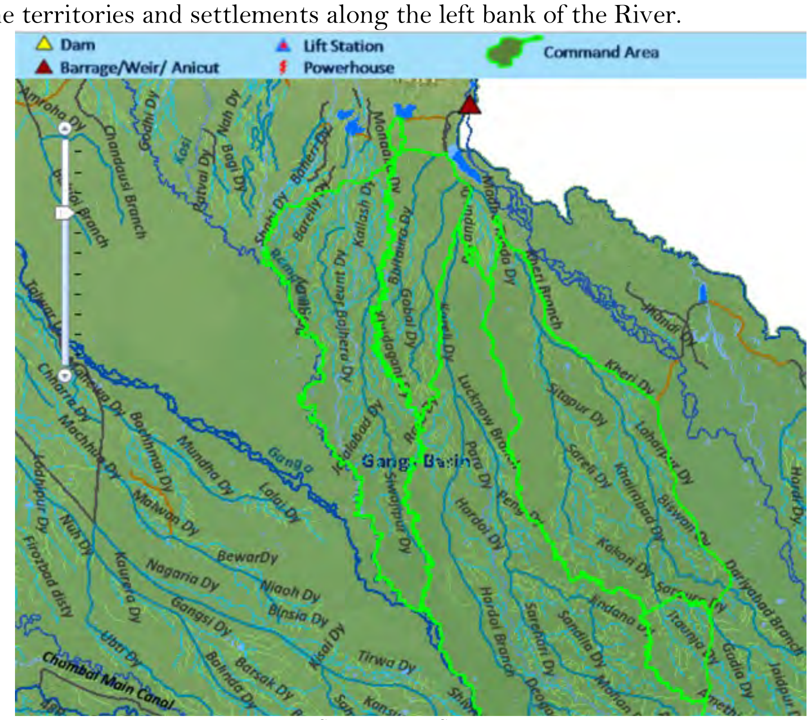


Figure 4a – Mahakali Sub Basin and its catchments

Sharda River is seen emerging out to the Terai's dense Sal forests

The Sharda canal system caters to India and Nepal, it is here that the Mahakali Treaty of 1996 assumes importance for both the governments and communities on the issue of water sharing. Around 350 cumec is what Nepal has been demanding. There are other numerous issues related to damages to the territories and settlements along the left bank of the River.



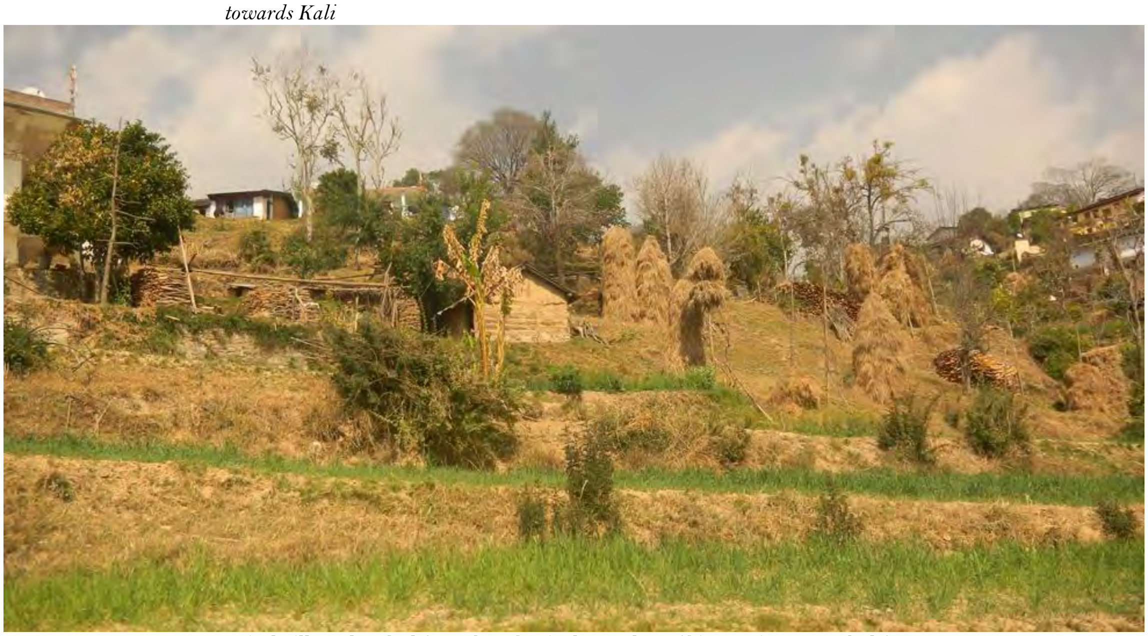
Source: WRIS, 2017

Figure 4 - Sharda canal system's command area is shown in green polygons, it is this terai area which benefits from the flows of Kali/Sharda. The canal irrigation system is administered by the Uttar Pradesh Government.

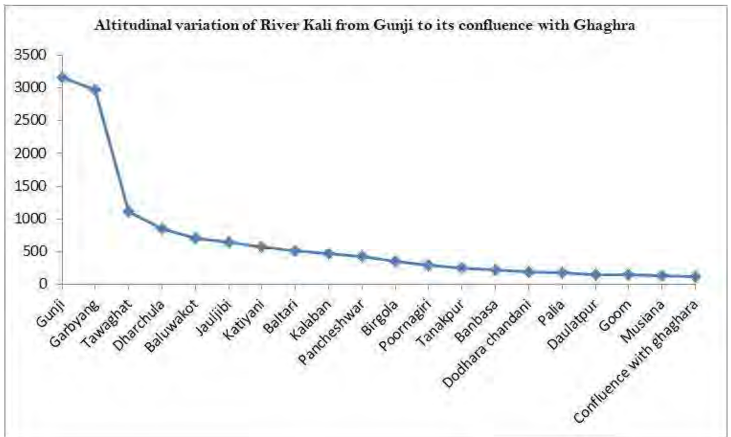
Between Baluwakot and Chharcham showing river cutting the terrace towards Nepal side

Agricultural land developed on the Nepalese side gently sloping towards Kali

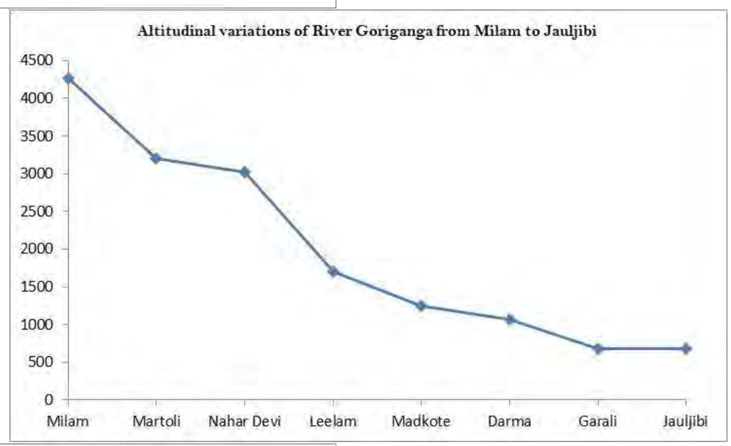
A Few kilometers before Kalika enroute Dharchula



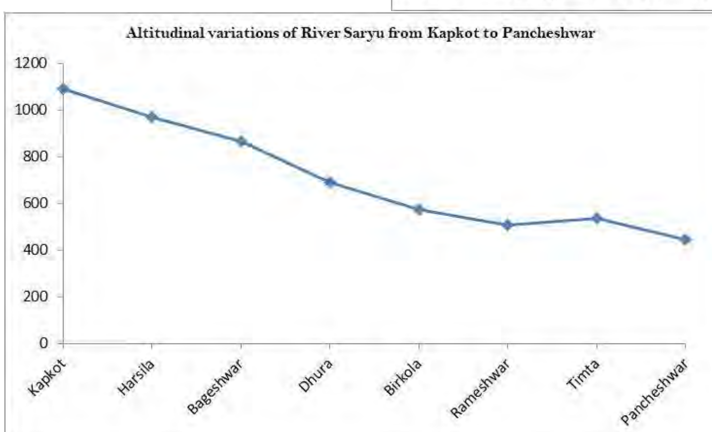
A typical village detached from the urbanised zone, lots of biomass is seen stacked for use!



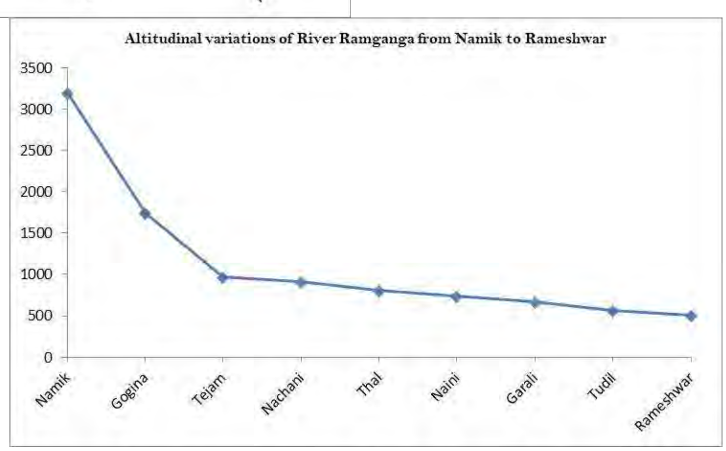
The highest fall (1850 m) is between Garbyang and Tawaghat which is a distance of approx. 40 kilometers. After Jauljibi, the river slope is gentle and reduces to 250 m at Tanakpur and further to 218m near Banbasa



River Gori rises from Milam Glacier at an altitude of 4265 m approx. and treads its path through the scenic valleys and eventually is received by River Kali/Sharda at Jauljibi.



Within the upper Mahakali basin, Saryu river flows down from Kapkot through Bageshwar (confluence of Gomti and Saryu) at 868 m, thereafter venturing in even lower valleys and meet Ramganga at Rameshwar (506m) and further downstream meeting Kali at Pancheshwar (442m)



Ramganga emerges from the slopes of Namik glacier and takes a sharp dip till Gogina (1750 m) and further upto Tejam (969 m) after which it gently slopes downstream to meet at Rameshwar with Saryu.

2.2.1 Important Rivers in the Mahakali Catchment

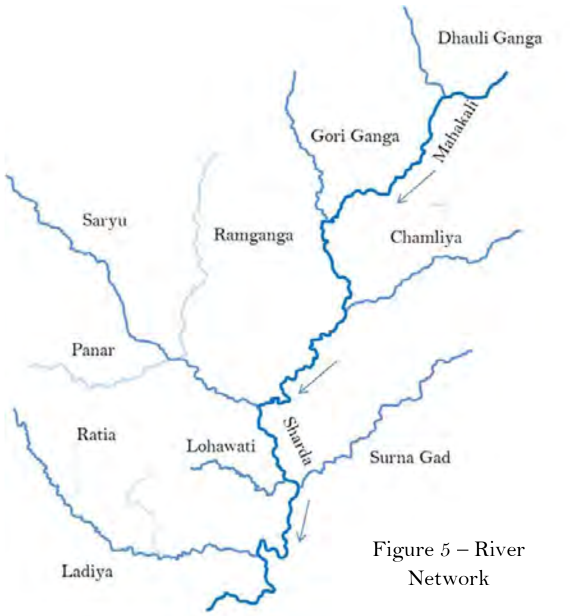


Figure 5 – River Network

The detailed account of the region is described in the Gazetteer written by Atkinson which provides for an easy reference to the current situations. The following section takes an opportunity to compare the current state of river, wherever possible, with what has been described by Atkinson in the Himalayan Gazetteer.

Kuthi Yankti: The longest and most important branch of the Kali River in Kumaon takes its rise in a small glacier at the southern base of the Lunpiya-lekh pass from Patti Darma Malla. Webb who visited this spot, describes it: "The river, two furlong distant, its breadth reduced to four or five yards, at two and a quarter miles in a north-west direction, it is covered with snow, and no longer to be traced; neither is the road passable beyond this point at the present season. After the middle of July, when the thaw is perfected, it may be traced as a small stream for about four miles more, and from thence to its head in the snow, NW two miles further. The stream scarcely flows in winter, being derived almost exclusively from the thawing snow. "The Lunpiya-lekh pass itself has an elevation of 18,150 feet. The river takes a south-easterly direction through the Byans valley to its junction with the Kali, thirty miles from its source. It receives numerous snowfed torrents on both banks passing by the encamping grounds of Walshiya, Jhamathi, Rarab, Jolinka, Sangchuma and Kuthi where it derives its name. To the right and left of the Kuthi-Yankti there are peaks over 20,000 feet high and the entire valley is bordered by glaciers from which torrents flow into the Kuthi river. Numerous tributaries of Kali like Nagling Yankti, Pulung Gad, Nati Yankti, Piear Yanki, Dangiang Yankti are identified for small hydro projects whereas the main stem of the river Kali has no existing project.

Ladhiya: A tributary of the Kali river in eastern Kumaon takes its rise in Patti Malli Rau and parganah Dhyaniran on the southern slopes of the range along which passes the road from Dol to Devidhura. It has a south easterly course through Chaubhainsi, Malli Rau, Talli Rau, Palbelon and Tallades to its junction with the Kali on the right bank. Its only considerable affluents are the Ratiya gadh which joins on the left bank near Chaura in Talli Rau and the Kuirala river which joins it on the same bank in Palbelon. A much frequented road to the Bhabar passes down the left bank of the latter stream crossing the Ladhiya by a suspension bridge below their confluence at Chalthi and thence by Bastiya to Tanakpur in the Bhabar.

There is no reference to the Sikh Shrine of Reetha Sahib at the confluence of Ladhiya and Ratiya gad, whilst there is a reference to Ratia gad. Kuirala or Kaurala River is a seasonal river and brings with it boulders enroute its path and its bed widens once it lays down after Bastiya. Near Chalthi is an arch bridge (bow shape) from where Ladhiya diverts away from the road to a relatively inaccessible area. Mining activity is prevalent in Ladhiya, several trucks ferry the dug up material to and fro along the river bed. These trucks are also only modes of travel for people living in cut off zones like Chukha. Now several hills are defaced due to rapid expansion in the road network.

The wide river bed of Ladhiya - lean (winter) flows in Ladhiya in March. Kaurala, a seasonal outer Himalayan stream meets Ladhiya near Naulapani.

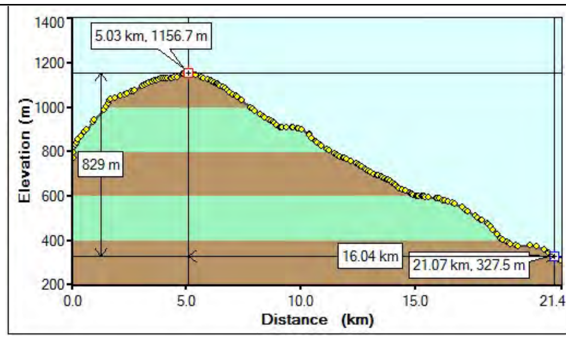
Trucks parked on the river bed – readying themselves for the loading schedule.

The terai forests of Sal between Tanakpur – Bastia delineate the boundary of the outer Himalayas and are the gateway to the mountains of Kumaon through Banbasa – the Boom and Danda Range form part of the Purnagiri trail whereas Devidhura, Mornala, Debguru form part of the upper Ladhiya catchment / sub basin. The ranges from Mornaula (2135m)-Debguru extends upto Sukhidhaang and Chukha (380 m) near Purnagiri and on the other side range from Devi Dhura-Mayapatta extends through Chida and Ghat (475m). River Saryu forms a boundary between forest ranges of Champawat and Pitthoragarh Districts. The Purnagiri mela which is held every year after the winters turns into a pilgrimage centre for people from India, especially from Kumaon/Garhwal-UP and parts of Nepal. A highway is proposed from Tanakpur to Jauljibi along the Kali / Sharda and will reduce distance between these two places. Devotees come in large numbers in the month of March-April (Chaitra Navratri) to offer prayers in the temple and seek blessings. Due to its proximity to Tanakpur and in the lower hills devotees visit throughout the year but the peak is seen in the month of April. Roughly around 200 shops, eateries, shops cum dharamshalas (night halt) engulf the walkway on either side and many are being refurbished and new one's being built on the valley side. Almost each of the dharamshala has washrooms, some even having a dozen of them under one roof and an average size dharamshala can accommodate 50-60 people on an average! Every year, a fair is organized on Vishuwat Sankranti, which continues for about forty days.

Downstream: River Sharda seen from Purnagiri Temple – here it is leaving the outer Himalayan range and entering the Terai of Tanakpur-Banbasa-Brahmdev. The (left) image from Google Earth is depicted through a photograph (right).

Found enroute pedestrian track to Purnagiri Temple: Nephila Pilipes, a golden orb web spider found in Purnagiri hills

Slopy Affair: The pictures above are distinct, the one on left is cloth, plastic & few eatables dumped over hill slope alongside walkway just below purnagiri temple and the picture on right is a problem of SWM dumped over slopes, this problem is brimming in small hill towns and burning is taken as the only solution. Mostly found much before the entry to an urban area, large panchayat



This is an elevation profile from Chaura Kot (Between Chalthi and Sukhidhaang) and Bastia. The highest point being Sukhi Dhaang. Over a distance of 16 kms from Sukhidhaang to Bastia, there is a fall of 829 m or broadly 1 in 20

Dhauli (eastern): A principal tributary of the Kali river in eastern Kumaon, has its remotest sources in the glaciers to the NW of the Dawa encamping ground (14,860 feet) leading to the Naya Dhura or Darma pass into Tibet. The source lies to the north of the main range of the Himalaya and the valley of the river forms one of the two into which Malla Darma is divided. It passes by Dawa, the Pungrung encamping ground, Khimling, Rama to its junction with the Lissar on the left bank.

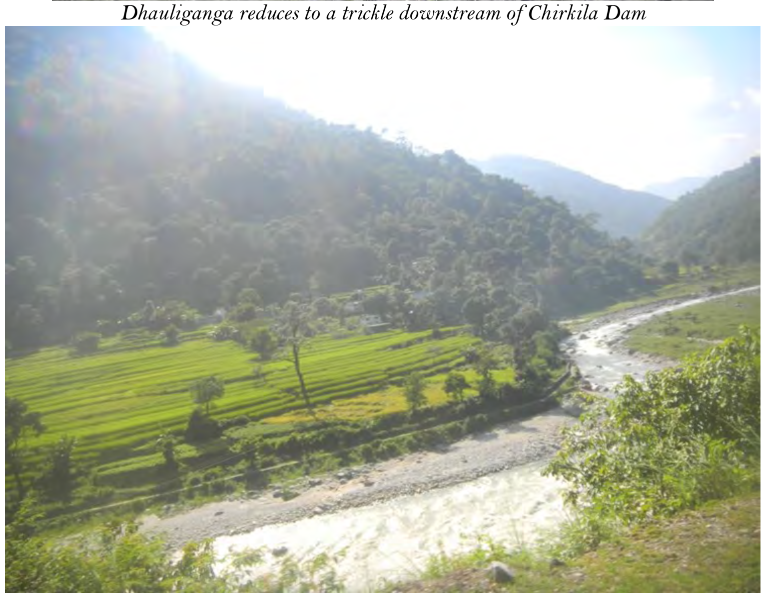
Dhauliganga's flows are also substantiated by numerous torrents from the snow clad mountains. As one moves upstream of Dhauli, the river bed narrows. The high sound and echo of flowing water over the stoney bed reminds of the slope and velocity of the river bed and water respectively. The lone Chirkila dam in the Indian side of Mahakali catchment makes the river quite when it forms a pool of water behind the dam gates. Kanchyoti fall, a few kilometres before Sobla is a vibrant fall and just a few 100 meters on the road side is the Central Water Commission (CWC) camp. The wide cut off zone on the right bank of Dhauliganga shows absence of Sobla market which used to be there till 2013, when the floods wiped the whole market.

The Kanchyoti fall few kilometres before Sobla enroute Darma.

Gori or Goriganga or white river, one of the most considerable feeders of the Kali river, takes its rise in patti Malla Juhar of parganah Juhar in Kumaon. Properly speaking there are two branches, that known as the Ganka or Gankha on the east and the Gori proper on the west. The latter rises in an immense glacier lying to the NW of Milam, and divided from the glaciers giving rise to the Ganka by a considerable ridge running south from the Untadhura ridge, by which the pass of that name leads to Hunder. Weller who visited this glacier described it in detail and he adds that the source of the Gori was formerly opposite Milam, and a Bhotiya told him that within his memory the snow bed had receded some three to four hundred yards in forty years. The junction of the Gori with the Kali takes place immediately below the fine ridge on which Askot itself is built. Several local streams / gads like Charma, Rauntis meet between Goriganga and Sarju. Some of the villages in the vicinity are Tham, Kimkhola, Chamlekh, Garjia, Askot, Jagiura, Bagrihat, Jauljibi.

The flow of Gori seems equivalent to that of Kali near Jauljibi. The productive terraced fields near Balmara makes it amply clear that productivity is high with relatively high humus in the lower valleys. As one climbs up, the scenario changes and gives way to limited productive systems.

Dhauliganga reduces to a trickle downstream of Chirkila Dam



Gori receives Rauntis Gad before its confluence with Kali near Jauljibi.

Sarju (as its names registered by Atkinson in the Gazetteer) rises on the southern slopes of a ridge in patti Malla Danpur of Kumaon. Thirty five miles below the confluence of the Ranganga with the

Gomti it receives the Panar river on the same side and about three miles further down on the left bank the Ramganga (eastern) at Rameshwar with an elevation of 1500 feet above the level of the sea. About ten miles above its confluence with the Panar, sixty miles from its source, the average breadth is about fifty yards and the drift four and half to five miles an hour, with a depth in May of eight feet and fordable in December. It further drains into Kali. A large fish called gunch or fresh water shark (Bagarius Yarrellii) is found in the Sarju from Bageshwar downwards. It is said to attain a length of six feet, scaleless and with teeth like a dog.

History tells us how species have transformed over time and why confluences are important points in a rivers journey. It is at the confluences that the past and the present still exist as is referred in the Gazetteer 'The confluences at Bageshwar with the Gomti, at Rameshwar with the Ramganga and at Pancheshwar with the Kali are *sacred prayagas* or junctions which have periodical semi-religious assemblies in their honor'. *Be it the geological hardships which the rivers need to negotiate to make way for its course or the mythological beliefs, both seem true to the audience then and now. This is how it is mentioned* 'The local Brahmans say that the Sarju could not force its way through the mountains until the present channel was formed by a great devotee by virtue of the power acquired by his authorities.'

Panar flows circuitously but generally in an eastern direction forming the boundary between the eastern half of Malla Salam and Talla Salam and between Rangor on the north and the Chalsi, Gangol, Sui-Bisung of Kali Kumaon on the south to its junction with the Sarju on the right bank above Rameshwar. Total length is about 39 kms.

Confluence of Saryu and Panar before their combined flow joins Ramganga at Rameshawar, only a few kilometres downstream – Panar, the narrow stream joining the flows of Saryu

Ramganga (east) a river which has its source in patti Bichhla Danpur in Kumaon, in a horseshoe shaped depression of a very mountainous tract. To the north the ridge culminates in a peak 19,554 feet, on the east, the ridge runs south with a series of peaks ranging from 16,321 to 9,814 feet (to the west of Ganagarh on the Milam route) and which form the water-parting between it and the Gori.

On the west the ridge has also a southern direction and in the upper portion separates the Ramganga from the Kuphini and lower down from the Sarju. It receives numerous torrents on either bank during its course but none of any great importance. The name Ramganga is often given to the united stream of the Sarju and Ramganga from their confluence at Rameshwar to Pancheshwar, where it joins the Kali.

Lohawati is a small rivulet emerging from the hill springs of Lohaghat forests. It passes through the rich Deodar forests surrounding the Lohaghat-Champawat belt, small fields are seen along. As it passes through the backyard of Lohaghat market, garbage, sewage and other plastic waste finds its way to the river. A small stream called 'Salna' meanders its way through Khetikhan belt and meets Lohawati upstream of Lohaghat, a lift scheme is also operational on both Salna & Lohawati.

Lohawati flowing through Lohaghat; Salna lift scheme (below)

Choti Gandaki is the only stream encountered in Champawat which flows in northwards direction as most of the rivers emanating from the Himalayas flow from North to South. It springs near village 'Chirapani' situated seven kilometres south of Champawat and meanders its way through dense forests of Rhododendron and Oak passing by Dharakudi, Killa and Matiyala. Just through four kilometres of its journey, it is joined by a stream emanating from a neighbouring hill top Banlekh, it is also called Gandak. The place of their confluence is called Tadkeshwar – where Government's Directorate of Cold Water Fisheries is also located. It traverses through the valleys of villages Mudiyani, Fulargaon, Setuda, Shaktipur – Once Fulargaon was famous for growing flowers like rose, gladiola and few others owing to water availability through the year. Now it drifts away towards east wandering by villages of Chowki and Laloli before it is received by Lohawati river at village Gaudi.

Gandaki meandering its way, a little upstream of Chirapani

Table 3 - Confluences Upwards of Tanakpur					
	River/Stream	**Left Bank (Nepal)**	**Right Bank (India)**	**Nearest Settlement(s)**	**Other features**
1.	Stream	Puntara Gad Rangun Gad	**Ladhiya River** meeting Kali between Chuka-Shim	Jogbura (where these 2 gads join); Basigora Kharka; Khaldunga (meets river Kali)	It forms Jogbura Dhar. Sharp/short meander at Khaldunga.
		Sirse Gad		Parigaon (in between i&ii); Thapla, Lopa, Chaur, Sirsegaon	Khitkeshwar Peak (6607). Deep Meander at Sirse Gad-Kali Confluence
2	Thuli and Chawandi Gad Meeting Surna Gad which meets Kali near JAKH		Lohaghat Nadi/Lohawati meeting Kali near Maduwa	Many settlements as compared to the above two sections	
			Saryu River meeting Kali at Pancheshwar		Ramganga-Sarju Confluence at Rameshwar
3	**Chamlia River** (Dhak Gad & Parchuni Khola meet Chamlia from South and Nangarh Gad meets from North)			Ratur, Lumsal, Jaibalishera, Bhaura, Basali, Gobra, Khimtola, Gorari, Kailith, Dhik	Chamlia meets Kali Sarda between Ratur and Lumsal.
Many Gads like Maur, Chal, Laso meet Kali Sarda (from Chamelia's Confluence with River Kali) upto Khela (India) and Dogli (Nepal) where DhauliGanga's confluence is there.					
4	**Goriganga**		Three Gads viz. Shangri, Charma & Rauntis between Sarju & Goriganga	Tham, Kimkhola, Chamlekh, Garjia, Askot, Jagiura, Bagrihat, Jauljibi	Rauntis Gad meets Goriganga near Garjia-Tham and Goriganga meets Kali in Jauljibi
5	**Dhauliganga**			Pangu, Khela, Dogli, Unchikang, Syankuri	

Source: Local & Google Earth

Waters of Himalayan rivers has driven the Governments thrust for harnessing hydro energy and fascinated hydropower developers to exploit the potential. Ecological concerns of hydropower generation have also grown as more and more thrust has been thrown upon the Himalayan rivers without qualitative and comprehensive environmental assessments as noticed in other Himalayan basins like Sutlej basin where numerous projects are at various stages of development in upper reaches like in District Kinnaur and Lahaul-Spiti. Thus it would also be important to understand the river basin now and how will it respond if energy from its flowing power is harnessed. Broadly, there are several proposed projects, for many of them survey and investigations were done and many were held up due to wildlife concerns in the upper reaches and also after the impact of 2013 floods in the River valleys of Garhwal and Kumaun. Based on the sites identified for numerous projects by the authorities, it can be safely estimated that around 10,000 MW of potential lies in the Mahakali Catchment which has major rivers of Kali/Sharda, Dhauliganga, Eastern Ramganga, Goriganga and Saryu. The large concentration would be in the main stem of River Kali estimated to be around 7500 MW.

2.3 Socio-Cultural Relations

India and Nepal have common and shared cultures. The communities on either side are bonded through social links and economic common space in terms of valley markets which drive the economy and provide service to the whole landscape to a larger extent. Moreover, Rivers and religious sites are synonymous to the hilly landscape, annual fairs and several localised fairs/events bring together people from both the sides together. The famous Jauljibi mela dates back to the 19th century and continues till now – it is a trade centre for Nepal, India and Tibet. Such trade centres or markets provide opportunity to people in the glacial margins to earn their seasonal livelihoods – thus providing a stimulus for the family to move their children for education from their native places to the terai or the hill towns in vicinity.

Socially, economically and culturally, several centres of importance along the river portray significance for people across the border. Few of them are religious centres like the Poornagiri Shrine, Taleshwar, Hansheshwar, Pancheshwar temple and traditional bazars like Jauljibi-Dharchula-Jhulaghat etc. to name a few. The Sharda river is an important tributary of Ghaghara river, which forms the boundary between India and Nepal for some portions. It's a trans boundary river not just in terms of its function as some physical feature demarcating administrative boundaries but a river around which resource sharing, socio-cultural interactions take place which are important to the communities on either side. It thus implies that the tributaries have a greater role in their localised management in order to make sustainable contributions to the river flows. In the basin's context, integrated management is thus important where the main River cannot be treated in isolation. Its management is thus has to be on a basin level involving multiple layers of stakeholders.

There are marriages among the communities living on either side of the Kali and this social fabric is seen across several pockets in the hills & in terai. Many from the FWDR terai have married and settled in Champawat's terai. Moreover many of the festivals are also similar like Dusherra and Holi. Thus the socio-cultural exchanges keep occurring at the larger community level as well as at the family level too.

Contextualising Links of Communities to Ecology and Land

Darma valley is a difficult valley in terms of its geological formation, weather, productivity and connectivity. Means of livelihood are limited and only available for a limited period during the months from May-November. The Bhotias in these upper valleys migrate downwards upto Jauljibi and beyond during the winter months. With their ancestral villages in the Darma valley and similar landscapes, finding land and settling along the Kali was not much of a difficult task (administratively) during earlier days. This belt along the river is generally called *Bagad belt* in this region and is also a productive land. Bhotias and other communities are settled on this land along the river and around Jauljibi, as it is a centre of trade catering to Nepal and India. Some people say that in the older days, land was given on compassionate ground/mutual understanding to these communities merely in exchange of a goat or a herd of goats. Since then there is a symbiotic relation among the communities but with changing times, when systems became more formalised, the issues of encroachment and unclear titles still haunt the communities. This uncertainty remains. Bhotias venture out upwards in the hills during the month of May-June to harvest medicinal plants and fungus, especially Yarsagumba[7] (ophiocordyceps sinensis). While there are reported incidents of illicit trade of high value fungus, there is little the state has been able to control or manage this illicit trade. The outreach of the administration is also limited.

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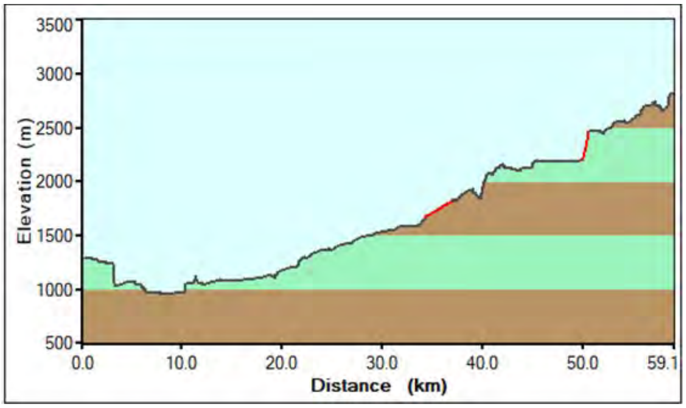
[7] Yarshagumba can be found in the high alpine grasslands of the Kumaon and Garhwal regions, mainly above 3,700 m elevation from May until late June. It grows in unspecified forested areas, reserved forests, grasslands, and protected areas, as well as in Van Panchayats (VPs). The potential habitat consists of approximately 300 km^2 in the Kumaon region, with one quarter lying within the Askot Wildlife Sanctuary. [Management Deficits of Yarshagumba collection, ICIMOD]



From Tawaghat to Nangling, the distance is 40 kms and the altitude gained is 1720 m. i.e. 43m gained every 1 kilometer route distance on this route. Below mentioned places with altitude and their respective distance from the last place:

Dharchula (910m), Elagad Bridge (1140m, 13.4 kms), Tawaghat (1129m, 18.7 km), Chirkila Dam (1357 Road level, 24.2 km), Khet Nala/Bridge (1448m, 26km), Kanjoti (1517m, 28.6 km), Sobla (1721m, 31.6 km), Hardeol enroute Tejam (1775m, 36.4 km), Bongling (2226 m, 44.3 km), Urthing (2328 m, 49.3 km), Nangling (2849 m, 58.2 km)

Turning westwards from Tawaghat (Tawaghat is a trijunction linking Chaudhans, Darma, Byans valleys), habitations become lesser and as one moves further up towards Sobla-Nangling, the glacial belt along the ridge allows snowmelt to flow down the slopes to Dhauliganga. Sobla was considered as the last motorable village along the river. Sobla as a market place fed the upstream villages with daily needs etc. but in 2013 it was swept away by the heavy rains and the eventual flooding of River Dhauliganga. Now, the road is being extended further into the Darma valley but there are several blockages enroute due to rockfall – triggered by road cutting and due to plenty of water. The above figure shows the approach to Darma valley with gradual increase in altitude. Chirkila dam is just 2 kms downstream of Khet, defacing of the adjoining (left bank) hills is noticed clearly. Urthing-Sobla were the twin sites earlier being explored for hydropower projects in the Dhauli River but off-late there has not much investigation undertaken.

From the pages of History

The pargnah of Darma has always been divided into three pattis, Darma, Byans and Chaudans. At the settlement in 1872 the Darma Patti was further subdivided into the Malla and Talla pattis. Darma is bounded on the north by Hundes; on the west by the chain containing the Panchachuli group and the Chhipula peak; on the south by a line drawn from the latter peak due east to the Kali rivers, and on the east by the chain culminating in Yirgnahjung (20,264 feet) separating it from the Byans valley and Patti Chaudans. The boundary between the Malla and Talla pattis runs along the ride stretching NE from the Chhipula peak to Tejam on the right bank of the Dhauli river. The Darma patti occupies both banks of the eastern Dhauli as far as the western spurs of Yirgnajung whence it is confined to the right bank of the river to its confluence with the Kali. Talla Darma or the lower part of the valley, is more open and resembles the lower portions of the other Bhot parganas as far as Sobhula, where the Malla patti commences.

2.4 Land and People

Physiographically, Nepal is classified into 3 broad zones viz. terai, mountains and hills; the hill system is further classified into Siwaliks, middle and high Himalayas and trans Himalayan region or Himal. The Far Western Development Region (hereafter FWDR), as the name suggests is a region in the western part of Nepal which shares its boundary with India and the hill region of Uttarakhand. District Kanchanpur (FWDR) is majorly a Terai belt constituting as far as more than

80% of the landform and extends upto Siwaliks, the outer Himalayas. Districts of Dadeldhura and Baitadi are majorly middle Himalayan regions; Dadeldhura relatively has 25% of its area in the Shiwalik zone i.e. a transition zone to Terai or middle Himalayas. District Darchula comprises of trans Himalayan and higher Himalayan region in almost equal proportion of its geographical area, however almost 1/6th of its area falls in the middle Himalayas. In the overall context, a little above 76% of the ecological area of FWDR[8] is in the lower to higher hill system and the rest form the terai region.

Figure 6 – Districts in Mahakali Zone

As per a report by UNFCO[9] the human development index (HDI) varies with the development region, rural-urban area and ecological belt. HDI for FWDR was 0.461 as per UNDP in 2006 whereas the HDI of the mountainous region and hill region is even lower at 0.435 and 0.443 respectively, the terai belt fairs better at 0.503 due to access ease. The report put the Gender Development Index of the FWDR at 0.447 and the GEM at 0.456, ranked fourth out of five regions.

Table 4 - HDI, Far Western Region - 2006

Development Index	Nepal	FWR	Mountain	Hill	Total
Human Development Index (HDI)	0.509	0.461	0.435	0.443	0.503
Gender Development Index (GDI)	0.499	0.447	0.414	0.421	0.492
Gender Empowerment Measure (GEM)	0.496	0.456	0.413	0.396	0.469
Human Poverty Index (HPI)	35.40	39	48.1	44.9	35.3
Poverty incidence (poverty head count rate)	30.80	41			

Source: An Overview of the Far Western Region of Nepal, UN Field Coordination office, Dadeldhura, Nepal (accessed online)

The Mahakali catchment is limited to the four bordering districts of FWDR with India whose HDI scores in 2011 stood between 0.416 to 0.475, averaging to about 0.442. If the Seti zone is taken into account (of the FWDR) the HDI average score is 0.394 indicating more efforts required to be done.

[8] Far Western Development Region comprises of two zones viz. Mahakali and Seti. There are nine districts, four of them in the Mahakali zone viz. Dadeldhura, Kanchanpur, Darchula and Baitadi
[9] United Nations Field Coordination Office

The Mahakali zone in comparison has open borders with India and access to commodity markets as well as for labour jobs is much easier than the Seti region (HDI from 0.364 – 0.460)

Table 5 - Food Security Situation, FWR, 2009

District	Food Production (MT)	Food Requirements (MT)	Food Surplus/deficit (MT)
Kanchanpur	134,420	120,066	+14,353
Dadeldhura	19,859	23,358	-5,464
Baitadi	39,685	47,118	-7,433
Darchula	17,950	27,078	-9,128
Bajura	19,973	23,362	-3,390
Doti	40,407	42,746	-2,339
Bajhang	30,840	37,622	-6,782
Kailali	212,148	124,627	+87,521
Achham	31,521	51,660	-20,139

Source: An Overview of the Far Western Region of Nepal, UN Field Coordination office, Dadeldhura, Nepal (accessed online)

As per the Nepal food security monitoring system[10], in the year 2010, Far Western Districts of Darchula and Baitadi's 18% and 10% population was highly food insecure whereas over a period of 5-6 years, in 2016, the region has said to have some 56 VDCs which have been classified as moderately food insecure. In case of Darchula and Baitadi, the incidence of food security has gone down from highly insecure to moderately insecure.

Nepal measures population density per agricultural holding area as a measure or index of population pressure on the agricultural holdings. it is the density of population per square kilometer of agriculture holding area. In the FWDR density is 972, a bit higher than Nepal's average of 872. It is second in comparison to the Central development region (1070). Kanchanpur which is located partly in terai and shiwalik range has a density of 800-899 whereas Darchula is further lower at 697

Nepal measures sex ratio as males per 100 females whereas it is females per 1000 males in India. All the four districts have high sex ratio hinting at more male population. In the FWDR, sex ratio is 98.2 which is second to the WDR whereas the national average is 99.8

Table 6 – Demography and Agricultural Potential

Districts in Mahakali Zone	Households		Area	Population			Land Available for Cultivation	Land Under Farming	Irrigated Land (including rainfed)
	2001	2011	Km²	2001	2011	2016	Km²	Km²	
Darchula	21029	24618	2322	121996	133274	139269	295.45	225.92	46.95
Dadeldhura	21980	27045	1538	126162	142094	150805	192.42	183.23	48.97
Baitadi	40387	45191	1519	234418	250898	259575	314.85	257	105.2
Kanchanpur	60158	82152	1610	377899	451248	493004	597.83	595.32	595.32
Total	**143554**	**179006**	**6989**	**860475**	**977514**	**1042653**	**1400.55**	**1261.47**	**796.44**

Source: Regional Agricultural Directorate, Dipayel

As almost the administrative divisions of the Mahakali zone (four districts) come under the catchment area of Kali river (Mahakali Catchment which is a part of Ghaghra sub basin), the district level statistics are used. As per population figures there is a growth rate of 13.60% in this zone over a decade (2001-2011). With Darchula, Dadeldhura and partly Baitadi being the hilly districts, the population density is low whereas in the Terai belt of Baitadi, the population density rises to 306

[10] District Food Security Network anticipated that an additional 171 VDCs may be classified as moderately food insecure (Phase 2) in Achham (55), Baitadi (25), Bajhang (13), Bajura (14), Darchula (25), Doti (33) and Dadeldhura (6)

persons per square kilometers. The total land available for cultivation is 1400 Km^2 which is almost 20% of the geographical area in this zone and almost half of this cultivable land is irrigated.

As far as Uttarakhand is concerned, a report[11] places Uttarakhand at top of the HDI ranking among the eight Empowered Action Group (EAG) states viz. Rajasthan, Madhya Pradesh, Chhattisgarh, Bihar, Uttar Pradesh, Odisha, Jharkhand and Uttarakhand itself. It followed the UNDP methodology and focused on three parameters of Health, Education and Standard of Living. The overall HDI values for these are 0.6786, 0.8213, 0.603 for Uttarakhand whereas the average for eight EAG states for health, education and standard of living is 0.5745, 0.6245 and 0.4437 respectively. All the thirteen districts of Uttarakhand have been assessed as having very high HDI.

Among the four administrative districts within the Sharda catchment, Champawat has registered decadal population growth of 15.63% owing to its proximity to the terai and lower Himalayas. Also Tanakpur is a big trading centre for commodities brought down from the hills as well fulfilling the commodity demand from the hills. On the other hand, Bageshwar and Pitthoragarh have registered a modest decadal population growth of 4.6% and 5.15% respectively; however there are few blocks which registered negative growth viz. Kanalichina, Didihat, Munsiyari in Pitthoragarh District. The negative growth of 1.64% is registered in District Almora. Each of the four districts have a municipality each which is the major urbanisation driver - in Pitthoragarh district, the Pitthoragarh municipality has a high proportion of overall urban population (80.52%), In Almora it is the Almora municipality with urban population proportion of 54.76% and in Champawat district, it is the Tanakpur municipality which constitutes 46% of urban population. Among the development blocks which are the micro planning units at the district level

One reason for migration has been the consistent decreasing share of agriculture in the state GSDP, it has come down from 12.19% in 2011-12 to 9.94% in 2015-16. In several valleys, especially in the lower and middle Himalayas, abandoning of farming activities due to lack of irrigation facilities, damages by wild animals is prevalent. Attacks by wild boar and the remedial policy is flawed as shared by the communities in different valley's.

2.5 Land Holdings and Land Use

In the overall context of Uttarakhand, private agricultural land is very less and that too layered into very marginal unconsolidated land parcels. Large percentage of land is under marginal land holdings (in the range of 0.5 – 1 hectare). Majority of the land holdings in the hilly districts of the basin are small and fragmented as evinced during interaction with many communities during the field visits. As per agricultural census, large number of marginal land holdings[12] in Pitthoragarh 88%, Bageshwar 90.69%, Champawat 75.08% and Almora 75.51% have similarly large chunk of land area under them viz. 67%, 71%, 49% and 45% respectively. The comparatively less percentage in case of Champawat is due to the terai plains in the district.

Table 7 - Land holdings in Kumaon Region

Land Holding Size (Hec.)	Pitthoragarh		Bageshwar		Almora		Champawat	
	No. of holdings	Area	No. of holdings	Area	No. of holdings	Area	No. of holdings	Area
0.5	45971	12707	34858	8507	43532	12888	15848	5122
0.5-1.0	24603	16976	13998	9427	38511	27854	11542	8566
1.0-2.0	7881	10669	4479	5742	22451	30577	6517	9382
2.0-3.0	1169	2787	447	1076	3832	9074	1598	4027
3 & above	20	878	87	350	942	12626	769	3168

[11] Development of Human Development Index at District Level for EAG States, Statistics and Applications{ISSN 2454-7395(online)} Volume 14, Nos. 1 & 2, 2016 (New Series) pp. 43-61 [http://ssca.org.in/media/4_2016_HDI_t1hcMZm.pdf]

[12] Less than 1 hectare

Total	79846	44018	53869	25103	109268	83945	36274	30266

Source: Agriculture Census

Lay of land and the land holdings in the Mountains

Agriculture land near Madlak Bend enroute Madlak

A good agricultural belt overlooking Bisang-Chumula

Between Badam-Bajgel leading to Sunkuri

River floodplains and protection to agriculture land, near Amori (Champawat)

Sobla, as seen from Hardeol – the road was uptill sobla, its market washed away in 2013 deluge!

Disturbed slopes, downstream of Sobla

The problem portrayed by unconsolidated land holdings in the state were brought forward in the Ladhiya valley wherein the people complained about lack of political will to conduct 'chakbandi' for better land management and land owners. Uttarakhand followed the Uttar Pradesh rules for the same i.e. Uttar Pradesh Chakbandi Adhiniyam 1953. In 1960, to end the zamindari system in the hilly regions 'Kumaon and Uttarakhand Zamindari Vinash Adhiniyam – 1960' was brought up which resulted in formation of Garhwal Mandal or Division in the year 1968.

Lack of land consolidation in the state has brought up multiple problems which are interlinked;

- Small and fragmented[13] land holdings become economically unviable and the cost increases for their resource management, operation and maintenance – irrigation facilities especially.
- Due to fragmented holdings, securing the crop from wild animals becomes a daunting task and farmers slowly abandon cropping. Wild boar menance is highly reported from the lower and middle Himalayan belts of India, Nepal and even Himachal Pradesh.
- Given the morphology of land parcels in the hilly regions, more the number of land parcels fragmented, more likelihood that a farmer will not be able to cater to all the lands and hence deterioration
- Missed opportunity unless a legal regime consolidate these to enable a viable and benefit sharing mechanism among the community
- A person or a community can make a bankable project to begin a new livelihood with their consolidated land holding as collateral.

A legislation 'Uttarakhand Consolidation of Holdings Act, 2015' was proposed to tackle the problem of fragmented land holdings in the hilly regions of Uttarakhand but it hasn't been rolled out on the ground. The two lines which succinctly describe the problem of fragmented holdings and potential to correct them are;

दूर धार तक फेल्यां खेत । चकबंदी माँ होला एक ।।

"The fields are spread far and wide, consolidation will help organising them"

Khetikhan-Lohaghat belt used to be a famous 'potato-belt' having many indigenous varieties but now almost all these varieties have vanished, says Sh. Yogesh Oli. Potato cultivation has been worst-hit by wild boar menace. He himself has spent a lot to protect his farmland from wild boar menace but even than they make way into the fields. As per one recent news report, around 200 sq.km area is affected by wild boar and their number is expected to be around 50,000. (https://www.hindustantimes.com/dehradun/uttarakhand-seeks-fresh-permit-to-hunt-wild-boars-as-farmers-cry-crop-damage/story-YNCWOiLolqZbumM8hQLJDL.html)

A contrasting situation was seen in Leti-Nagrughat belt along River Kali where people have been able to grow vegetables etc. in the area affected by wild boar, the reason being collective community watch and availability of irrigation which gives people a reason to keep a watch onto their fields. People also blame the policy of Government which makes it difficult for the farmer to produce evidence that requires the hunted animal to be found in the complainant's field.

[13] Few employees in Horticulture department pointed that this is one of the main reasons why farmer is unable to economically do agriculture and horticulture

The situation is not too different in Nepal where land fragmentation is also high and average land holding size is less. Nepal categorises its statistical information as per ecological areas divided into terai, hills and mountains.

Table 8 – Land Holdings in Mahakali Zone of Far Western Development Region

Parameters	**Far Western Dev. Region**			**Districts in Mahakali Zone in FWDR**			
	Mountain	**Hill**	**Terai**	**Darchula**	**Dadeldhura**	**Baitadi**	**Kanchanpur**
				Mountain	Hill		Terai
No. of Holdings	77500	150200	182200	22400	24800	43500	70600
Area (ha)	38600	67800	111000	17380	11620	21330	44350
Average holding size	0.5	0.5	0.6	0.8	0.5	0.5	0.6

Source: Statistical Book of Nepal, 2016 – Central Bureau of Statistics, Government of Nepal

The far western development region constitutes two zones, viz. Mahakali zone and Seti Zone. The land holdings in the FWDR as per 2011 statistics is 4.09 lakh covering an area of 2174 sq. km. whereas mahakali zone has around 1.61 lakh land holdings 947 sq. kms. The average holding size is 0.53 hectares. It is interesting that between 2001-02 to 2011-12 there has been increasing fragmentation of land holdings, especially in the terai ecological zone (39.5%) followed by 15.6% increase in the mountain region and 11% in the hill region. Obviously, the average size of holdings decreased in proportion to fragmentation of land holdings over the period.

Table 9 - Land Utilisation in Districts of Uttarakhand

Categories	**2005-06**	**2011-12**	**2005-06**	**2011-12**	**2005-06**	**2011-12**	**2005-06**	**2011-12**
	Pitthoragarh		Bageshwar		Champawat		Almora	
Agriculture, Crop land	323.92	375.75	138.73	280.78	49.93	352.02	564.46	1296.96
Agriculture, Fallow	289.41	0.72	205.16	0.18	217.99	-	726.65	1.53
Agriculture, Plantation	0.79	88.97	-	73.09	-	2.24	1.15	4.73
Barren/unculturable/wastelands, barren rocky	1354.98	1704.42	67.03	146.15	1.44	2.12	-	0.1
Barren/unculturable/wastelands, scrub land	56.79	142.78	15.61	16.1	1.93	2.97	84.52	63.36
Built up, Urban	-	**12.83**	-	**1.35**	2.6	**3.13**	-	**5.96**
Builtup, Mining	-	-	1.38	**2.61**	-		-	**1.98**
Builtup, Rural	8.59	5.26	0.24	2.49	-	0.67	5.86	5.73
Forest, Deciduous	285.18	73.21	100.5	73.76	433.67	350.37	426.52	346.08
Forest, Evergreen/Semi evergreen	1682.7	1725.55	1221.8	1231.68	848.75	858.36	1226.9	1287.18
Forest, Scrub Forest	109.47	476.89	71.77	92.31	138.66	140.95	76.62	92.31
Grass/Grazing	984.46	1366.6	179.45	157.9	23.58	4.24	-	-
Snow & Glacier	1932.17	1021.87	229.38	149.79	-	-	-	-
Wetlands/Water Bodies, Reservoir/Lakes/Ponds	0.1	0.38	-	-	-	0.04	-	-
Wetlands/Water Bodies, River/Stream/Canal	62.43	95.77	18.96	21.8	47.45	48.18	21.31	28.04
Total Area in Sq. Kms	**7091**	**7091**	**2250**	**2250**	**1766**	**1766**	**3134**	**3134**

NRSC (2014), Land Use / Land Cover database on 1:50,000 scale, Natural Resources Census Project, LUCMD, LRUMG, RSAA, National Remote Sensing Centre, ISRO, Hyderabad

Note: More details on forests of Uttarakhand is described in Chapter 5

As far as geographical area is concerned, Pitthoragarh alone has the largest geographical area than the other three districts combined but much of its area upwards has steep slopes, low vegetation and covered under snow. Land use is broadly determined by the physiographic regime of an area, in the Mahakali catchment Pitthoragarh and Bageswhar are two administrative districts within the basin which have areas under snow and glaciers, thus on an annual basis or after a certain period there is a likely change in the land utilisation pattern, interchangeably among the different categories viz. people may have to leave more land fallow as a result of accessibility. In case of Pitthoragarh district, there is an increase in barren land, built up area, forests, grass/grazing land from 2005-06 to 2011-12 whereas a decrease in area under agriculture, snow and glacier is reported in the same period. This is a peculiar feature in the high hill districts. The built up area indicates that more urban areas got developed after 2005-06 or transformation from rural to urban happened during this period.

Forest classification of Forest Survey of India differs from the one outlined in the table above. As per the report[14], Pitthoragarh has 29.65% of its geographical area under forests, amongst which dense forest it only 24.21%. Even though the combined geographical area of Almora, Bageshwar and Champawat districts is less than that of Pitthoragarh, all the three districts have high percentage of forests in proportion to their geographical area, viz. 50.43%, 60.69% and 67.04% respectively.

Bageshwar also showed the similar trend but it closely shows decrease in snow and glacier and relative increase in barren area. Area under agriculture remains more or less same, more fallow area was brought under agriculture during 2011-12 as compared to 2005-06. Built up increase is seen in rural areas (from 0.24 km^2 to 2.49 km^2) and mining (from 1.38 km^2 to 2.61 km^2). Mining of soapstone and partially limestone is prevalent in Bageshwar, especially the Kapkot region.

Champawat is a low hill district extending to the terai of Banbasa bordering Uttar Pradesh. The huge change in agriculture area might be due to the fact that during remote sensing analysis a transition (harvesting) was underway which is reportedly seen in the fallow land left in 2005-06. There is a marked decrease in the forest area in the deciduous forests.

Almora district has the largest agricultural land among all the other three districts in the Mahakali sub basin. The small land parcels along the river best exemplify the symbiotic water-productivity cycle in these narrow valleys of Ramganga, Panar, Saryu.

[14] Table 7.29a: District-wise Forest Cover of Uttarakhand, State of Forest Report 2015, Forest Survey of India

3

Contents

3. HISTORY OF TRANSBOUNDARY WATERS OF KALI/SHARDA AND DEVELOPMENT PLANNING IN HILLS

3.1 Indo-Nepal Bilateral Water Sharing Agreements

The geographical location of India and Nepal demands each other's co-operation for various multipurpose works and specific-works for mutual benefits or benefits for either of the nations, separately. These works included barrage and head-works on the rivers with flood banks, storage dams, detention dams and canals for flood control, irrigation, generation of hydroelectric power, prevention of soil erosion, etc. Canal head regulators were also required for the purpose of irrigation and development of power. Some works were to be constructed in Nepali territory and therefore the land for the same had to be acquired by Nepal but India, also being the beneficiary of such works, had to share the cost of the same.

Being conscious of its sovereignty, Nepal, while entering into any arrangements with India, had to protect its sovereign rights as well as riparian rights within its territory. On the other hand, for the purpose of proper execution of the contemplated works and effective implementation of the involved schemes, India had to ensure freedom of operational activities within Nepalese territory wherever necessary. These nation-specific perceptions form the core of contention in water sharing of riparian rivers between the two nations, as corroborated by all such agreements in the past.

The rivers which pose challenge of co-operation, development and utilization of common water resources between India and Nepal are – Ghaghra, Gandak, Bagmati, Kamala, Kosi and Mahakali/Sarda.

The First Official Correspondence

The first official correspondence between the two countries has been traced in the year 1874. A letter was written by the British India government to the government of Nepal during the time of Prime Minister and Maharaja Jung Bahadur Rana in relation to the three *Sagars* (ponds) straddling Nepal-India border in Kapilvastu district. This was the first official record between two countries on water resources. Interestingly, this letter treats the pondage sill level issue an international border level issue. Thus, a controversy emerged from the very beginning.

3.1.1 The Sarda Barrage Treaty

The Mahakali River or Sarda/Sharda River is also called Kali Gad or Kali Ganga in Uttarakhand where the river demarcates Nepal's western border with India. This boundary was established under the Sugauli treaty in 1816.

In 1909 AD, the then British Indian government ordered a re-alignment of the boundary between the two nations and the process was completed in February 1912. Immediately after this, British India began preparatory work on the Sarda Barrage for irrigating agricultural fields of western Uttar Pradesh. The first bilateral water arrangement between Nepal and then British India, the Sarda Treaty, was concluded in 1920 for this purpose. It has been reported elsewhere that Nepal traded only 1,658 hectares of its land and in return received an equivalent area in five patches dispersed over three districts.

One important point deserves to be mentioned here that Sarda Treaty was never concluded through a joint document signed by both involved parties but it was led to fructification merely by correspondence between the British India and Nepal. So the entire correspondence between the two countries pertaining to the issue of Sarda River in 1920 itself constitutes the Treaty.

The salient features of this Sarda Treaty are:

1. Transfer of 4,093.88 acres of eastern bank of Mahakali River to India by Nepal, to facilitate the construction of Sarda Barrage.
2. In exchange, India would transfer 4,000 acres of forested land to Nepal in areas further to the east of Mahakali.
3. India would pay a sum of Rs. 50,000 to Nepal.

4. The withdrawal in wet season could be increased upto 28.34 cumecs if water were available.

To cap it all, the exact location of 4,000 acres of land, supposedly received from British India, has remained a mystery till date and nobody knows if the land was actually transferred or if transferred then where it rests. Nepal thinks that there are reasons to believe that this transfer of land never took place. Nepal was informed in 1920 that the land to be transferred to it has been identified in five patches in three districts of the United Province (presently Uttar Pradesh) namely Kheri (2914 acres), Bahraich (1114.58 acres) and Gonda (65.3). Yet in reply to a fresh inquiry by Nepal in 1980, Mr R C. Gupta, the Additional Chief Engineer, Irrigation Department, Uttar Pradesh, informed that the 4,000 acres of Bahraich district was transferred to Nepal. Thus, the overall picture is still not clear regarding the exact units of land transferred by Nepal to India and the land handed over to Nepal in lieu.

3.1.2 Tanakpur Barrage

In 1983 India completed the technical study of a 120 MW hydroelectric project on Mahakali River near Tanakpur, district Nainital, now in Uttarakhand. Nepal became concerned about the possible adverse impact of Indian project regarding Nepali land and its own Mahakali Irrigation Project and raised the matter with India. Nepal's concern was that during dry season, the proposed 120 MW power plant would have emptied tail-water into the Sarda Canal (feeding the U. P. system) and not into the river upstream of Sarda Barrage from where Mahakali Irrigation Project of Nepal receives its water. On these objections from Nepal, India agreed to redesign its project so that Nepal's existing project is not adversely affected in any manner.

India completed the construction of Tanakpur Barrage and powerhouse by 1988. During the construction of barrage, the bank cutting in Nepal from India's diversion work affected about 80 families, but they were not compensated. But the left afflux bund that was needed to tie the Barrage to the high ground on the left bank in Nepal and was yet to be constructed, as it involved Nepali land. India has earlier insisted that it was a completely Indian project within its own territory and therefore Nepal need not worry. But now it became necessary for India to request Nepal for 577-meter afflux bund to be built on Nepali land. Here the geometry of the land is such that if India tied the afflux bund to the high ground in Indian Territory, then a significant portion of Brahmdeo Mandi in Nepal would be submerged.

Later at the government level Tanakpur Agreement was signed as a Memorandum of Understanding (MOU) on 6 December 1991. Under this, left afflux bund (577 meters long) on Nepalese territory and 2.9 ha of land was provided by Nepal Government. The afflux bund is in Nepal and remains under Nepalese sovereignty.

Under this agreement, India agreed to provide Nepal 150 cusec of water from 1,000 cusecs capacity. Tanakpur head regulator was constructed for irrigating 4,000 to 5,000 hectare of land in Nepal. India also agreed to provide Nepal with 20 million units of energy annually free of charge and to construct a road link from the barrage to connect with Nepal's East West Highway at Mahendra Nagar. The provision of water and electricity by India to Nepal was seen as the *quid pro quo* to Nepal for providing India 2.9 ha of land needed to construct the afflux bund. So at the two government's level, the matter appeared to be resolved.

But there are serious issues involving rural community. It is not known about the ownership of land but the land was definitely not under the control of government of Nepal, as there is a section of population living in villages in the immediate vicinity of the afflux bund. It is still unclear whether those who made way for the afflux bund were adequately rehabilitated or their issue was overlooked over the larger bilateral water issues.

Further, the 577 meter long left afflux bund was built in Nepalese territory, so there must have been some backwater impacts, affecting the local community residing there. Was there any assessment of back-water effects and measures taken to contain or compensate these effects? For instance, in the floods of 2013/14, vast tract of lands in Nepal were submerged and severe crop losses were reported. This may become a recurring issue in future with the projected scenario of climate change in South Asia and needs to be addressed in a long-term perspective. In absence of any framework to deal with it, rural population in the affected areas will continue to suffer, leading to severe erosion or permanent loss of their livelihood. Hence these and other similar related people's issues need to be resolved at the earliest.

In 1990, with newly-found restoration of democracy and transparency, such issues gradually began to unfold to Nepali people at large. A major controversy exploded on this issue of 2.9 ha land given to India and most importantly a new provision was added in the new Constitution. Under Article 126 (2) it was mandatory for any resource-sharing agreement to be ratified by a two-third majority in Parliament, if it was of "pervasive, serious and long-term nature."

Major political tussle ensued on this issue and each party took a stand which suited it – pro- or anti-government. This matter also went to Supreme Court to decide if it was a treaty or understanding. Soon political parties made it a political tool to arouse public sentiments for coming to power. Supreme Court on 15 January 1992 decided that it was a treaty, so a fresh round of controversy began. An all-party Parliamentary Commission was formed to deal with the issue of its ratification in January 1993. Commission later that year gave report that it does not demand ratification by 2/3 majority in Parliament.

In the intervening period between 1994 and 1995, two governments fell which led to the formation of new coalition government. Due to this instability the issue remained subdued. By this time, all the parties have been overtaken by 'Tanakpur fatigue'.

On 25 January 1996, a meeting of two representatives each of the three major parties - the Nepali Congress, the UML and the RSP – agreed and signed on a document, commonly known as "National Consensus on the Use of the Waters of the Mahakali River" including the Tanakpur Barrage, Sarda Canal and other related issues.

In a nutshell, the controversy emerging from Tanakpur Agreement was merely continuation of the same old pattern which followed the Kosi and Gandak Treaties. It had a snowball effect on the political climate in Nepal and continued to polarize the political parties on the issue of water. The issue has acquired emotional overtones and reflects the kinds of problem that water resources cooperation between India-Nepal keep on recurring.

Pashupati Shamsher Jung Bahadur Rana, former Nepalese Minister of Water Resources reportedly admitted - "*both (Kosi and Gandak) agreements were revised in the mid-sixties providing Nepal with compensatory benefits. But by the time the compensatory benefits were provided the Kosi and Gandak 'sell-out' had already entered the political lexicon of Nepal, and has been the basis of several popular movements. Many Nepalese scholars recognize that Tanakpur agreements is favourable to Nepal but the higher sensitivities of the Nepalese public opinion of this legacy (of Kosi and Gandak) is nowhere reflected than on the issue of Tanakpur project which in a normal situation would have passed off without generating much controversy.*"

It was in such an unfriendly environment that stage was set for Mahakali Treaty.

3.1.3 The Mahakali Treaty

It took five years of negotiation and prolonged discussion after the Tanakpur agreement (1991), to conclude a Treaty between India and Nepal for the integrated development of Mahakali River water resources, including Sarda Barrage, Tanakpur Barrage and the Pancheshwar[1] Project. The Mahakali Treaty was signed by the foreign ministers of India and Nepal on 29 January 1996. The treaty has a life of 75 years. There are provisions for review after 10 years and independent arbitration of disputes, with the chairperson being named, if necessary, by the Secretary General of the permanent Court of Arbitration at The Hague.

But the widespread opposition to the Mahakali Treaty, as witnessed by the furore in the National Parliament of Nepal and a very successful '*band*' next day after the ratification of the Mahakali Treaty by the Parliament of Nepal, once again opened the healed wounds and raises the question whether the justice has been done to Nepal in this Treaty.

In this treaty, Nepal is considered to be winner on many accounts:

[1] India-Nepal Cooperation at http://www.wrmin.nic.in/forms/list.aspx?lid=347&Id=4

1. Augmented supply of water for irrigation.
2. Sharing of additional power generated as a result of construction of left afflux bund on Nepal's territory.
3. Additional water to meet the needs of people of Dodhara Chandni.
4. Provision of an institutional mechanism.
5. Additional water supply from Tanakpur, besides the amount of water Nepal is entitled under Sarda Agreement 1920.

Ratification of Mahakali Treaty

As has happened in the case of Tanakpur Barrage, the ratification of Mahakali Treaty resulted in ruckus inside and outside the Parliament, both. During the process of ratification 17 new points were added as a condition for ratification to apply pressure on India, almost all of these points had nothing to do with river water issues, like – Grant Nepal access to sea route, Kalapani border dispute, road links, etc. The government of the day in Nepal also came under international pressure that failure in ratification of Mahakali Treaty will send a strong signal driving away international investment in Nepal.

After many twists and turns, finally on 20 September 1996, The Mahakali Treaty was ratified close to midnight by a majority of two-thirds of the joint Upper and Lower Houses of the Nepali Parliament (whose total strength was 205 and 60, respectively). However, before the ratification of the Mahakali Treaty, the Parliament unanimously passed a stricture on the Treaty (*Sankalp Prastav*), which is binding on the Nepali Government. The ratification of the Mahakali Treaty with unanimous strictures has been interpreted that it is merely a conditional clearance. But the India's Joint Secretary of Water Resources, responding to questions from Nepali journalists regarding Sankalp Prastav, said that India was not concerned what such *Sankalp Prastav* says, instead India was concerned with only the wording of the Treaty itself.

Both the countries prepared their version of Detailed Project Report and there appears to be severe differences and reservations and a deadlock has been reached. The truth is that the suspicion and mistrust generated by Kosi, Gandak and Tanakpur (1954, 1959 and 1991) agreements have formed the *in situ* bedrock of mistrust over which subsequent Mahakali agreement has been erected.

Nepal's Concerns over Mahakali Treaty

The Mahakali Treaty ratified by the Nepalese Parliament on September 20 has stirred a debate and concern in Nepal, with a section of the country insisting that the treaty is unfavourable for Nepal. Let us look at Nepal's concerns.

Nepal's location as well as its geographical continuity with India in general and the north-south flow of Nepalese rivers in particular, forces both the countries to cooperate in harnessing water resources. The present treaty is a result of this necessity. It requires the construction of a 290 meters high dam; a reservoir capable of generating 6,000 MW of electricity and irrigating 16 lakh hectare of land in India and 40,000 hectare in Nepal.

The very first concern in Nepal is over the unequal sharing of the river's water. India receives 9,000 cusecs of water from the Sharda and Tanakpur barrages against only 1,000 cusecs that Nepal receives. As the total water available in Mahakali is 24,000 cusecs, only the remaining 14,000 cusecs is available for re-distribution (meaning that both nations get 7,000 cusecs each). This works out to 16,000 cusecs for India and only 8,000 for Nepal.

Nepal's second concern is of forfeiting its rights on its share of excess water. This problem arises because Nepal requires only 4,000 cusecs of water for irrigating 93,000 hectare of Kailali and Kanchanpur. Here, Nepal has three options: leave it in the river; lease it out on royalty; and let India use this water in return for investing more in the project.

In the first case, the excess water will ultimately reach India. And for the remaining two options there is not a single word in the treaty, though Article 3 stipulates - "The cost of the project shall be borne by the parties in proportion to the benefits accruing to them". But certainly utilising excess water of Nepal's share does not come in the purview of profits accruing from the project. From this point enshrined in treaty, emerges another concern: for an equal investment by both parties, there is an unequal share of water.

Regarding the hydro-power development from the Ganges river system, Nepal has the largest potential. The total hydro-power generation potential of Nepal is about 83,000 MW, which is equal to the combined installed hydro-electric capacity of Canada, USA and Mexico. Nepal ranks first among the countries of South and South-east Asia and Far East Asia with regard to hydropower generation. The twin Karnali-Mahakali basin alone can generate 66.50 million KW of electricity.

Despite such huge potential to generate power, Nepal has not been able to achieve this due to a scarcity of financial resources. But, Nepal is bound by the provision in the Treaty to generate just as much electricity as India will. As the Treaty's Article 3 stipulates; "The Project shall be implemented or caused to be implemented as an integrated project including power stations of equal capacity on each sides of the Mahakali River. The two power stations shall be operated in an integrated manner and the total energy generated shall be shared equally between the parties."

However, considering Nepal's power requirements, a relatively higher percentage of this power produced, will be surplus. In this regard, Article 3 further stipulates the "A portion of Nepal's share of energy shall be sold to India." The quantum of such energy and its price shall be mutually agreed upon between the parties." This particular statement leaves room for ambiguities and sows seeds bound to give rise to future controversies as it virtually forces Nepal to sell electricity to India without defining any clear principle of deciding its price. Further, Indian market for the Nepalese electricity is not guaranteed.

Where are the People?

There exist joint committees with officials from both the countries representing the committees[2]. Three such committees/commission exist viz. Joint committee on water resources (JCWR), Joint standing technical committee (JSTC) and Joint Ministerial level commission on water resources (JMCWR). Over the years, this three tier arrangement has been discussing and following these four issues which require a long term cooperation and coordination among the departments, officials and the people.

The issues in the committees:

- Implementation of Mahakali Treaty
    - Pancheshwar Multipurpose Project
    - Sill level of the Head Regulator for Nepal at Tanakpur Barrage
    - Tanakpur-Mahendranagar Link Road
    - Release of irrigation water for Chandani Dodhara Area

The above concerns reflect the national perspective of water-governance wherein inclusion of communities is totally missing. Communities and people have been mere spectators as far as decision making in the context of transboundary waters is concerned. There is no say of communities in the Treaty's operation which calls for community participation in the process of decision making. The role of community institutions and communities will be instrumental in handling issues for long term sustenance of transboundary dialogue and evolve a process by which transboundary river management favours natural involvement of representative communities. The future of river valley development in context of transboundary rivers will depend on how well such an institutional framework is nurtured and how this structure give preference to the issues of people. Sharda catchment has a large Himalayan component which means exploiting the river flows of Kali and its tributaries for power generation in the future as enshrined in the treaty also. The moment a

[2] http://www.wecs.gov.np/bilateral-minute's.php

structural addition or a change is proposed on Kali/Sharda, the Treaty comes into play. Implementation of Mahakali Treaty over a long time horizon will thus require a participative approach for enabling amicable solutions for legacy issues as well as those erupting naturally and by virtue of climate change.

3.2 Transformation in the Development Planning Approaches

There are a number of other related issues regarding the development in the Himalayan mountain region. The first and foremost among them is - how does the issue of development in the Himalayas is viewed in the government circles, among the planners, policy-makers and administrators. The fiver year plans provide an outlook of changing perceptions of development policies in the Himalayas. In the run up to development phase after the 90s, three important phases become important as far as Uttarakhand is concerned; one is the phase of its transformation into a new state entity during the 9th Five year plan into the 10th Five Year Plan [FYP] (2002-2007); the 11th FYP (2007-2012) and 12th FYP (2012-2017). Rest of the phases of development planning are provided in the annexure to this Chapter.

From 1st FYP (1951-1956) to 4th FYP (1969-1974), there was no specific attention on development of Himalayan states. During this period, Hill States and hilly areas were considered as political-administrative units and were treated as special category states whose substantial developmental outlay came from Central assistance. The Programmes implemented during the Fifth Plan period were mainly beneficiary oriented and during this plan 'hill area development programme' initiated. During the 6th plan, focus was largely on development of hilly areas based on sound principles of ecology and economics. In the 7th plan, particular emphasis was laid on the development of ecology and environment, in three phrases, namely - eco-restoration, eco-preservation and eco-development. In the 8th plan, attention was paid to modernizing the agricultural practices and promotion of small scale industries at the household, cottage and village levels. The major challenge in 9th Plan period was to devise suitable location-specific solutions, to reverse the process and ensure sustainable development of the growing population and ecology of the hill areas.

During the 10th plan a scheme for undertaking state of environment in respective states was promulgated, several state and central nodal agencies were listed to coordinate the process. For the first time, in this plan targets for the growth rate for each state, in consultation with the State Governments were specified. Uttarakhand State Council for Science and Technology, an autonomous body of the Government of Uttarakhand, Department of Science & Technology started its activities from last quarter of year 2005. however it was registered under the Registration of Societies Act, 1860 in November 2002. With the formation of Uttarakhand as a separate State, Hills Area Development Plan in UP was stopped. In the 11th plan, the following states of IHR continued to enjoy 'special category' status - Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Uttarakhand.

The objectives set for 11th plan period were ecological balance and preservation as well as creation of sustainable livelihood opportunities. It was emphasized that the district planning guidelines should be followed, and District Plans should be prepared based on the vision for the district through a participative process starting from the grass roots level.

During 11th plan period the National Action Plan on Climate Change (NAPCC) was launched which has a specific provision for a Mission for Sustaining Himalayan Ecosystem. On 27 June, then Prime Minister established a Council on Climate Change under his chairmanship to co-ordinate national action for assessment, adaptation, and mitigation of climate change. It is envisaged that the Action Plan will deal with key vulnerabilities of India to Climate Change and, in particular, the impact on water resources, forests, coastal areas, agriculture, and health.

During the 12th plan period, *National Mission for Sustaining Himalayan Ecosystem* (NMSHE) was launched with a budget outlay of Rs. 550 Crore. Amongst 8 National Missions envisaged under NAPCC, NMSHE is the only area specific mission.

Annexure I

Development Policies for Indian Himalaya Region in FYPs

I FYP-IV FYP (1951-1974)

Planning Commission was established in March 1950 for implementing Five Year Plans (FYPs). From Ist FYP (1951-1956) to IVth FYP (1969-1974), there was no specific attention on development of Himalayan states. Though earlier in 1965, National Development Council (NDC) had identified 'Designated Hill Areas.' These included hilly regions of Assam (2 districts), West Bengal (1 district), parts of Uttar Pradesh (now in Uttarakhand), Tamil Nadu and the Western Ghats.

During this period, Hill States, the hilly areas were considered as political-administrative units were treated as special category states whose substantial developmental outlay came from Central assistance. These were the States and Union Territories of the North-Eastern Region, Jammu & Kashmir, and Himachal Pradesh. For the integrated development of Hill States and Union Territories of North-East Region, North Eastern Council was constituted by an act of Parliament in 1971.

V FYP (1974-1979)

During the first three years of plan (1974-77) Center provided Rs 76 Crore and concerned states contributed Rs. 68 Crore. The North Eastern Council started functioning from this plan by invoking Hill Area Development Program (HADP) and it can be said the beginning of dedicated development program for the mountain regions. The Programmes implemented during the Fifth Plan period were mainly beneficiary oriented.

VI FYP (1980-1985)

Realizing that this course of development has led to uneven economic growth and needs course correction so specific targeted programmes were designed for certain geographical areas with special ecological and socio-cultural features, for example, hilly areas of the country. It was also realized that the development of hilly areas has to be done hand-in-hand with the adjoining plains, with which their economy is closely inter-related. At the same time, development must proceed in a manner not to irreversibly damage the ecosystem which needs to be preserved in a suitable condition for future generation. Hence, development of hilly areas should be based on sound principles of ecology and economics.

Main thrust of Vth and VIth FYPs was on development of infrastructural facilities and social and community services. In the Sixth Five Year Plan emphasis shifted to eco-development.

VII FYP and Annual Plans (1985-1990; 1990-1991 and 1991-1992)

The need to conserve hilly areas (Himalayan and Western Ghat Regions) in national policies and programmes arose from the fact that they provide life-giving natural resources but have sensitive and fragile ecosystems. By this time HDP had entered in a crucial phase, especially w. r. t. complementarities between interests of hills and plains. Thus HADP now has a guiding principle - promotion of a secure, basic life-support system, and judicious utilization of land, mineral, water and biotic resources in a holistic manner embracing the inter-twined interests of both the hills and the plains. The strategy was focused around the active participation of the people, particularly of women, in the fulfillment of their basic needs.

Special category treatment was given to states of North-Eastern region, Jammu and Kashmir, Sikkim, and Himachal Pradesh whereas remaining IHR areas continued to be covered by HADP. In addition to normal funds, Special Central Assistance (SCA) was also being provided for the HADP. In this plan, particular emphasis was laid on the development of ecology and environment, in three phrases, namely - eco-restoration, eco-preservation and eco-development.

VIII FYP (1992-1997)

HADP continued in this plan period with basic objective of socio-economic development of the hills and of the people living there, to make progress in harmony with the ecological development of the area. The programmes (under HADP) aimed at promoting the basic life support systems with sustainable use of the natural resources. In this plan attention was paid to modernizing the agricultural practices and promotion of small scale industries at the household, cottage and village levels.

During this plan, HADP was provided with Rs. 1,450 Crore out of it Rs.4.67 Crore per annum as additional grant for Darjeeling were set aside. Remaining amount was distributed in the ratio of 87:14 between 'Designated Hill Districts' and 'Designated Talukas of Western Ghats', respectively. Budget for NEC was increased from Rs. 675 Crore to Rs.1,160 Crore in this plan.

IX FYP (1997-2002)

In preceding 4 FYPs substantial efforts and resources were provided in hill states but the achievements were not commensurate to it, despite providing Special Central Assistance under HADP and formulating Special Plan Strategies and Schemes drawn up by the State Governments. The major challenge in this Plan period was to devise suitable location-specific solutions, to reverse the process and ensure sustainable development of the growing population and ecology of the hill areas. To meet this challenge, eco-preservation and eco-restoration were seen as twin objective of programme, taking into consideration the ecological degradation of hill areas and subsequent impact on the economy and ecology of the hill as well as plains. The preservation of biodiversity and rejuvenation of the hill ecology was given emphasis in the developmental schemes. This perspective was also amalgamated in HADP whose basic objective was socio-economic development.

During this plan, thrust was given to –

(i) Eco-restoration and Eco-preservation,
(ii) Involvement of the local population,
(iii) Gender sensitive planning,
(iv) Use of appropriate technology,
(v) Redevelopment of traditional agro-ecosystems based on traditional knowledge and technology,
(vi) Scientific approach to agriculture, animal husbandry and horticulture in order to raise productivity, and,
(vii) Development of ecologically sustainable industries and tourism.

In this plan period, strategy for the programme was based on a two-pronged approach - Sub-Plan Approach (since Vth FYP) and Integrated Watershed Approach to be followed in HADP areas.

During this plan, Prime Minister announced in October 1996 at Guwahati, regarding earmarking and spending at least 10% of their annual gross budgetary allocation by all development Ministries/Departments in the Union Government to support for the Plan for specific programmes in the North-Eastern region. Annually more than Rs. 5,000 Crore was expected under this initiative by various ministries for the NE region.

X FYP (2002-2007)

For the first time, plan targets for the growth rate for each state, in consultation with the State Governments were specified. From here onwards the development planning in the NER gained momentum with a separate approach outlined for the NER while for approaches setup for the Tenth Plan for the Special Area Development Programmes for Hill areas, Western Ghats, border areas and the KBK region of Orissa continued to function in similar way. Formation of Uttarakhand as a separate State, HADP in UP was stopped. Designated Hill Areas under HADP include 2 hill districts of Assam (North Cachar and Dima Hassao), Darjeeling district of West Bengal.

A Department of North East Region (DONER) was established in 2001, as a lead department in the Government of India to create synergy and ensure convergence of programmes by coordinating the efforts of Central agencies and the State Governments to meet last mile resource needs for completion of projects.

DONER was upgraded as Ministry in 2004. Ministry of DONER, as it is commonly known, is a unique Ministry in the Union Government as its activities are regional and particularly focused towards advocating the special needs of the region to the other Ministries/Departments and the policy makers. In 2002, Sikkim was also included in NEC, by an amendment, and the Council was designated as the status of Regional Planning Body. NEC, since its inception, has invested Rs 7,182.61 Crore till the end of the Tenth Plan. Special Area Programmes and same objectives of HADP continued herein. As per the Tenth Plan, provisions the State Governments could use up to 15 per cent of the annual allocation for maintenance of assets in HADP areas.

XI FYP (2007-2012)

The following states of IHR continued to enjoy as Special Category States - Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Uttarakhand. Assam was an addition being the part of NER. The utilization of the 10 per cent mandatory earmarked funds by the Central Ministries for NER had gone up from 80.8% till the Tenth Plan to 89.7% in the first four years of the XI FYP.

Connectivity was considered as the key area for the development of NER. As per the recommendations by the Task Force (set up by the Planning Commission) -

- A special thrust was given to transport infrastructure,
- High priority was accorded for converting the Meter Gauge (MG) network to Broad Gauge (BG)

- To provide rail link to all State capitals of north-eastern region,
- Construction of three greenfield airports at Pakyong in Sikkim, Itanagar in Arunachal Pradesh and Cheithu in Kohima was taken up on priority,
- Important airports were proposed to be modernized.

In order to harness the potential of inland water and the River Brahmaputra as a mode of transport, fully functional National Waterway to provide trunk route connectivity to the region was emphasized.

HADP continued in the XI plan period with renewed vigour. Evaluation studies to assess the efficacy of HADP had shown that the outcome of these programmes are visible in the form of increase in the level of the water table, preservation of forest area, increase in irrigated area, decrease in fallow land, increase in income, and so on.

The objectives set for 11th plan period were ecological balance and preservation as well as creation of sustainable livelihood opportunities. It was emphasized that the district planning guidelines should be followed, and District Plans should be prepared based on the vision for the district through a participative process starting from the grass roots level.

During 11th plan period the National Action Plan on Climate Change (NAPCC) was launched which has a specific provision for a Mission for Sustaining Himalayan Ecosystem. On 27 June, then Prime Minister established a Council on Climate Change under his chairmanship to co-ordinate national action for assessment, adaptation, and mitigation of climate change. It is envisaged that the Action Plan will deal with key vulnerabilities of India to Climate Change and, in particular, the impact on water resources, forests, coastal areas, agriculture, and health.

XII FYP (2012-2017)

In February 2014, *National Mission for Sustaining Himalayan Ecosystem* (NMSHE) was launched with a budget outlay of Rs. 550 Crore. Amongst 8 National Missions envisaged under NAPCC, NMSHE is the only area specific mission.

According to the assessment made by MO DONER, by the end of XI Plan, the Central Ministries/Departments are likely to spend Rs 75,000 Crore in the north-east region, against total earmarked outlay of Rs 87,502.97 Crore. This plan continued with emphasis on the development of physical and social infrastructure so that the region can become strong, confident and capable of engaging with external market. Critical areas identified for interventions in the north-eastern region include road, railways, airways, and power.

Increased support of multilateral agencies for development in the North Eastern Region is seen in the launch of North Eastern Region Urban Development Programme with the assistance of the Asian Development Bank (ADB), at a cost of Rs. 1371.4 Crore. This programme provides support for three priority urban services (Water Supply, Sewerage and Sanitation, and Solid Waste Management) in the capital cities of five NE States - Nagaland, Meghalaya, Mizoram, Sikkim, and Tripura. In the XII plan period, these urban services have been taken under the JURUM initiative.

In addition to it, from time to time, Central government has constituted many Task Force, Working Groups, Expert Group, Committees, and Commissions whose recommendations were also clubbed in the ongoing work and schemes in IHR region.

Now, the Planning Commission has ceased to exist and one really doesn't know if the process adopted earlier as enshrined in planning commission will continue or another deviation will be made. So far, Niti Ayog had not come out with a clear vision of Himalayas.

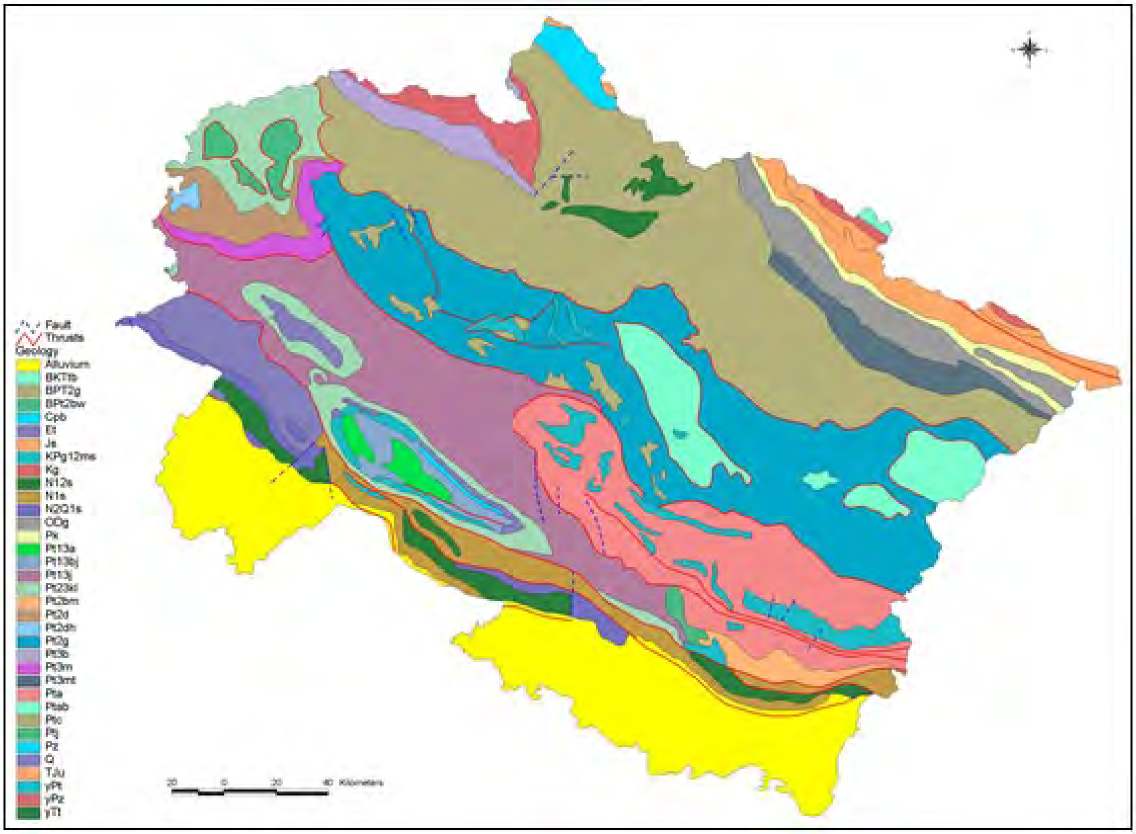
4

Contents

4. GEOLOGY, SEISMICITY, AND HYDROLOGY

Geologically, the Uttarakhand Himalayas is divided into five major regions viz. Trans Himalayas, Higher Himalayas, Lower Himalayas, Shivalik Himalayas, Bhabbar & Tarai. Different geological/lithological formations of Uttarakhand are shown in the geological map of Uttarakhand.

Figure 1 - Geological Map of Uttarakhand



Source: Government of Uttarakhand

4.1 Indian-Eurasian Plates Collision & Formation of Himalayas

The Himalayas are often called as 'living mountains' as they are increasing in height from a few mm to many cm throughout their length, owing to ongoing geological process of collision/subduction between Indian and Eurasian plate.

During pre-Cretaceous times Indian plate started moving towards the Eurasian mainland and by Late Cretaceous the two continents had moved closer to each other and the slippery sea floor beneath the Asian Plate resulted in the formation of deep oceanic trench. During this period materials resulted from the converging continents, preponderantly from the Indian Plate were deposited in the deep trench. The convergence of continents continued till India plate was resisted by Eurasian land mass.

The north-western portion of the Indian plate docked with the north-western portion of the Eurasian plate and became part of the Eurasian land mass. Due to immense pressure created between the contacting zones, the rocks of the Eurasian n plate were pushed against the Indian continental margin. The fossils found in the sedimentary rock within the contact zone along the Indian continental margin indicate a timeline of sixty-five Ma (Beck et al., 1995) for the collision to complete and became part of the Eurasian land mass. This collision eventually resulted in the massive upliftment of landmass in the form of Himalayas.

This collision activity was completed in three distinct phases –

i. Suturing between Kohistan arc (then part of Eurasian plate) and Karakoram micro plate of Asia margin in the Middle Cretaceous,

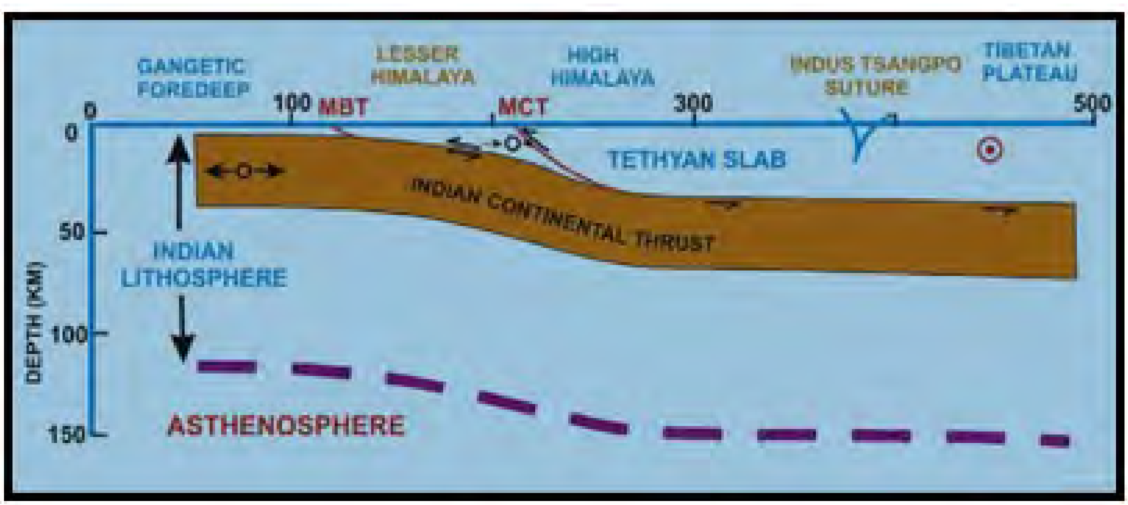
ii. Collision of north-western tip of the Indian Plate with the Kohistan-Karakoram in the Palaeocene, and

iii. Oblique collision between the western margins of Indian Plate in the Late Eocene to Early Oligocene (Zaman et al., 1999)

Interestingly, the speed of northward moving India at the rate 180-195 mm/ yr. suddenly slowed down to 45 mm/yr. at 55 Ma, implying the resistance that the fast-moving Indian Plate had encountered due to its collision with Asia (Klootwijk et al., 1992). Based on global Paleo-magnetic data, it is inferred that the rate of northward moving India abruptly decreased at 57±3 Ma, corresponding to the time when India collided with Asia (Acton, 1999). The various researches conclude it took nearly 8 to 10 million years during the Mesozoic-Tertiary transition period for the complete amalgamation of India with Asia.

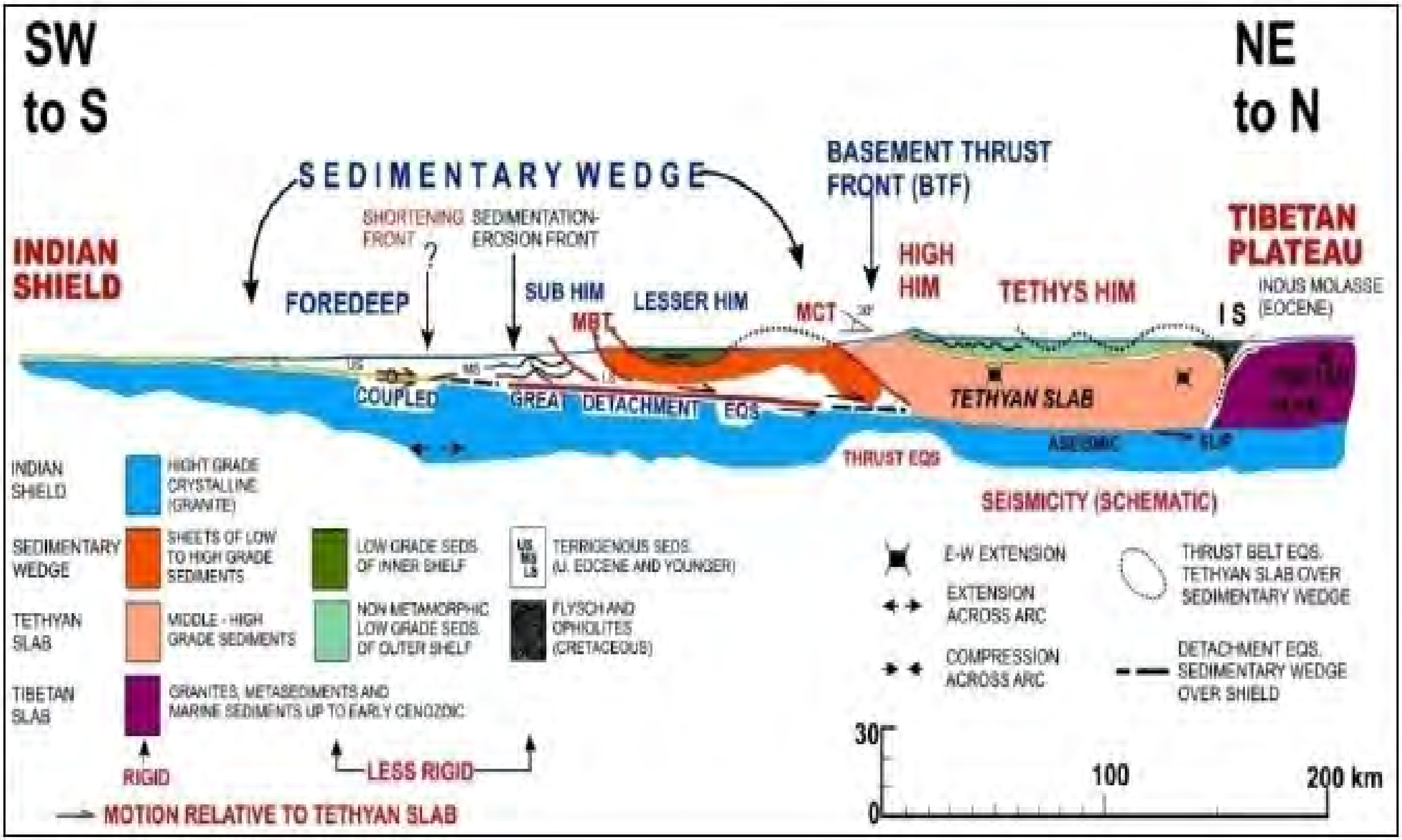
Two types of models – evolutionary and static state – have been proposed for the Himalayas, as shown below. The evolutionary model of Ni and Barazangi (1984) postulates that the zone of plate convergence has progressively shifted south by formation of intra-crustal thrusts. It hypothesizes that the MBT (Main Boundary Thrust) is the most tectonic surface and that seismicity is concentrated in a 50 km wide zone between the MBT and MCT (Main Central Thrust), shown in figure 2. This model suggests that the rupture of the Great Himalayan earthquakes may have started in the inter-plate thrust zone, which propagated south along the detachment to the MBT and further south to the subsidiary blind thrusts, making MBT the most active thrust rooted in the detachment.

Figure 2 - Evolutionary Tectonic Model of Himalayas



Source: Ni and Barazangi (1984)

Figure 3 Steady State Tectonic Model of Himalayas



Source: Seeber and Armbruster (1981)

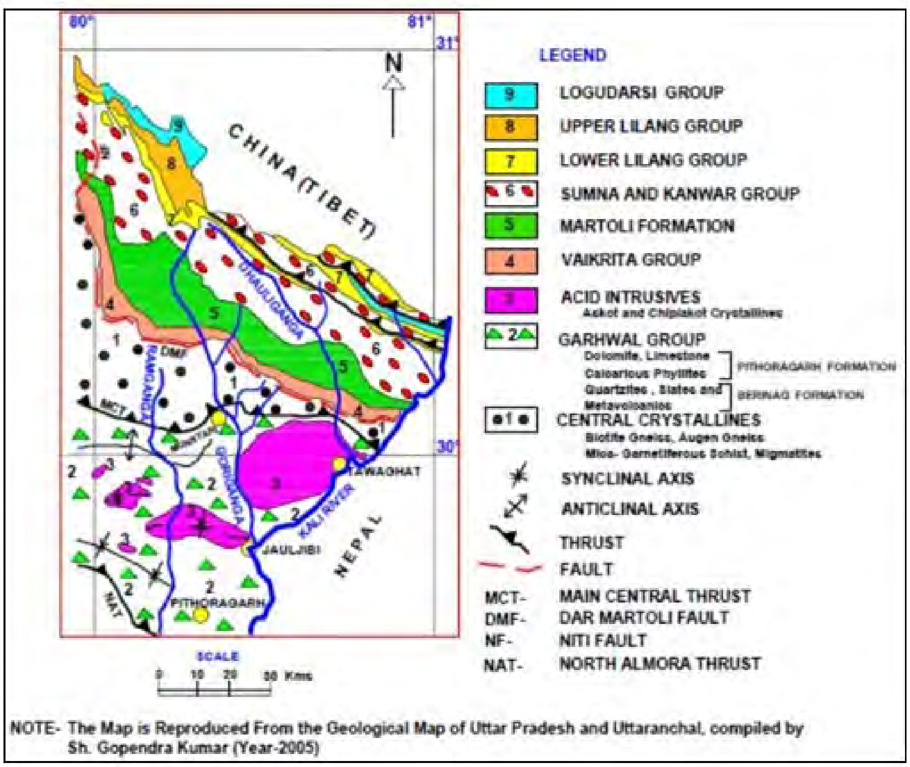
The steady state model (Seeber and Armbruster, 1981, figure 3) postulates that the active low angle contemporary thrusts i.e., main Central thrust (MCT) and Main Boundary Thrust (MBT), converge with the plain of detachment, which marks the interface between the sub-ducting Indian Slab and overlying sedimentary wedge. Part of the shallow dipping detachment surface is considered as basement thrust where the MCT merges with the detachment surface. According to this model, the great Himalayan earthquakes are related to the detachment surface.

Both the models have determined that the seismicity in the Himalaya is the manifestation of the ongoing geo-tectonic process and is discussed in the next section but before that a brief commentary will be relevant on how the geologic features have determined the geomorphology in the Himalayas, and geological evidence of continued neo-tectonic activities in the study area.

4.2 Geologic Controls over Geomorphology

Himalayan physiographic divisions show severe contrasts in terms of geologic and climatic controls, from the terai to the snow clad mountains on the top. The geomorphic landscape is essentially controlled by synclinal valleys within the hill ranges. Subsequently shaped by linear stream erosion parallel to tectonic grain of the structural ranges. Valley floors contain fluvioglacial outwash materials as seen in Korala-Ladhiya section and often form eorsional terraces due to entrenchment of longitudinal streams. The mountain ranges show a deep dissection by transverse drainage system. The individual ridges are not continuous and are frequently dissected by deeply entrenched transverse streams. Surface texture is characterised by subangulate-subdendritic drainage pattern. Essentially a denuded tectonic mountain rane with imprints of NW-SE tectonic grain. Subsequent fluvial and glacial erosion are guided by tectonic planes and retains the mountain topography regardless of intensity of linear stream erosion (figure 4).

Figure 4 - Fluvial and glacial erosion are guided by tectonic plane



Source: GSI Report

The Goriganga and Dhauliganga Valleys[1]

The Central Crystallines represent the oldest rocks exposed in Higher Himalayas and consist of gneisses, migmatites, psamitic and mica gneiss, calc gneiss, quartzite, marble mica schist and amphibolite. The MCT is a north-northeasterly dipping major tectonic plane in Kumaon region defining the northern tectonic limit of sedimentation of the Garhwal Group with the Central Crystallines. It marks the position of the MCT north of Dharchula in the Mahakali valley and north of Munsyari in the Goriganga valley in Kumaon region. Another major plane of dislocation exposed in Mahakali valley near Dar separates the Dar Formation from the Central Crystallines. It is traced to south of Martoli and named as Dar Martoli fault. It is traceable to Dhauliganga valley at Matoli where it is offset by Matoli fault.

The Saryu and Ladhiya Valley in Pithoragrh

The sequence of Garhwal Group comprises shale, slate, phyllite, quartzite, dolomite, limestone, magnesite, occasional calc slate and metavolcanics. The rocks of Garhwal group are represented by Rautgara, Pithoragarh and Berinag formation. The Rautgara Formation is represented by brownish fine grained quartzite interbedded with purple green mottled slate and calcareous phyllite in Sarju valley in Kumaon region. The Pithoragarh Formation is divisible into lower and upper members. The Lower member comprises stromatolite bearing dolomitic limestone, calcareous phyllite, quartzite and marble. The Upper member consists of dark grey calcareous slate and limestone. Berinag Formation (Nagnithank Formation) comprises quartzite interbedded with metavolcanics, gneisses and slate.

The Chiplakot and Askot Crystallines exposed in the study area are granitoid intrusives in the Garhwal Group. It comprises biotite granite gneiss of two different ages, the older intrusive dating 1900 Ma and other 1200 Ma. These two phases of acid magmatism are not clearly differentiated. The older includes the Chiplakot and Askot Crystallines. The Askot Crystallines forms a doubly plunging synform with its western closure near Berinag and eastern closure near Askot. It's in the form of a klippe, surrounded by younger quartzites of Berinag Formation.

In the outer Himalayan setting, Chalthi and nearby area is a critical place falling in a zone of intense shearing and shattering where two major thrust, viz. Ramgarh Thrust (Ladhia Thrust) and Main Boundary Thrust traverse adjacent to each other. Geologically, Chalthi is situated between the Siwaliks (sandstone) in the south and Nagthat quartzite towards north. Due to closeness of these two major thrust systems, tectonically the area is unstable and also prone to landslide and subsequent erosion. As the rocks are disturbed and fragile, voluminous amounts of consolidated and unconsolidated rock material are being transported downstream in the form of debris flow. River bed mining is also noticed in this region (see picture below).

[1] The explanation on the geological formations in the basin is described valleywise from the references taken from the Geological Suvery of India.

Flooding of the river channel with gravels is very common scenario in the Bisoria gad (a tributary of Ladhiya river). During the rainy season increased discharge causes huge amount of unconsolidated to consolidated material transport in the form of mud/debris flow and many a times impounds the river channel modifying landforms.

The two arrows show sliding and loose material flowing over hill slopes abutting River Ladhiya (2014). Also notice the river meanders indicating past and present tectonics

The increase in volume of sliding is clearly visible in 2016 (see arrows)

Naulapani – Geomorphologically, this belt shows signatures of intense shearing and faulting – here Ladhiya Thrust and MBT traverse adjacant to each other.

Debri flow into Ladhiya near Reetha Village located in Valley

A planer view from Google Earth showing Reetha

4.3 Geological Evidence of Continued Neo-tectonic Activities

I. Activation of Faults

Regarding the activation of faults, a universally accepted definition evolved by the California Geological Survey, will be relevant here. According to it, an active fault is defined as a fault that has had surface displacement within Holocene time (approximately the last 11,000 years). Sufficiently active is also used to describe a fault if there is some evidence that Holocene surface displacement occurred on one or more of its segments or branches.

A potentially active fault is a fault that has shown evidence of surface displacement during the last 1.6 million (16 lakh) years, unless direct geologic evidence demonstrates inactivity for the last 11,000 years or longer. This definition implies that faults lacking evidence of surface displacement are necessarily inactive.

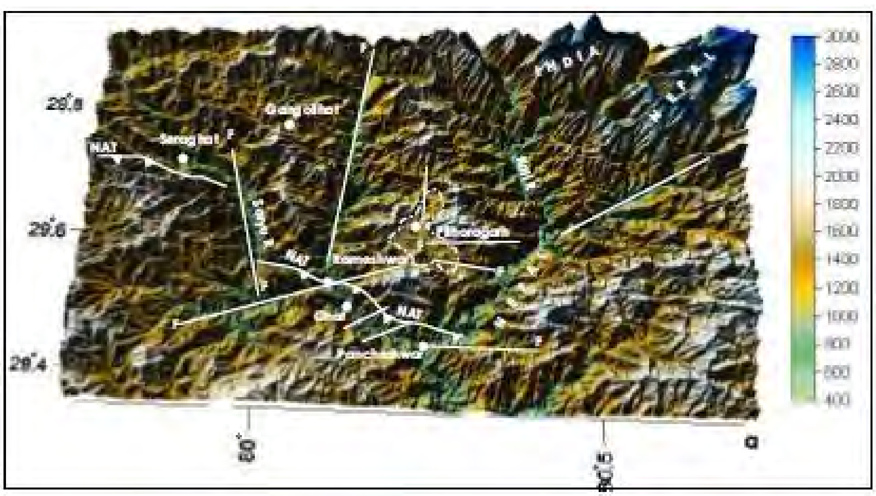
II. Significance of North Almora Thrust (NAT)

In his doctoral thesis titled "*Quaternary Reactivation of North Almora Thrust in Central Kumaun: Implication to Neo-tectonic Rejuvenation, Lesser Himalaya, Uttarakhand (2007)*" Kumaun University, Nainital, Uttarakhand, Girish Chandra Kotyari has discussed in detail the implications of reactivation of North Almora Thrust. In a recent research paper [(Possibility of Induced Seismicity in Pancheshwar Dam Site on Kali River, Uttarakhand), published in International Journal of Engineering Research & Technology (IJERT), Volume 4, Issue 12, December 2015], Suman Rawat and Girish Chandra Kotyari, have expressed apprehension of RIS after completion of Pancheshwar dam.

Let us briefly look at the critical geological evidence on which this inference is based.

- The geomorphological and seismic evidence near North West of the confluence of Saryu and Kali at Pancheshwar on Kali River in Kumaun Lesser Himalaya suggests influence of neo-tectonics along imbricated zone of high-angle North Almora Thrust (NAT) dipping towards South West.
- The NAT zone represents the deformed northern margin of Almora nappe. It separates the granite gneisses of Almora crystallines from the quartzites and slates of Lesser Himalayan sequence.
- Region shows earthquakes swarm with strongest event of M=6-7.5 in the years of 1966 and 1974. The seismicity of M≥ 3.5 is being continuously recorded till very recently.
- The region has not experienced any major earthquake since 1974. A prominent seismically active linear segment is noticed near NW of study area.
- The chlorite-sericite schist developed within shear zones may accommodate the on-going convergence of Indian plate towards Himalaya in the form of shear strain in the subsurface region.
- This accumulated strain may cause gravity collapse along steeply dipping shear planes. Thus the reservoir-induced seismicity may be one of the consequences of active deformation prevailing in the region.

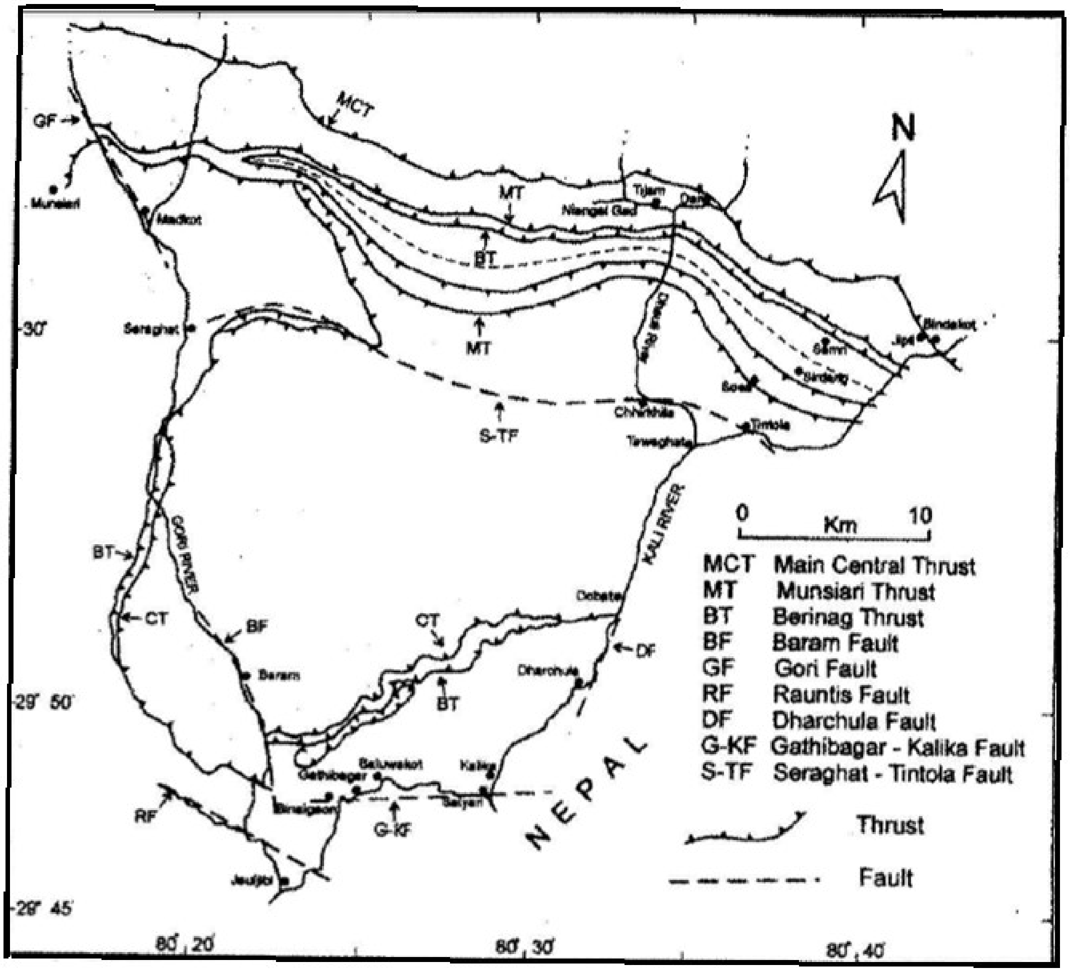
Figure 5 - Digital Elevation Model of eastern Kumaun Lesser Himalaya shows development of geomorphic features and traces of North Almora Thrust



III. Other Field Evidence

The existence of numerous active faults and thrusts in the Mahakali sub-basin is an ever-persisting threat as these triggers have potential to induce landslides and or seismic event or RIS. Many of the faults and thrusts, namely Rauntis fault (above Jauljibi across Rauntis gad), Gori fault (from Gathibagar to Kalika), Berinag thrust which joins Baram fault, and others fall in the Mahakali river basin.

Figure 6 - Network of faults and thrusts between Kali and Gori Valley



The north-eastern Kumaun part of the Kumaun Lesser Himalaya is seismo-tectonically one of the most active segments of the central Himalaya. The major as well as minor thrust and faults in Dharchula and its environs are neo-tectonically quite active and as such their movements have made this region vulnerable to landslides. The recent tectonic movements along these thrusts and faults are expressed in the geomorphic rejuvenation of the terrain such as entrenched meandering, river courses characterized by deep gorges, unusual widening of the river valleys, formation of palaeo-lakes, deflection of rivers, and offsetting of the river terraces. Abrupt deflection of the Kali river course from general flow-direction, i.e. NNE-SSW to EW is observed, which reflects the rejuvenated movements of the faults. Reactivation of the faults has resulted in the formation of six levels of terraces in Gatibagar (figure7). Relicts of lacustrine deposits formed due to abrupt changes in the drainage regime are also observed along Jauljibi-Dharchula section.

Figure 7 - Formation of six levels of terraces of local extent in Gatibagar area

Mud deposits of about 80 cm thickness is observed in the terrace T 2 that indicates deposition of T 2 in a shifting depositional environment. Deposition of mud is a sign of temporary stagnancy of the fluvial phase leading to suspended deposition. This abrupt change in the deposition is influenced by tectonic activities, which is corroborated by two field evidence. First, Himalayan rivers have high flow gradients and resulting pattern s of deposition. Second, the mud layer is tilted 90 towards NE, again suggesting a tectonic event that caused the de-confinement of the ponded river (figure 8).

Figure 8 - Mud deposits in between terrace T 2 exposed at Jauljibi-Dharchula road

Sarda River flows in a deep gorge, enroute Nagrughat

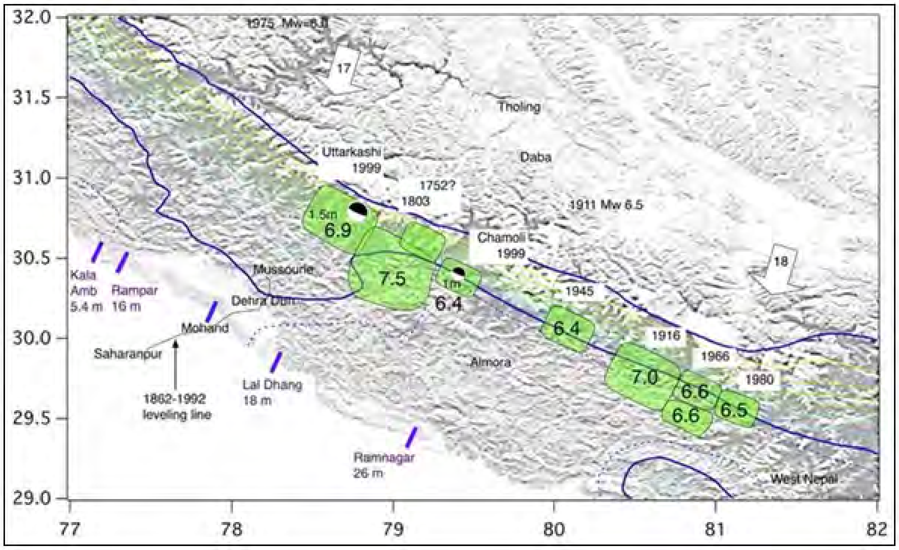
4.4 Neo-tectonic Activities and The Seismic Gap

Bilham et al have made detailed analysis based on their personal work and from the results of several studies on the implications of the elastic energy storage post Gorkha earthquake and other incomplete ruptures. This has great significance to any significant structural change and any attempt to gloss over the hard evidence can be disastrous. Bilham et al state in the discussion on the segment "Attempts to quantify these relations directly from the measured dip of the MHT near the decoupling zone are challenging because insufficient precise dip data are available along the arc, and because those that are available from focal-mechanism solutions sample the diversity of mechanisms discussed by Mugnier et al. (2013). Attempts to test this relation against the maximum slip observed in paleo-seismic trenches using the published inter-seismic decoupling-width of Stevens and Avouac (2015) and assumptions about uniform strain at failure, in general, indicate that observed paleo-seismic slip is much larger than anticipated from the mapped width of the inter-seismic decoupling zone, but this could arise as a consequence of the presence of incomplete ruptures in the Himalaya. A specific example is the region between 78.5° E and 81.5° E where paleo-seismic trenches record maximum co-seismic slips of 18 - 26 m, and where we predict slips of 1 -5 m.

The continued rupture of the 79° E 82 ° E segment in moderate earthquakes, and the absence of creep processes to remove it, with one caveat, must therefore result in the incremental growth of a mid-decollement, heterogeneous reservoir of stored elastic strain. The caveat is that many minor earthquakes rupture steep reverse faults that release strain to the free surface above the decollement (Kayal, 2001). That these are insignificant in the long term comes from the approximate equality between geological advance over the Indian plate and present day geodetic convergence rates in the Himalaya (Lyon Caen and Molnar, 1985; Wesnousky et al., 1999; Lave and Avouac, 2001; Stevens and Avouac, 2016). In the same way that the Gorkha earthquake, and presumably the 1833 earthquake before it, have incremented the strainfield in mid-decollement near Kathmandu (Mencin et al., 2016), we envisage that numerous modest earthquakes with shallow dip in the Dehra

Dun/Almora segment have incremented strain on the decollement near and north of these cities awaiting a future triggering event that will permit wholesale rupture to the MFT."

Figure 9 - Implications for elastic energy storage in the Himalaya from the Gorkha 2015 earthquake and other incomplete ruptures of the Main Himalayan Thrust



Source: Roger Bilham, David Mencin Rebecca Bendick, Roland Bürgmann, Quaternary International 462 (2017) 3 - 21

Geomorphological features of active tectonics and ongoing seismicity of north-eastern Kumaun Himalaya in Uttarakhand is shown in the figure 9.

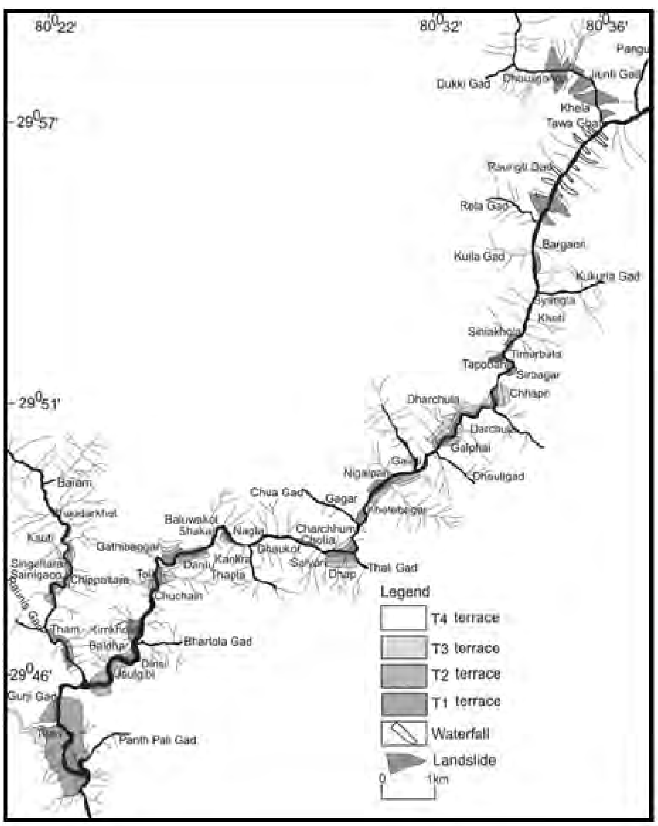


Figure 10 - Geomorphological features of active tectonics and ongoing seismicity of NE Kumaun

Source: https://www.researchgate.net/publication/281833598_Geomorphological_features_of_active_tectonics_and_ongoing_seismicity_of_northeastern_Kumaun_Himalaya_Uttarakhand_India_Vivekanand_Pathak1_Charu_C_Pant_and_Gopal_Singh_Darmwal

[accessed Dec 29 2017]

4.5 Seismicity

As per earthquake zoning map of India (figure 11), the entire state can be divided into two zones, i.e. Zone V and Zone IV. The State has experienced many earthquakes of small and large scale with their epicentres located within the Himalayan region. These earthquakes have demonstrated that the seismic vulnerability of the building stocks in the region is primarily responsible for a large number of human casualties. The State has witnessed two major earthquakes in the recent past i.e. the Uttarkashi earthquake in 1991 and the Chamoli earthquake in 1999. About 768 people died in Uttarkashi and 106 died in Chamoli earthquake. The districts of Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi, which were most severally affected in the 2013 flash flood, also fall within the Seismic Zone V.

As shown in the map four of the thirteen districts of the state (Pitthoragarh, Chamoli, Bageshwar and Rudraprayag) fall completely in Zone V (representing damage risk of ≥ IX on MSK[2] scale), while five other districts (Uttarkashi, Tehri-Garhwal, Pauri, Almora and Champawat) fall partially in Zone V and partially in Zone IV (damage risk of VIII on MSK scale) and the rest (Dehradun, Haridwar, Nainital and Udham Singh Nagar) fall totally in Zone IV (of the seismic risk map of India).

The vulnerability of the region to earthquakes is characterized by the fact that during the last century, the region had experienced 11 earthquakes of magnitude greater than 6.0 on the Richter scale. A number of earthquakes in the Mahakali River Basin have also been recorded (figure 12). As per IMD, there have been 65 earthquakes of varying intensity since 1803 (table 1).

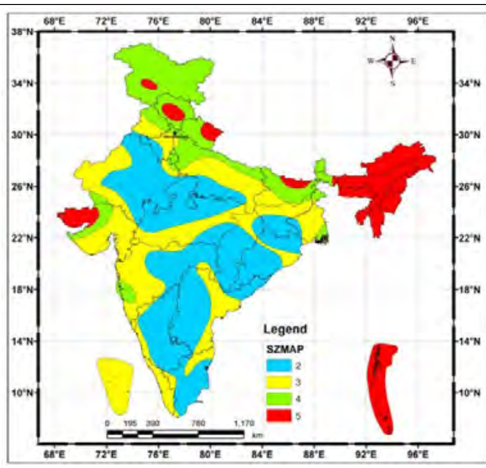


Figure 11 - Earthquake Zoning Map of India
Source: Bureau of Indian Standard, Government of India

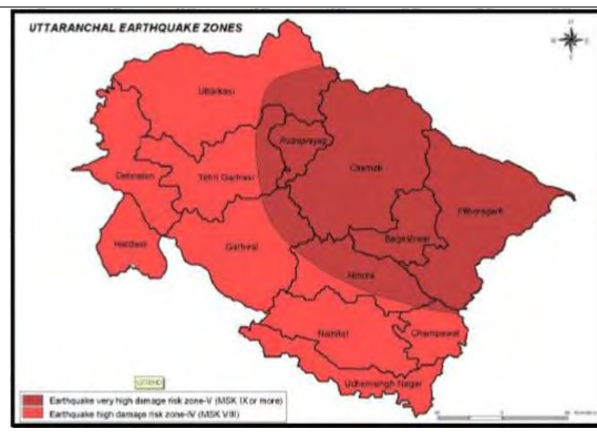


Figure 12 - Earthquake Zones in Uttarakhand
Dark shade representing very high damage risk zone-V (MSK IX or more)
Source: Uttarakhand National Disaster Risk Reduction Portal

Table 1 Earthquakes in Uttarakhand

S N	Date of occurrence	Magnitude	Affected area
1.	1st September 1803	9.0	Badrinath
2.	1809	9.0	Garhwal
3.	26 May 1816	7.0	Gangotri
4.	25 July 1869	6.0	Nainital
5.	28 October 1916	7.5	Dharchula
6.	28 October 1937	8.0	Dehradun
7.	27 July 1966	6.3	Kapkot, Dharchula

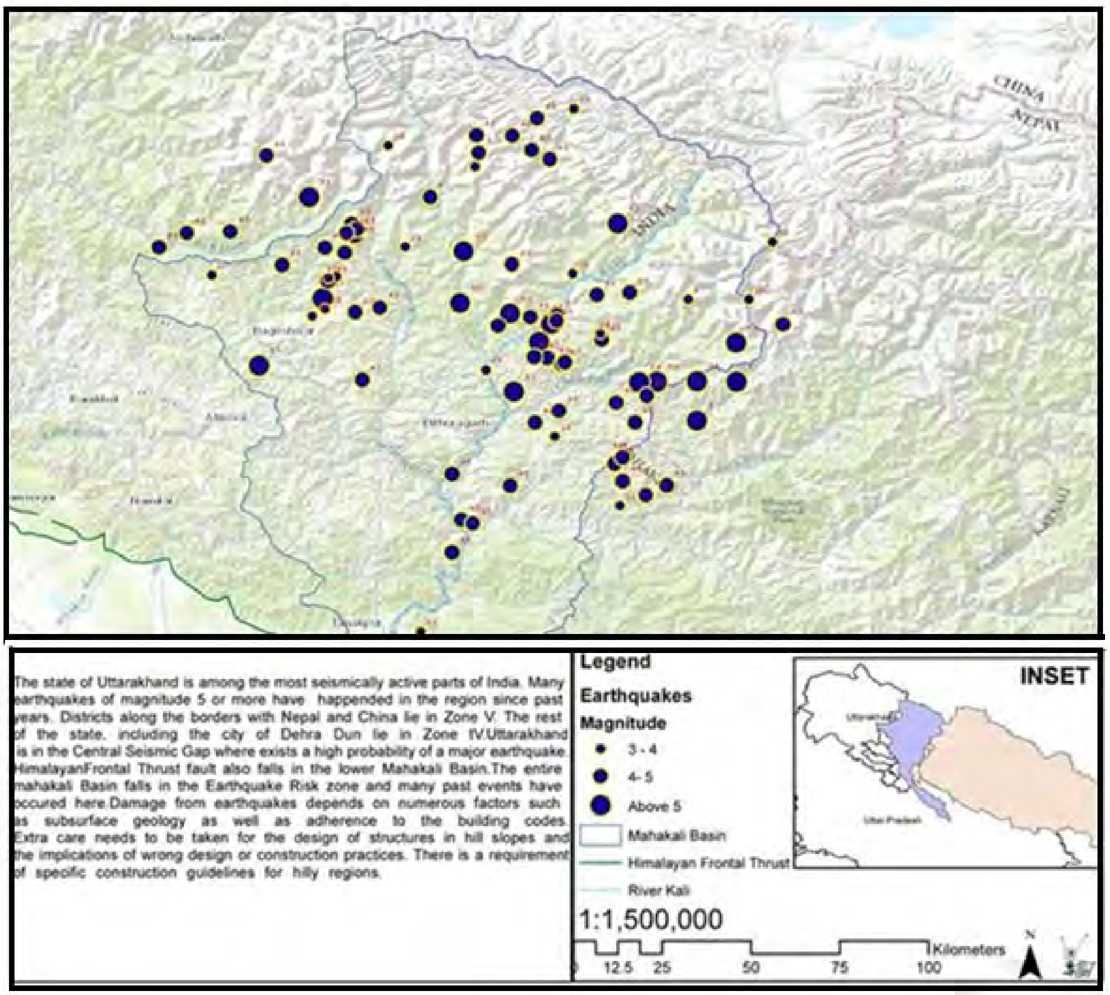
2 Medvedev–Sponheuer–Karnik scale, also known as the MSK or MSK-64, is a macro seismic intensity scale used to evaluate the severity of ground shaking, on the basis of observed effects in an area of the earthquake occurrence.

S N	Date of occurrence	Magnitude	Affected area
8.	28August 1968	7.0	Dharchula
9.	29 July 1980	6.5	Dharchula
10.	20 October 1991	6.6	Uttarkashi
11.	29 March 1999	6.8	Chamoli
12.	1 February /2006	5.2	Indo - China Border
13.	14 March 2006	5.0	Indo - China Border
14	27 October 2006	3.8	Bageshwar
15	31 March 20006	3.1	Chamoli
16	5 August 2006	5.0	Indo - Nepal Border
17	26 September 2006	4.1	Indo - Nepal Border
18	27 October 2006	3.8	Bageshwar
19	5 February 2007	3.5	Indo - Nepal Border
20	27 March 2007	3.2	Uttarkashi
21	22 July 2007	5.0	Uttarkashi
22	7 August 2007	3.5	Uttarkashi
23	3 November 2007	2.7	Uttarkashi
24	25 January 2008	3.5	Rudraprayag
25	13 August 2008	3.6	Bageshwar
26	4 September 2008	5.1	Indo –Tibet Border
27	25 February 2009	3.7	Uttarakhand
28	18 March 2009	3.3	Uttarkashi
29	15 May 2009	4.5	Chamoli
30	27 August 2009	3.9	Uttarakhand
31	18 September 2009	3.4	Uttarakhand
32	21 September 2009	4.7	Uttarkashi
33	3 October 2009	4.3	Bageshwar
34	11 January 2010	3.9	Pithoragarh
35	22 February 2010	4.7	Bageshwar
36	3 May 2010	3.5	Uttarakhand
37	31 May 2010	3.6	Almora
38	22 June 2010	4.7	Pitthoragarh
39	10 July 2010	4.1	Almora
40	14 March 2011	3.3	Chamoli
41	20 June 2011	4.6	Chamoli
42	24 June 2011	3.2	Indo – Nepal Border
36	3 May 2010	3.5	Uttarakhand
37	31 May 2010	3.6	Almora
38	22 June 2010	4.7	Pitthoragarh
39	10 July 2010	4.1	Almora
40	14 March 2011	3.3	Chamoli
41	20 June 2011	4.6	Chamoli
42	24 June 2011	3.2	Indo – Nepal Border
43	4 July 2011	3.4	Chamoli & Almora
44	21 September 2011	3.1	Uttarkashi
45	24 September 2011	3.0	Uttarkashi
46	6 September 2011	3.8	Indo - China Border
47	20 November 2011	3.2	Uttarkashi
48	14 December 2011	3.2	Chamoli
49	9 February 2012	5.0	Uttarkashi
50	10 May 2012	3.9	Chamoli
51	1 June 2012	3.7	Chamoli
52	26 October 2012	3.5	Chamoli
53	12 November 2012	2.5	Uttarkashi

S N	Date of occurrence	Magnitude	Affected area
54	15 November 2012	3.0	Pitthoragarh & Bageshwar
55	26 November 2012	2.8	Bageshwar
56	27 November 2012	4.8	Uttarkashi
57	30 January 2013	2.6	Bageshwar
58	11 February 2013	4.3	Uttarkashi
59	17 February 2013	3.2	Uttarkashi
60	25 February 2013	3.1	Uttarkashi
62	6 March 2013	3.2	Indo - Nepal Border
63	24 March 2013	2.9	Indo - Nepal Border
64	6 April 2013	4.3	Rudraprayag
65	5 September 2013	3.5	Uttarkashi

Source: Uttarakhand National Disaster Risk Reduction Portal

Figure 13 - Earthquakes in the Mahakali River Basin



The Himalayas by virtue of being mountainous terrain are gifted by a steep gradient in practically all the rivers as well as their tributaries and thereby good sites for harnessing hydropower generation. All in all, 336 hydro power projects in Uttarakhand are in existence, proposed or under construction (table 2).

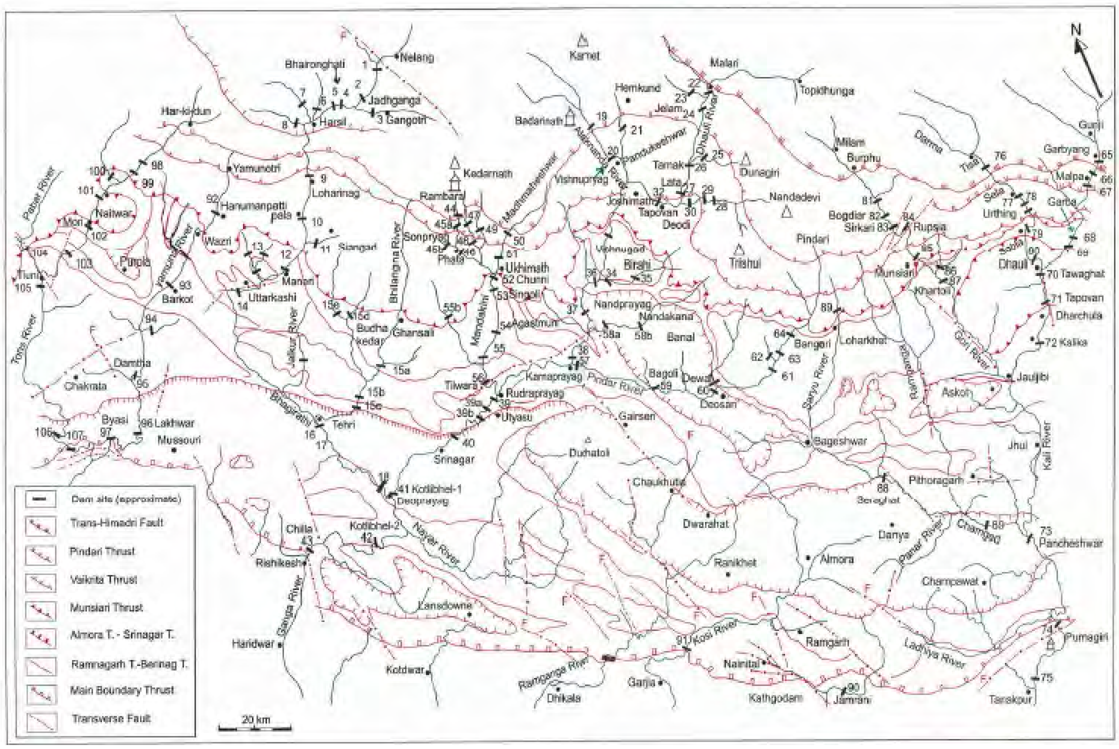
Table 2 - Existing, under construction and proposed hydroelectric projects in Uttarakhand

S N	River	Existing	Under Construction	Proposed	Total
1.	Bhagirathi	13	13	22	48

2.	Alaknanda	32	16	74	122
3.	Mandakini & Pindar	04	02		006
4.	Ramganga	12		20	32
5.	Kali (includes Gori & Darma)	28	08	48	84
6.	Yamuna	09	02	33	44

Valdiya has shown the location of dams and on or in close proximity of major faults/thrusts, as shown in figure 14.

Figure 14 - Locations of dams, major thrusts and transverse (tear) faults in Uttarakhand



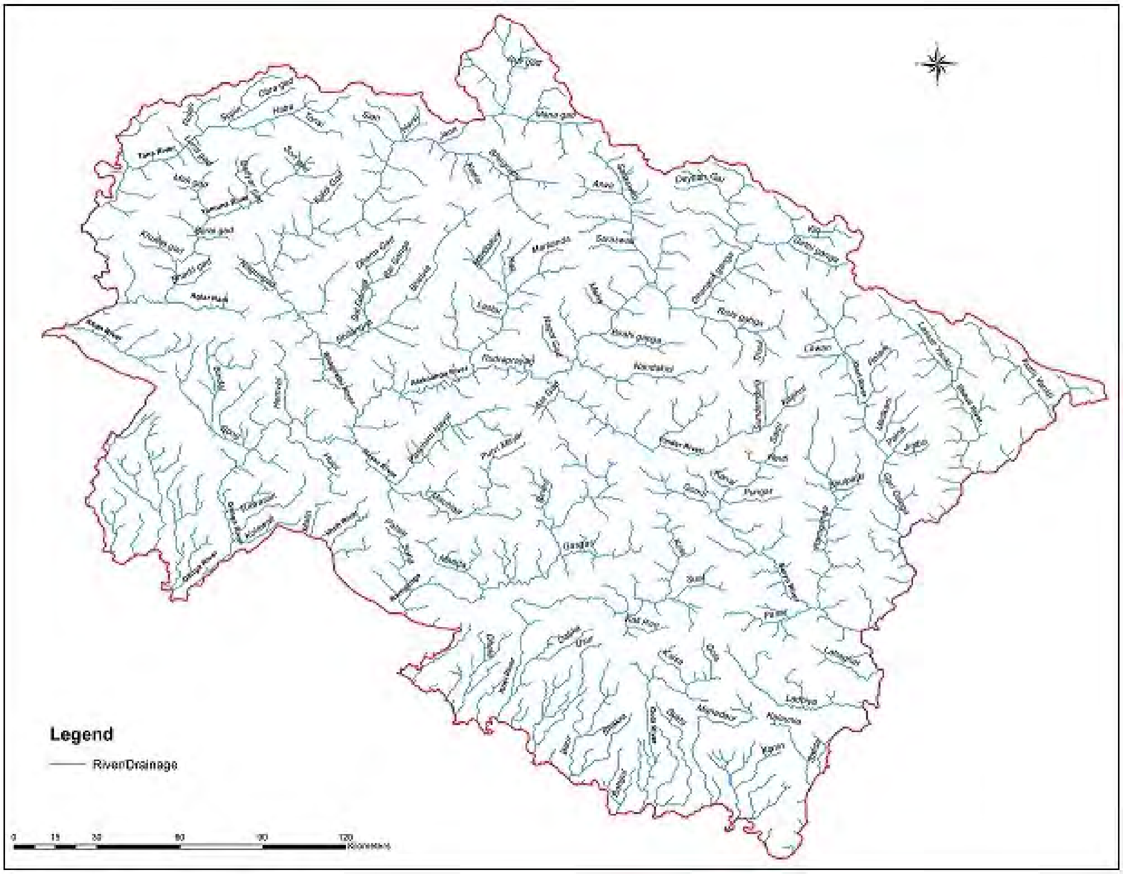
Source: K. S. Valdiya (2014) Structural map of Uttarakhand showing locations of big dams (height >25 m) in existence, under construction and those planned. The positions of dams are approximate. The structural elements comprise major thrusts and transverse (tear) fault dissecting the land.

4.6 Brief Note on Hydrology

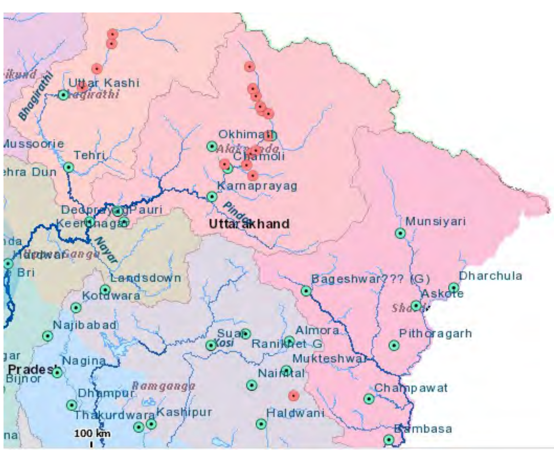
The Mahakali basin has a varied hydrogeological[i] setup and can be divided broadly into two distinct hydrogeological regimes viz. the Gangetic alluvial plain and the Himalayan mountain belt. The former is covered with a vast expanse of alluvium and unconsolidated sedimentary material of varying size fractions (ranging from boulder to clay) and is a promising zone for ground water development. The latter zone, being predominantly hilly, offers much less potential for large scale development of ground water. Ground water in the hilly region occurs mostly in fissures/fractures and emerges as springs. The springs are amenable to small scale development of ground water resources in the State.

The geological units, composed of different lithological formations have their characteristics like the altitudinal extent, climate and geologic interlink that play distinct role in the development of surficial structural configuration, forming different kinds of landforms or slopes. As there are variations in these distinct aspects, there are differences in the nature of geomorphic processes which may either be glacial or fluvial, and this ultimately has an impact on the discharge and seasonal fluctuation of water flow in rivers originating or flowing through different geological units (see figure 16, an example of Gori River). The interrelation of hydrological regime of a basin with the ecological function is closely linked like grasslands in the terai region of Mahakali basin are supported and replenished by the flows of Sharda. Distinct changes are seen when hydrology is seen in terms of the surface and the ground water flows in the hills and the terai-bhabar belt e:g agriculture is largely dependent on the individual capacities of farmers to install tubewells as water is easily available at a shallow depth and thus water intensive agriculture is practiced in canal dependent areas – policies too have a large role in the whole mix.

Figure 15 - Network of rivers in Uttarakhand



Source: AHEC, IIT Roorkee



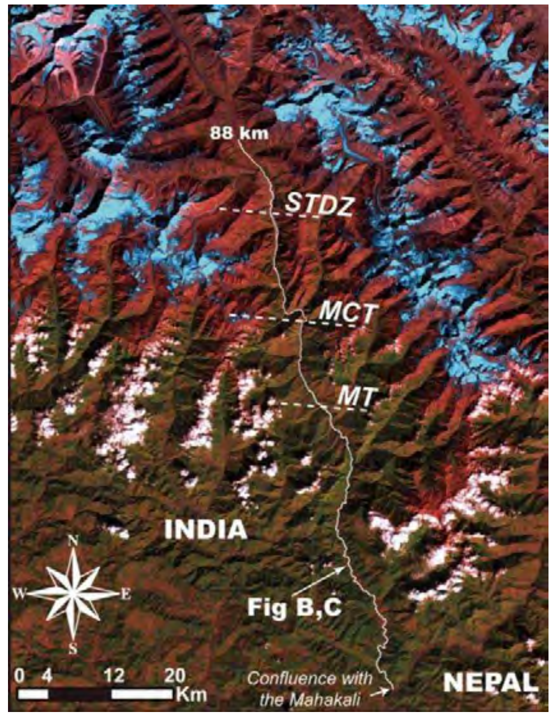
WRIS map showing IMD meteorological stations (in green

The purple coloured text represents CWC meteorological stations *colour with black dot) which are District rainfall monitoring stations (DRMS), no weekly monitoring station in the basin. The dark pink colour with black dot represent ISROs automatic weather stations in the adjoining Alaknanda & Bhagirathi basin, largely covering the char dham route. No such station is available in the sharda/mahakali basin. This basin is also vulnerable to cloudbursts and floods.*

in the basin. One can see Tijam and Narayan Ashram stations in the Darma-Chaudans valley. Tejam-Berinag-Pharsali in the Ramganga valley and others in the Saryu/Kali valley, overall 17 stations in the basin

Source: HydroMet Sub info system of WRIS

CWC has a Western Himalayan subzone classifying the hydro observation stations. Total stations = 12; Gauge stations at Dharchula, Jhulaghat and Banbasa; Gauge and Discharge stations at Tawaghat, Jauljibi & Banbasa; Gauge-Discharge-Silt measuring stations at Ghat, Pancheshwar, Rupaligad and Purnagiri; Gauge-Discharge-Water quality measuring stations at Thal & Ghat



A false colour Landsat image of Goriganga River catchment with major structural boundaries;

STDZ – South Tibetan Detachment Zone

MCT – Main Central Thrust

MT – Munsyari Thrust

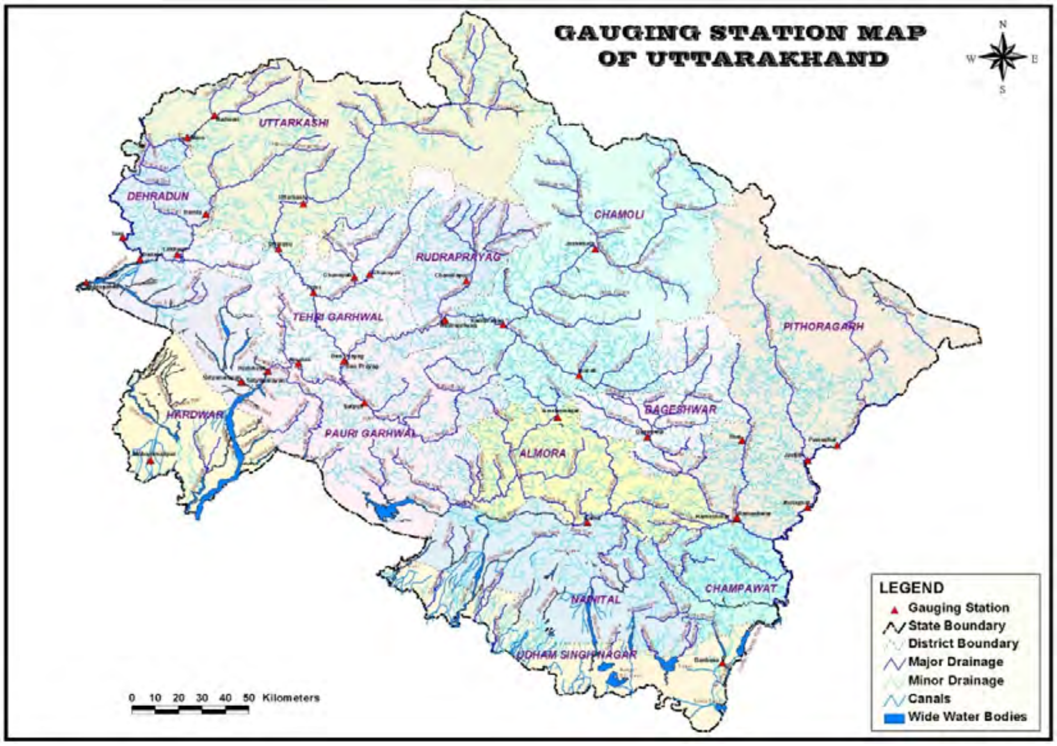
Source: Geological Society of America Special Papers 2012, 492, 1-22

Figure 16 – Metereological and Hydrological Stations in Mahakali Basin

However, there is a dearth of data on rivers and their discharge which primarily emanates from the paucity of rain-gauge stations and hydrological observatories of both state and central governments. In the entire Mahakali river basin, a few meteorological and hydrological stations established by different authorities are witnessed (figure 16). Furthermore, the data pertaining to Ganga river basin is declared as 'classified.' There is hardly much available on the flow regime of rivers but one of the old study[3] which concludes that July and August are the months of highest water discharge in all the rivers like Dhauli, Gori, Eastern Ramganga, River Saryu and River Ladhiya. But the fluctuation between the highest and lowest discharge is more pronounced in Ladhiya which has its entire course in the lesser Himalayas near Mournala. In case of other rivers, the seasonal fluctuation of water flow is more or less uniform. In Nepal, seven meteorological stations are listed by Department of Hydrology and Meteorology (2 each in Baitadi, Darchula and Kanchanpur and 1 in Dadeldhura).

[3] Seasonal regime of water flow in Rivers of Pitthoragarh District: Some Geomorphic Implications Chand M, Joshi SC and Pande KN, Himalayan Research Group, Vol. 7, 1988

Figure 17 - Rain gauge stations in Mahakali River Basin



Source: AHEC

There is an acute need to enhance the number of hydro observation stations alongwith basic meteorological stations which lay a basis for hydrological assessment. The existing gauged catchments cover a large area from the outlet to the upstream which provides for a broad idea of eventual volume, flow and sedimentation but to ascertain the direct causative factors triggering an increase of flow etc. would require much more micro level gauging of catchments or more scientific basis of assessing the ungauged catchments.

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[i] **Himalayan Mountain Belt**

This regime constitutes a major part of whole geographical area of the state and can be categorised in the following units:

i. Outer Himalaya (Siwalik Mountain Range)

This part has potential ground water holding units with highly fractured or jointed rocks.

ii. Lesser Himalaya

Springs as a major source of groundwater occurs in this part. Many hand pumps have been installed satisfactorily and some tube wells in river valleys also.

iii. Central Himalaya

There are cold water and hot water springs (i.e. thermal springs) in this zone.

iv. Tethys Himalaya

Usually this is an appropriate zone for ground water development because of the presence of porous and permeable nature of the litho-structures present in the zone.

Indo-Gangetic Alluvial Plain

The Indo-Gangetic Alluvial Plain Belt is covered with a vast expanse of alluvium and unconsolidated sedimentary material of varying size fractions (ranging from boulder to clay) and is a promising zone for ground water development. The latter zone, being predominantly hilly, offers much less potential for large scale development of ground water. Ground water in the hilly region occurs mostly in fissures/fractures and emerges as springs. The springs are amenable to small scale development of ground water resources in the state.

This zone is further divided into 3 parts as:

i. Axial Belt (Alluvial Plains)

The aquifers of this zone are of unconfined to confined nature and in general ground water potential in this zone is good.

ii. Tarai

Several potential aquifers with good quality of ground water occur in this zone due to the presence of highly porous and permeable nature of the sedimentary derived constituting material.

iii. Bhabar

It has a potential hydrogeological unit but the ground water occurs at much deeper levels (> 100 m below ground level).

In general, in the Indo-Gangetic plain yield varies from 90 m3/hr to 198 m3/hr. The yield of tube wells in Siwalik formation ranges from 50.4 m3/hr to 79.2 m3/hr and in Bhabar formations yield is upto 332.4 m3/hr. In Tarai belt yield of tubewell ranges 36m3/hr to 144 m3/hr. In general, in the Indo-Gangetic plain yield varies from 90 m3/hr to 198 m3/hr.

Dynamic groundwater resources of Uttarakhand have been estimated as follows –

S N	***Dynamic Groundwater***	***Quantum***
1.	Annual Replenishable Ground water	2.27 BCM
2.	Net Annual Ground Water Availability	2.10 BCM
3.	Annual Ground Water Draft	1.39 BCM
4.	Stage of Ground Water Development	66 %

Source: Central Groundwater Commission, MoWR, GoI

Groundwater quality problems exist in Dehradun, Haridwar and Udham Singh Nagar as all three districts suffer from nitrate (>45 mg/l) and iron content (>1.0 mg/l) more than the permissible limits.

Let us look at the water quality indices in four major districts falling in the Mahakali River Basin.

Almora: During the water quality study of Almora district in 2009 by Ministry of Rural Development, government of India, the faecal and chemical contaminations have been found high in three and two blocks of Almora district (IMIS, 2009).The nitrate concentration has also been found high in some other studies (Kumar et al., 1997) but no proper authentication was found for some of the data.

Bageshwar: The Central Groundwater Board has done the quality assessment of groundwater of Bageshwar district in 2009 that indicates the high quality of fluoride, magnesium and sodium in groundwater at different sampling sites (CGWB, 2009a). However, 58 water sources of Bageshwar district have also been studied by Ministry of Rural Development in 2009 and all sources have been found free from any pollutants (IMIS, 2009).

Champavat: Groundwater quality status of Champavat district has also been exhibited by Central Ground Water Board in 2009 which expressed that EC, pH, Ca, Mg, bicarbonate, chloride, and total hardness are under permissible limits. Hence the overall quality of water is good and suitable for domestic and other purposes (CGWB, 2009a).But large number of sources have been found contaminated due to faecal coliform through another study of Ministry of Rural Development in 2009 (IMIS 2009)

Pithoragarh: The water quality of Pithoragarh district has been assessed by the Ministry of Rural Development in 2009 that expressed the contaminated water quality of 17 sources out of 74 water sources due to high faecal and other multiple contaminants (IMIS, 2009).

The above statistics cryptically point to a disturbing scenario on the front of groundwater. It is commonly perceived that Uttarakhand has a large vegetal cover but the fact is that less than 10% area of state is covered with the dense forest and rest of the area under forest is mere 'open' or 'degraded' forest. Globally, dense forests have been scientifically recognized as 'provenance' of water (especially groundwater as tress increase run-in and add to groundwater) and this poor state of forest is reflected in the poor water yield. That is why 30 sub-critical blocks are found in Uttarakhand and a huge quantum of water is required for artificial recharge.

5

Contents

5 FOREST, ECOLOGY AND CLIMATE CHANGE

5.1 Physiography and Climatic Zonation

The Sarda river basin, like any other river basin, has a diverse climate and physiography. The Terai plain is sub-tropical while the Siwaliks are sub-tropical to warm temperate. The climate in the middle hill varies from warm to cool temperate whereas high Himalaya experiences a temperate to alpine climate. On one hand valleys benefit from gently sloping fertile lands for agriculture and face fury of the river from time to time. Hills on the other hand have small land holdings, mostly rainfed.

Figure 1 - Map showing the Siwalik Range, Nepal Himalayas and Kumaon Himalayas
Source: WRIS

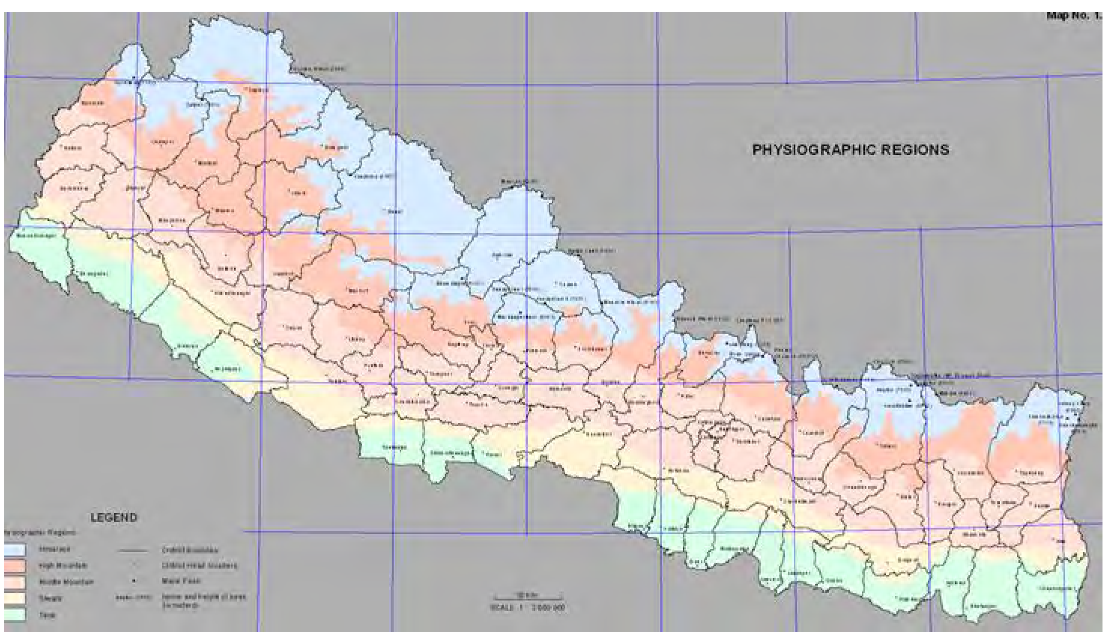


Figure 2 – Physiographic divisions, Nepal; Source: Census of Nepal

The map depicts physiographic regions of Nepal which extend from NW to SE axis. The region lying to the NW edge is the Mahakali zone within the Far Western Development Region. The lowermost district of Kanchanpur is in the Terai; Dadeldhura is partly Siwaliks and its upper part is middle mountain; Baitadi is in the middle mountain and the physiography transforms to high mountains and Himalaya or the alpine zone beyond Baitadi into Darchula.

As per agro-ecological zones, WRIS[1] assigns Uttarakhand as 'warm to sub-humid to humid with inclusion of per-humid eco-region with brown forest and podzolic soils[2]'. This relatively means that the average annual rainfall is around 1100-2000 mm which provides wet conditions. Uttarakhand's agro ecological zones are also characterised by their ecological and resource functions like the alpine grazing lands or Bugyals, Terai & Bhabbar tracts in the Shivalik zone, oak forests in the middle Himalayas regulating the water regime (per-humid conditions) and the cold desert areas in the higher Himalayan zone, the spread of protected areas from the Higher Himalayas (like NDBR) to Middle Himalayas (Askot Wildlife Sanctuary) to (Pilibhit National Park PNB) in the Terai mark controlled zones of human interference. The natural forests comprise sub-tropical pine and sub alpine forests including moist forests.

The formations in the Ganga Basin, at least in north-west Himalayas (NWH) portray a similar structural representation of Tarai-Bhabbar[3] belt carrying sub surface flows with huge debris load eroding from the Himalayas. The trans Himalayan region or the Tibetan Plateau and the transformative zone from the Higher Himalayas to Tibetan plateau is termed as 'cold desert' regions with very low rainfall, largely covered with snow i.e. the wet clouds hardly reach out to this altitude.

Figure 3 - Watershed programmes under various phases, Images from Bhuvan

Bageshwar

Champawat

[1] Water Resources Information System of India

[2] Coniferous-dominated plant communities are the major vegetation type found on Podzolic soils

[3] Topographically most significant and complex part of the region is the sub-montane belt, running at the foot of the Shiwaliks from west to east across the area on the northern border consisting of the two parallel strips – the piedmont zone, the Bhabar (the Doab region) and the adjoining relatively gently sloping Tarai belt. Source: Ganga Basin, MoWR, GOI

Pitthoragarh

Almora

Watershed development programmes like ILSP (Integrated Livelihood Support Programme) has four components including participatory watershed development as component '2', component 1 being food security and livelihood enhancement and component 3 being livelihood financing. It is being implemented in the 55 Gram Panchayats of 3 development blocks which will cover around 126 revenue villages covering an area of 15851 hectare. Another programme 'Uttarakhand decentralised watershed development project – II (Gramya)' has an objective to develop/benefit 82 micro watersheds over 263837 hectares spread in 9 districts. In Pitthoragarh it covers 9 micro watersheds over an area of 25739 hectare and some part of Dhauladevi block in Almora and Kapkot block in district Bageshwar in context of Mahakali basin as a whole.

Agroclimatic Atlas of Nepal

Agricultural development and increase in crop production is the prerequisite for sustained economic growth of a country and agriculture remains largely rain-fed. Climatologically, Nepal is one of the most vulnerable Himalayan countries in the world. Rapidly retreating glaciers, upward movement of snow lines, decrease in snow cover and increase in the number of glacial lakes and their rapid growth have led to increased events of disastrous floods, including Glacial Lake Outburst Floods (GLOF) in the Himalayan countries. Recurrent severe droughts in parts of Nepal have significantly impacted agricultural production and chain of trade of agro-products. The severity and extent of drought not only depends on low rainfall but also on other hydro-meteorological factors like soil moisture, infiltration and moisture-retention capacity of the soil.

Standard data set of 30 years from 1981 to 2010 was used to prepare the Atlas. In this Atlas, the meteorological parameters, such as precipitation, temperature, relative humidity and numbers of rainy days have been used to prepare the climatic maps in the first section. The second section of the Atlas incorporated Agro-climatic zoning especially for the four crops (Rice, Wheat, Maize and Potato), drought index and soil moisture index (percentage saturation).

This atlas is a useful addition to the facts and knowhow on the climatic indices of Nepal and will serve as a useful reference tool for the planners, technical experts and finally to farming community as well as for the readers interested in the climate of Nepal. However, it would have been truly helpful to farming community, had it given a one-page brief of each district, specifically informing the implication of these changes on agriculture and few location-specific points towards the coping mechanism.

These are some of the important aspects related with Sarda/Mahakali River in Nepal and India, both.

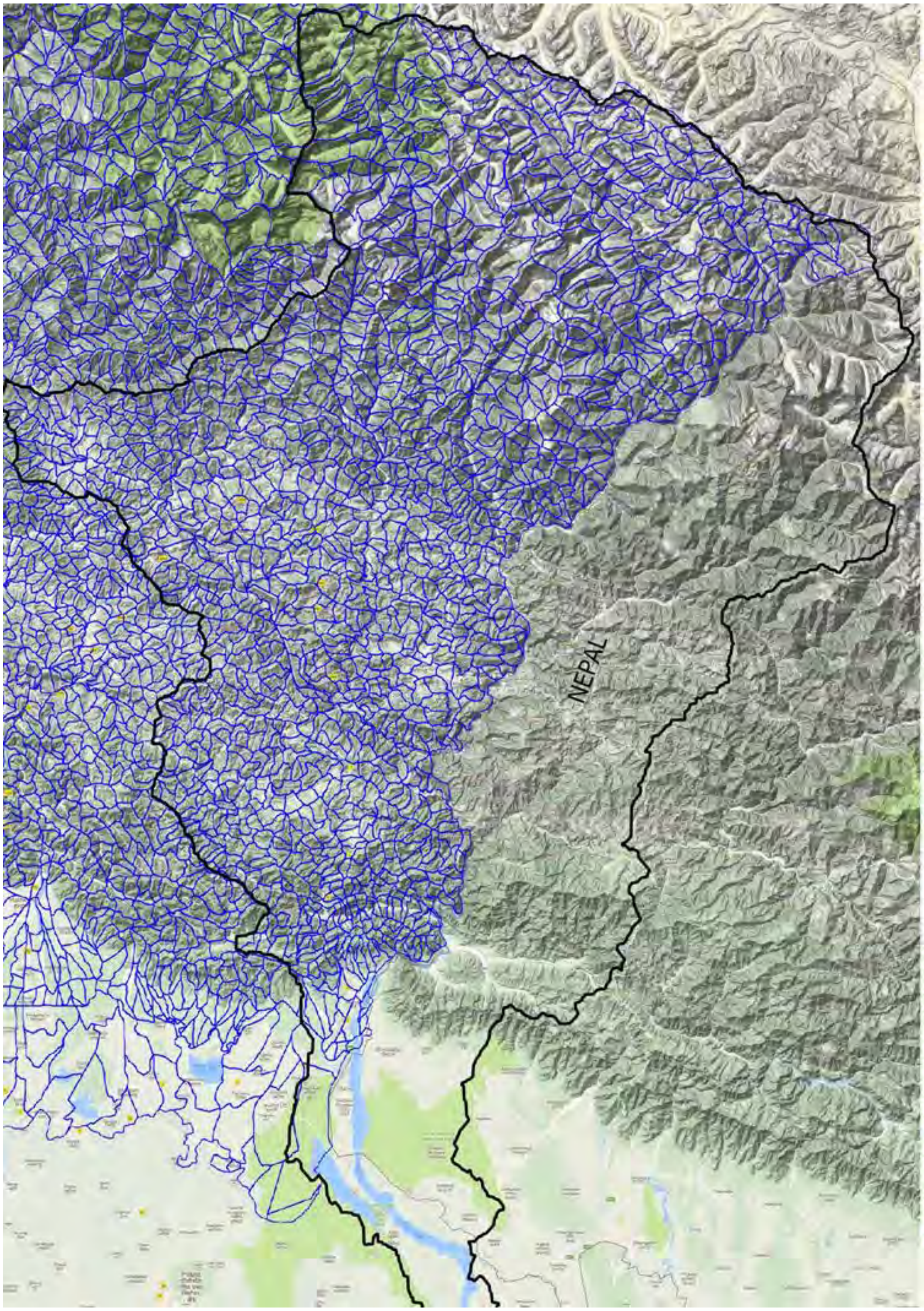


Figure 4 – Watersheds in the Mahakali basin marked over the terrain. Slope, aspect and land capability determine how the basin will yield in terms of water and sedimentation load.

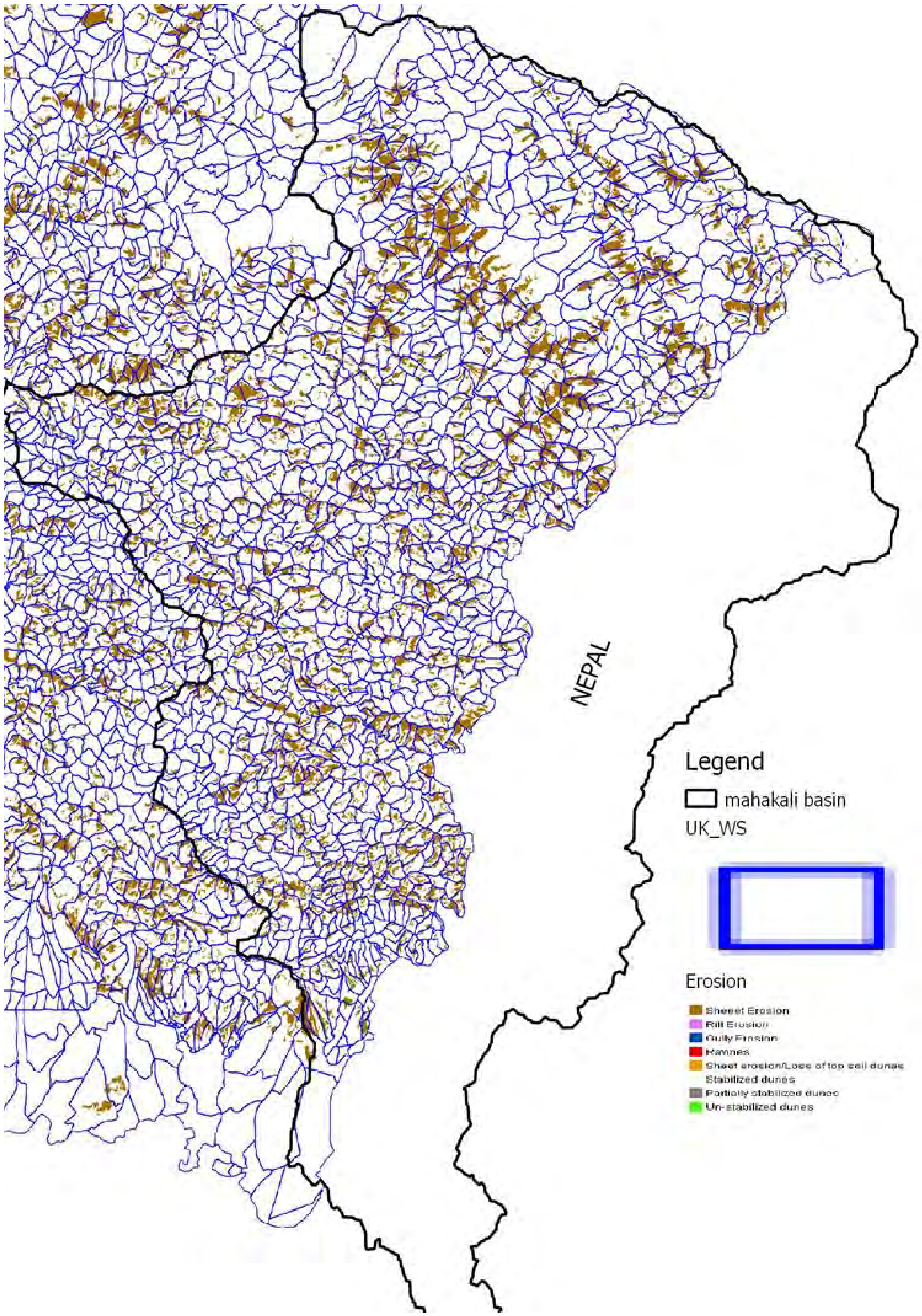


Figure 5 – Watersheds in the basin overlaid by erosion, high in the upper reaches along the Dhauli and Gori valleys

5.2 Forests and Ecology

"As per first National Forest Policy of 1952 which was maintained in second policy in 1988, the forest and tree cover should be of one-third of total geographical area of a country." According to India State Forest Report 2015 -

- Forest cover of India has increased by 5,081 square kilometres between 2013 and 2015.
- Very dense forests in India cover 2.61 percent of the total forest area, moderately dense forests account for 9.59 percent while open forests stand at 9.14 percent.
- Although the total forest cover has seen an increase, around 2,510 square kilometre of very dense and mid-dense forests have been wiped out since 2013
- States of Jammu and Kashmir, Uttarakhand, Meghalaya, Kerala, Arunachal Pradesh, Karnataka and Telangana have suffered huge loss of forest cover
- Around 2,254 square kilometre of mid-dense forest cover has turned into non-forest lands in the past two years.

Total forest area in Uttarakhand is about 34,651 sq km. The forest cover in the state, based on FSI, 2011 data is 24,496 sq km, which is 45.8 % of the state's geographical area. In terms of forest density classes, the state has 4,762 sq. km area under very dense forest, 14,167 sq km area under moderately dense forest and 5,567 sq. km area under open forest. Reserve forests constitute 71.1%, protected forests 28.5%, and unclassified forests, 0.35% of the total forest area (FSI, 2011). The state has 7418 sq. km under Protected Area Network (PAN), the fourth largest among the Indian Himalayan Region (IHR), comprising 6 national parks and 6 wildlife sanctuaries and two conservation reserves (WII, Dehradun).

Some significant trends pertaining to Uttarakhand from the report of Forest Survey of India 2015 are given below -

- Total forest and tree cover of Uttarakhand is 71.05% of total geographical area. Around 36 different types of forest are spread across 11,404 patches.
- Uttarakhand has total geographical area of 53,483 sq. km out of which 34651 is recorded forest area (RFA). Of this 3912 sq. km has been termed as very dense forest (VDF), 9691 sq. km is medium dense forest (MDF), 3089 is open forest (OF), thus total 16692 sq. km. 48.17% of forest cover is within RFA. Uttarakhand has a total area of 53,483 sq. km, of which 86% is mountainous and 65% is covered by forest. Most of the northern part of the state is covered by high Himalayan peaks and glaciers.
- The Forest Survey of India (FSI) in its 2015 report revealed that the forest cover of Uttarakhand has found to be decreased 268 sq. km in last two years - at present total area being 24,240 sq km. The main reason for decrease in forest cover has been described as rotational felling and diversion of forest land for development activities in the report.

Table 1 Changes in Recorded forest area in Uttarakhand

S N	Forest	Year of Assessment (in sq. km)		
		2011	2013	2015
1.	Reserved Forests	24638	24643	26547
2.	Protected Forest	9882	9885	9855
3.	Unclassed Forest	131	123	1568
4.	Total Forest area	34651	34651	38000
5.	% Forest area to geographical area	64.79%	64.79%	71.05%

Source: Forest Survey of India (FSI), 2015

Table 2 District-wise Forest Cover in Uttarakhand 2015

S N	District	GA	Forest Area 2015 Assessment (in sq. km)				% of GA	Change	Scrub
			VDF	MDF	OF	Total			
1.	Almora	3139	224	929	430	1583	50.43	06	10
2.	Bageshwar	2246	200	834	329	1363	60.69	-22	4

3.	Champawat	1776	348	570	266	1184	67.04	-03	6
4.	Pitthoragarh	7090	509	1013	580	2102	29.65	02	39

Source: Forest Survey of India (FSI) in its 2015

GA=Geographical area; VDF=Very Dense Forest; MDF=Moderately Dense Forest; OF=Open

Note: Only those districts which are fully or partly in the Sharda basin

The dominant tree species in this region are Chir pine and Quercus leucotrichophora (Oak), Quercuss semicarpitolia smith (Khirsu) with others like Alnusnepafensis D.Don (Utis), Toona Ciliate Roem (Tun), Shorea Robusta Gaertn (Saal) in the lower reaches. The symbiotic relationship of forest with agriculture-livestock system and consumptive use has remained the mainstay of input economics of agriculture and non-timber forest produce supplementing the livelihood needs.

Around 19% (7350 sq. km.) of forests is under the control/management of Van Panchayats of which 31% is reserved forests whereas the majority is in civil and soyam forests. Pitthoragarh has around 1666 forest Panchayats with a maximum area of 2772 sq. kms, Bageshwar has 822 forest Panchayats over 388 sq. km. and Champawat having 629 forest Panchayats over an area of 312 sq. km. Community forestry is a strong institution in this region and several other Himalayan sub basins, largely concentrated in Uttarakhand and the adjoining Nepal region. Most often the ex-servicemen in the hills who came back to their villages took charge due to their experience and acceptance as a neutral or managerial person who can take the forest users/right holders along. But these institutions are riddled with fund constraints as well as have to face the ire of communities, who are in need of forest resources, especially timber to repair their houses.

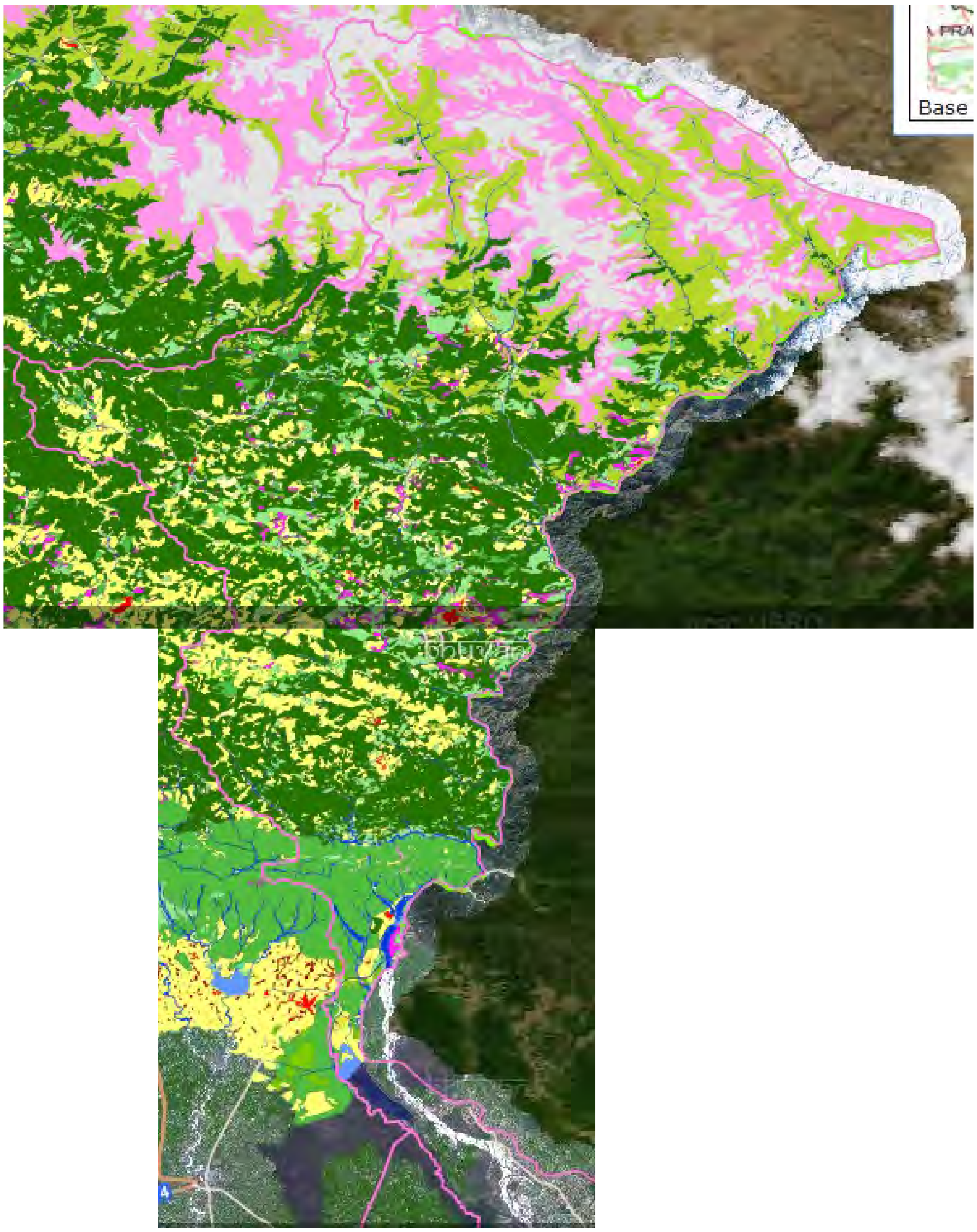
While there is a set of rules for Van Panchayats, the 2006 Forest Rights Act brings in a structure of forest rights committees (FRCs) at the revenue village/habitation level to prepare, verify and communicate the claims of respective community to the upper levels of vetting by the state. Uttarakhand, among several other states has not fully initiated[4] the process of the provision of this unique Act. In fact it seems, the FRA comes into reference only when a proposal for forest diversion is moved. This is to comply with of MoEF's August 2009 guideline on evidences for having initiated and completed the process of settlement of rights under the Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006 on the forest land proposed to be diverted for non-forest purposes read with MoEF's letter dated 5th February 2013 wherein MoEF issued certain relaxation in respect of linear project. But how the claims will come through in non-linear projects when the basic procedural step of formation and capacitating the so formed FRC is not done.

Forest diversion for non-forestry use or developmental projects has been the maximum for mining sector at 7400 hectares[5] followed by 6400 hectares (rounded off) for road construction projects, hydroelectric projects alongwith transmission lines it is around 4400 hectare.

[4] As of September 2017, merely 182 individual claims have been reported to be received with no further progress

[5] Forest Statistics 2014-15

Figure 6 – Greener patches in the central part of Mahakali sub basin (Indian part) are forests, lighter green portions are alpine meadows or grazing areas with lesser vegetation. Agricultural land in yellow and forests in green indicate the inseparable bond between the two.



Ecology, as we all know, is the study of the interactions of organisms with each other and their environment. Devising testable hypotheses about ecosystems and generating complex mathematical models to simulate ecosystems are integral part of ecological analysis and synthesis. Quality of habitat in an environment and activities affecting its functioning become a direct threat to the species and eventually the ecology. Musk deer (Moschus leucogaster) is one of ungulates which has adapted well in altitudes where other ungulates migrate lower down during winters, its status is threatened from 2003 onwards and as per recent assessment in 2014[6] it has remained threatened. Few years back a mining project in Askot to mine multi-metal deposit was met with high resistance from locals owing to threat to the sanctuary, the Askot town and River Kali/Sharda. Such extractive industries are not compatible in regions of high altitude. Snow leopard is another species which has recently been upgraded from the level of threatened to vulnerable by IUCN. For many species ecological and ecosystem level assessments are still a long way and require scientific and time series data to bring them into monitoring and evaluation framework.

The much larger Askot conservation landscape which extends beyond the wildlife sanctuary connects and reflects upon several ecological-cultural-environmental linkages coupled with conservation values within a community or around a resource. A Trans boundary region, like the one along the river systems of Kali/Sharda is one example of cross border socio-cultural ties and interactions which has also been religiously, environmentally and economically linked.

As per one paper[7], "the intactness of the belief systems surrounding the sacred natural sites showed a proportional relationship with the relative distance with the townships. This was more conspicuous in district Pitthoragarh, as compared to rest of the state. One of the causal factors remains the close ties of the populace of district Pitthoragarh, with the neighbouring Nepal across River Kali, where the institution of sacred is much stronger. This whole aspect of the traditional ties of the people across the borders, along with the resident Gods, has manifested itself in the form of sacred groves and forests, conspicuously duplicated across the two banks of River Kali". Pitthoragarh fairs much above with a mix of sacred groves, forests, alpine pastures and water bodies than the other districts of Almora and Champawat in the sub basin.

The high altitude pastures have their unique biodiversity and attain special significance for transhumance communities, many migrate to these bugyals for harvesting several precious medicinal plants. The Vyas sub region/block which is spread in 365 sq. km. has around ten large bugyals located between 3200m-5200m, the estimated livestock population is around 18,000 (around 2% is cow and buffalo, rest is sheep and goat). Similarly malla Darma has major 7-8 bugyals, other such large sub regions being Johaar (750 sq.km.) and others. The author[8] in this context gives example from Vyas valley (Askot Landscape) wherein grazing pressure is regulated by allowing only sacred Yak (bos mutus grunniens) and its local hybrid Jhuppu and Jomos, are allowed to graze. This is in Hya-Roshe bugyal near village Napalchhu & Putuk-tu bugyal near village Kuti. The prime examples of sacred forests are offered within the Askot Conservation Landscape, like Bombasing (above the village Tedang) and Bhujani (above the village Martoli) where the same are referred to as *Se-Rong* (Se-god, Rong-forest).

By such protection, only during the annual festivals is the collection allowed which resultantly save the villages down below during avalanches or any other natural fury. This is one of the kinds of practices serving ecological adaptations. Chaudans, Chipla Kedar, Ralam, Johaar and many other valleys have their unique set of such ecological benchmarks which still exist and have remained prevalent due to lesser outside influences over their environment so far.

The Kali/Sarda river comprises number of tributaries and sub-tributaries like Saryu, Panar, Eastern Ramganga, Dhauliganga, Goriganga, Lohawati, Ladhiya, Chamliya, Rangun Khola etc. – to name a few. All river confluences or *Sangams* are also places of spiritual and socio cultural exchanges and interactions. The confluence of the large and important Saryu and Kali rivers at Pancheshwar is particularly significant. Each of these rivers and their secondary and tertiary tributaries have their

[6] http://www.iucnredlist.org/details/13901/0

[7] Negi CS, Department of Zoology, Government Post Graduate College, Pitthoragarh "Traditional Knowledge and Biodiversity Conservation: A Preliminary Study of the Sacred Natural Sites in Uttarakhand"

[8] ibid

own unique ecological features, socio-cultural-spiritual attributes, characteristic flora and fauna, valley agriculture, and several other unique features, evolved over thousands of years of symbiotic relationship between the communities and nature.

Toli Village - Self Sufficiency in Water & Co-lateral Benefits

Krishna Gahtodi retired from army in 1987 and instead of settling in some town (where retired army personnel are in great demand in security business) like many of his colleagues, decided to return to his native village Toli, Block Pati, district Champawat, Uttarakhand. The first problem he encountered immediately was water crisis. He recalled his own experience when posted in Sikkim. His unit collected water from a source located in nearby hills and stored it in a concrete tank.

Since Toli village sits at the bottom of a hill, he explored the water sources in the hill and soon found one closest to his house. He measured the distance and brought a thick 60 meter PVC pipe and fixed it at the water source, the other end of pipe led to his home. To ensure the sustainability of water source, he sprinkled seeds of broad-leaved local plants and also planted local grasses around the water source. Earlier villagers were sceptical about his experiments but witnessed from their own eyes that his family no more faces water shortage. So under his guidance, gradually all the 40 households in the village followed the same practice. Since each family has his own personal water source, each family takes care of for its sustainability. In last 25 years all the families in the village have access to water at their homes. This also increased agriculture, horticulture and dairy activities in the village manifold.

The conventional thinking is that fishery can't be practiced in the hills. With access to water, Krishna Gahtodi tried to break this myth too. He constructed elongate concrete water tanks for growing fish like *grass carp*, *silver carp and* c*ommon carp*, *rohu*, etc. For the protection of fish from the cold, thick polythene sheets were used to cover fish tanks. Within a year he was producing more than his domestic consumption and hence started selling it to villagers. Again, his success attracted other villagers to follow suit and today 18 families of the village are engaged in fishery. Krishna Gahtodi also took steps to collective selling of fish catch of all 18 families and sharing the profits. Other villages also started fish-production. Today Pati Block has more than 50 farm fish-ponds and the area has been declared a 'fish-belt.'

He is associated with Centre for Cold Water Fisheries campus in Champawat and Toli is visited by trainees and trainers for listening to the success story of Toli and see the success on ground. He and his colleague, have effectively utilised water to showcase integrated farming activities.

Finally, his path-breaking work on 'fish production' and 'self-sufficiency in water' was recognized by the government and Indian Agricultural Research Institute awarded him the honor of "Matsya-Shree" and "*Matsya-Farmer*."

5.3 Climate Change

The Indian Himalayan Region (IHR) - one of the most climate sensitive regions of the country - stretches across states in the western and eastern Himalayas and provides critical ecosystem services for communities in mountains and downstream plains. Uttarakhand, a vital segment of the Himalayan Regime, is most vulnerable to climate-mediated risks.

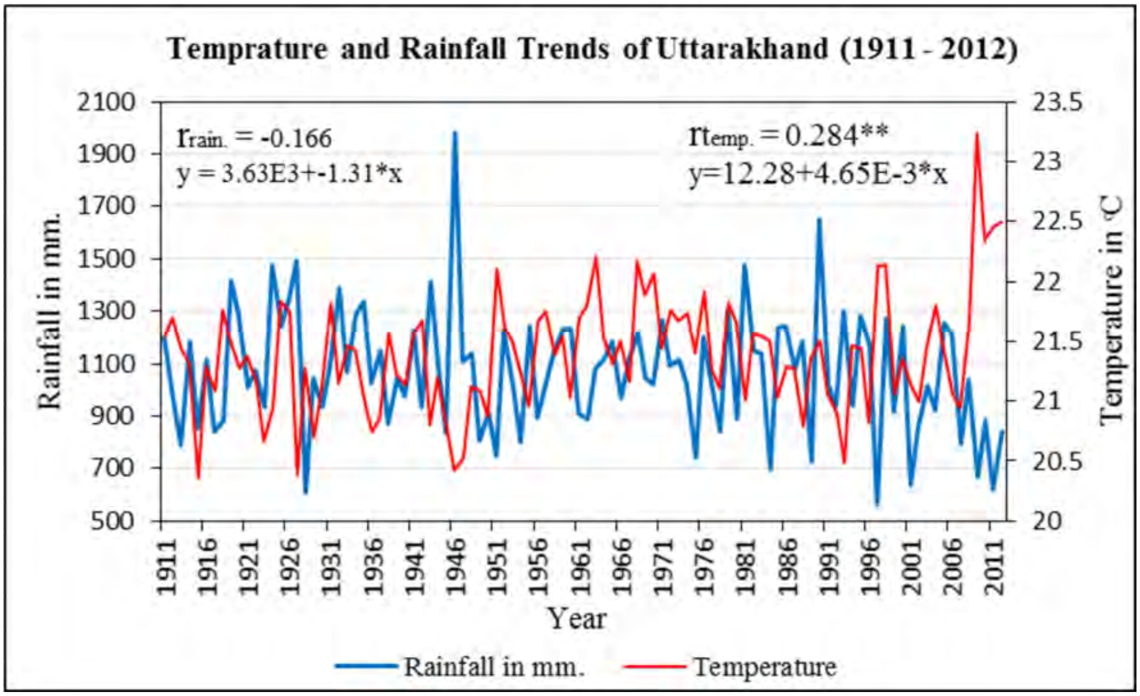
About three-fourth of state's population is rural and virtually all depend on agriculture. Tourism and Animal husbandry are other sources of income. With over 15 important rivers and over a dozen of major glaciers, Uttarakhand is a valuable freshwater reserve. Climate change will have severe impacts on livelihoods as most of the economic and livelihood sectors are vulnerable to the impacts of climate change.

There have been a number of significant changes in the pattern of precipitation and rainfall, snowfall, glacial retreat, etc. which point to the transitory changing environment in Uttarakhand, as discussed below.

5.3.1 Overall Changes in Rainfall & Temperature Pattern

An analysis of 100 years temperature and rainfall data shows that the region has recorded a declining rainfall trend during the period 1911-2012 and after 1970 onward, this trend has become steeper (Figure 7). Although the average reduction rate in annual total rainfall has been insignificant, yet it may put great stress on the water resources of the region. The rainfall declining trend is not the same all over the state. Haridwar, which is almost plain, has received more rainfall than normal. Rest all the districts have witnessed less precipitation. This rainfall shortage is more acute in Pitthoragarh, Bageshwar, Almora, Champawat and Nainital Districts.

Figure 7 - Analysis of 100 years temperature and rainfall data shows that the region has recorded a declining rainfall trend during the period and after 1970 onward, this trend has become steeper



Source: Ashutosh Mishra (2014)

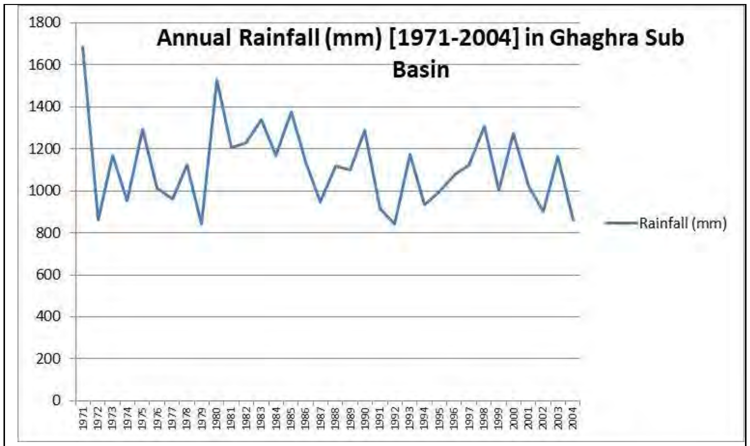
Temperature records of the region reveal a notable warming trend and this warming was more prominent during the last decade. While the entire region has shown a significant temperature increase, the mountainous districts - Uttarkashi, Chamoli, Rudraprayag and Pitthoragarh- were the warmest areas. On the other hand, Hardwar, Dehradun and Garhwal districts, which are low in relief, witnessed less warming as compared to others. This pattern may calls for faster melt of glaciers and more active geomorphic processes. Due to enhanced energy levels, the atmospheric processes may bring rapid and catastrophic changes and the climatological disasters like cloudburst, landslides, floods etc., may visits the region more frequently and intensely.

District level Temperature and rainfall data shows almost the similar trends and all the districts have noticed a significant decline in rainfall during past two decades. However, Almora, Bageshwar, Champawat, Nainital, Garhwal and Udham Singh Nagar districts were the most rainfall deficient; Uttarkashi district recorded no significant decline during the period. Between these deficiencies, there exists surplus too. In between 1950 to 1970, besides Uttarkashi, Rudraprayag, Garhwal and Pitthoragarh, all the districts have noticed extended precipitation spells. It is worth mentioning here that frequency of precipitation curve has been higher before 1950, and afterwards it continuously reduced significantly. Thus the decade of 1950-60 seems a time divide in precipitation patterns of the state.

5.3.2 Rainfall at Basin and District Level

Rainfall is by far the single most important meteorological event which boosts life-forms, aids irrigation, improves moisture content and regulates the micro climate. It can also become a destructive force in the form of flash floods, activate landslides and sometimes leads to subsidence etc. Its role in rejuvenating valley lands with rich nutrients due to flooding cannot be side-lined either. Its relevance in the young Himalayan ecosystem is relatively most important for humans, species and resources in order to determine the productivity systems as well as optimal utilisation of land.

> Places like Paati, Khetikhan, Mournala and others where apple used to grow have given way to mango or certain citrus fruits, says Mahendra Pal, a farmer from Roulamel in Pati Block.
>
> There is an aged farmer, Shri Prem Singh, 93 years old in Reetha Saheb. He was awarded in 1962 by Late Prime Minster Jawaharlal Nehru and bestowed upon him an honour of 'Krishi Pandit'. He received the attention of late prime minister as he grew a cauliflower weighing 66 kilogram, an (*colocasia*) arbi weighing 15 kilogram and 35 kilogram wheat from a plot of 35'X35'. His experience could become handy in the wake of climate change and growing inconsistencies in raising crops
>
> Kaafal Is a local plant whose edible fruits fetch a good price even selling on the roadside – this forest produce adds a little to the earnings during tourist season as people cherish this local fruit . The fruits on this tree appear in the April-May month. But now because of changes in weather, these are getting ripe in the month of late February to early-March.



Source: Annexure II A, Ganga Basin Document by MoWR, GoI

The average annual rainfall for the basin is estimated as 1059.74 mm. There are consistent peaks and troughs but the overall rainfall is decreasing (1989 to 2004). As per IMD monograph[9] there is a drop of 1.07 mm of average annual rainfall throughout the state of Uttarakhand. In the Upper Ganga, almost all the streams follow a NW-SE course concomitant with the lie of the land. The region has a pinnate drainage, an extreme case of the dendritic pattern on macro level. A comparative of rainfall parameters of two Himalayan states of similar physiography is shown below;

Table 3 – Sorted Meteorological Observations, IMD

Parameter	Uttarakhand	Himachal Pradesh
Annual mean max. Temp. trends	+0.02*	+0.06*
Annual mean min. temp. trends	-0.03	-0.01
Annual mean DTR# trends	+0.03*	+0.06*
Annual average rainfall trends	-1.07	-3.26
SEASONAL (Winters)		
Winter mean max. Temp. trends	+0.02*	+0.06*
Winter mean min. temp. trends	No trend	-0.02
Winter mean DTR trends	+0.03*	+0.09*
Winter mean rainfall trends	-0.01	-0.18
Summer mean max. Temp. trends	No trend	+0.06*
Summer mean min. temp. trends	-0.03*	-0.03*
Summer mean DTR trends	+0.03*	+0.10*
Summer mean rainfall trends	+0.86	+0.31
Monsoon mean max. Temp. trends	+0.01	+0.06*

[9] State Level Climate Change Trends in India, Meteorological Monograph No. ESSO/IMD/EMRC/02/2013 - IMD brought out state wise long term changes in surface temperature and precipitation from observational records of IMD from 1951-2010. 282 stations w.r.t temperature trends and 1451 stations for precipitation trends were selected. The analysis is presented for four seasons viz. winter, summer, monsoon and post monsoon. The central theme revolves around trends in maximum temperature, minimum temperature, mean temperature, mean DTR trends and average rainfall trends.

Monsoon mean min. temp. trends	-0.04*	No trend
Monsoon mean DTR trends	+0.04*	+0.05*
Monsoon mean rainfall trends	-1.45	-2.85 (highest decline)
Post Monsoon mean max. Temp. trends	+0.03*	+0.07*
Post Monsoon mean min. temp. trends	-0.01	-0.03*
Post Monsoon mean DTR trends	+0.03*	+0.09*
Post Monsoon mean rainfall trends	-0.63	-0.21

Temperature trend in ^{0}C/year and rainfall trend in 'mm'
diurnal temperature range

Rhododendron (locally called Burans) grows in the middle altitude of around 1800-2200m but its early blooming or flowering in February is recurring, the same is being observed for Kaafal (a wild berry) indicating warming of the fruit belts. Such early flowering is a biological indicator of climate change. Photo between Mournala and Bedchula

There is a decrease in monsoon mean rainfall as well as post monsoon mean rainfall in both Uttarakhand and Himachal Pradesh, the average annual rainfall trends show declining trend as highlighted in the table above. Further analysis of seasonal, monthly rainfall data from IMD is presented in the forthcoming sections and those also corroborate with the overall climate change trends as indicated by the IMD study. The annual average rainfall trends as well as monsoon mean rainfall trends indicate declining rainfall pattern. A negative trend of 1.07mm indicates need for reassessment of water budgeting from the micro watershed levels and then arriving at the sub basin and subsequently at the basin level. Instrumentation is the most important link between micro climate assessment and creating an early warning or advisory for a variety of sectors.

Table 4 - Monthly Trends of Temperature and Rainfall, Uttarakhand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly mean max. temp trends	+0.03*	+0.01	+0.01	+0.01	-0.02	-0.02	+0.01	+0.02*	+0.01*	+0.01*	+0.02*	+0.01*
Min temp trends	NT	-0.01	-0.03*	-0.03	-0.04*	-0.06*	-0.04*	-0.04*	-0.03*	-0.02*	NT	NT
Monthly mean DTR trends	+0.03*	+0.03*	+0.03*	+0.03*	+0.02*	+0.03*	+0.05*	+0.05*	+0.04*	+0.04*	+0.03*	+0.03*
Monthly rainfall trends	-0.53	+0.49	-0.10	+0.40	+0.62	+0.6	-1.71	-0.41	+0.39	-0.42	NT	-0.01

State level trends are categorised as (-) decreasing, (+) increasing and (NT) no trends and those with significance at 95% are shown with star (*)

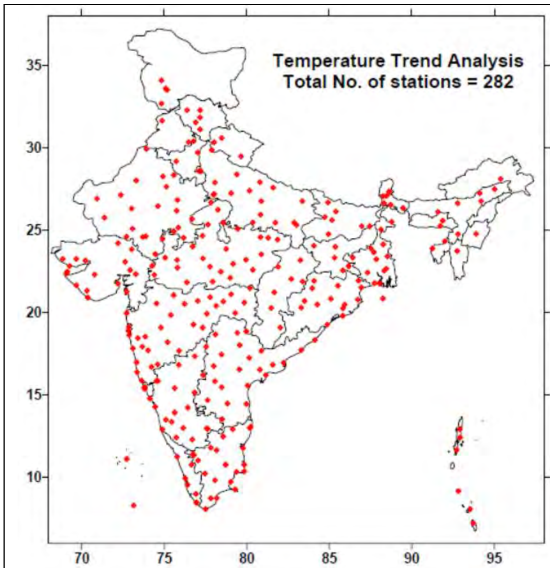


Figure taken from IMD Monograph showing distribution of 282 surface meteorological stations used for state level temperature trend analysis for 1951-2010. One can notice low density of stations in Uttarakhand[10] in comparison to Himachal Pradesh

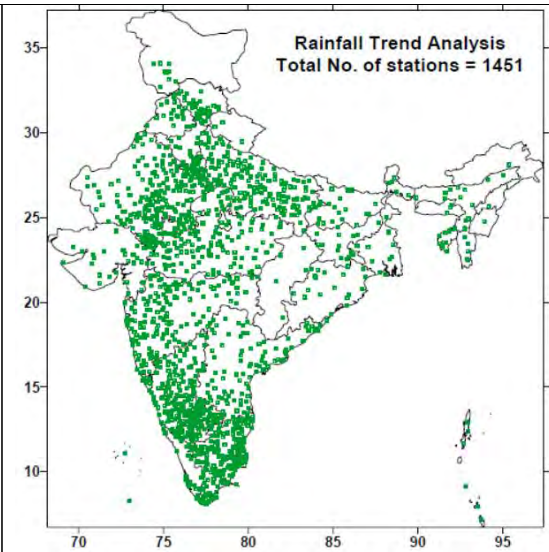


Figure taken from IMD Monograph showing distribution of 1451 stations used for state level rainfall trend analysis for 1951-2010. One can notice low density of stations in Uttarakhand in comparison to Himachal Pradesh and other states.

It can be noted clearly that the observations are based on the average of stations in respective states. Most of the data is not generated from the upper reaches.

The rate of decrease in annual mean minimum temperature is highest in Uttarakhand (-0.03 ^{o}C/year). The highest decrease in mean maximum temperature in monsoon season is observed in Uttarakhand (-0.04 ^{o}C/year)

Table 5 - Seasonal Rainfall from 2012-2015

Uttarakhand	Winter (Jan-Feb)		Pre monsoon (Mar-May)			Monsoon (Jun-Sep)				Post monsoon (Oct-Dec)			Annual
Subdivision-wise Seasonal & Annual Rainfall Normals (mm)	106.2		156			1229.1				89.6			1580.9
2012 seasonal rain figures	66.7 (-37)		88.1 (-44)			1122.2 (-9)				32.7 (-64)			1309.7 (-17)
Monthly Normals	52.1	54.1	57.6	33.3	65.1	167.8	428.1	426.3	206.9	58.6	9.7	21.3	
Actual Rain 2012	53.4 (2)	13.4 (-75)	30.8 (-46)	46.6 (40)	10.7 (-84)	48 (-71)	389.8 (-9)	461.2 (8)	223.3 (8)	8.8 (-85)	4.6 (-52)	19.2 (-10)	
2013 seasonal rain figures	261.3 (146)		65 (-58)			1373 (12)				36.2 (-60)			1735.4 (10)
Actual monthly Rain 2013	73 (40)	188.3 (248)	22 (-62)	24.7 (-26)	18.2 (-72)	488.9 (191)	413.4 (-3)	359.4 (-16)	111.3 (-46)	29.1 (-50)	3.2 (-67)	3.8 (-82)	
2014 seasonal rain figures	145.8 (37)		158.8 (2)			897.7 (-27)				85.1 (-5)			1287.4 (-19)
Actual monthly Rain 2014	45.9 (-12)	99.9 (85)	68.4 (19)	37.6 (13)	52.9 (-19)	62.9 (-63)	462.7 (8)	264.2 (-38)	107.9 (-48)	40.8 (-30)	0 (-100)	44.3 (108)	

[10] It is important to note that state averages of temperature and rainfall are calculated as simple arithmetic means of number of stations in the state.

2015 seasonal rain figures	117 (10)		222.6 (43)			881.9 (-28)				26.2 (-71)			1247.6 (-21)
Actual monthly Rain 2015	54.4 (4)	62.5 (16)	127.3 (121)	57.3 (72)	38 (-42)	187 (11)	337 (-21)	305.3 (-28)	52.6 (-75)	16.6 (-72)	2.3 (-76)	7.2 (-66)	

Source: Rainfall Statistics of India, Hydromet Division Report, IMD

The monsoon in the WHR sets in the last week of June and maximum monsoon rainfall is received from July to September. There was an excess monsoonal rain in 2012 (by 12%) whereas there was very high excess of June rainfall (by 191%) which is the beginning of rainfall period. In absolute terms, an excess rainfall of 144 mm in the monsoon season (2012) took place. Another trend visible in the monsoonal months is the decrease in rainfall after the mid monsoon period. The maximum decrease has been in the post monsoonal rains in the months of October and December. In fact the monsoon rains from July to September in 2012 were almost normal whereas it has remained highly distracted afterwards (2013-15). In 2016 too, lack of winter rains from October to December[11] were in the news and it also impacted the sowing of winter crops during that period. In January, 2017 (winter season), there were heavy rains witnessed in the Ladhyia (lower Sharda) catchments between 24-26 January.

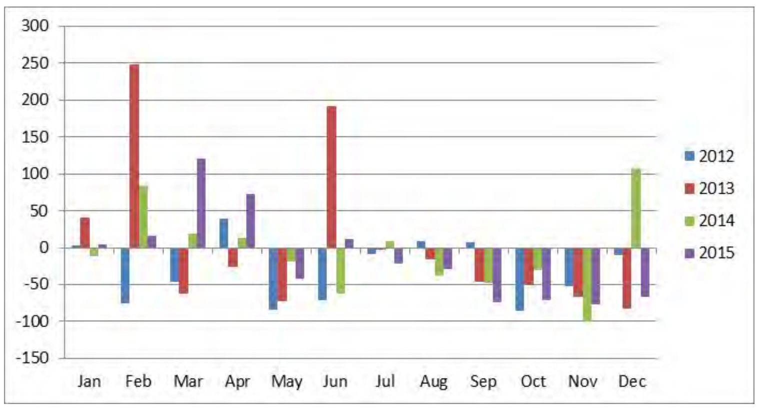
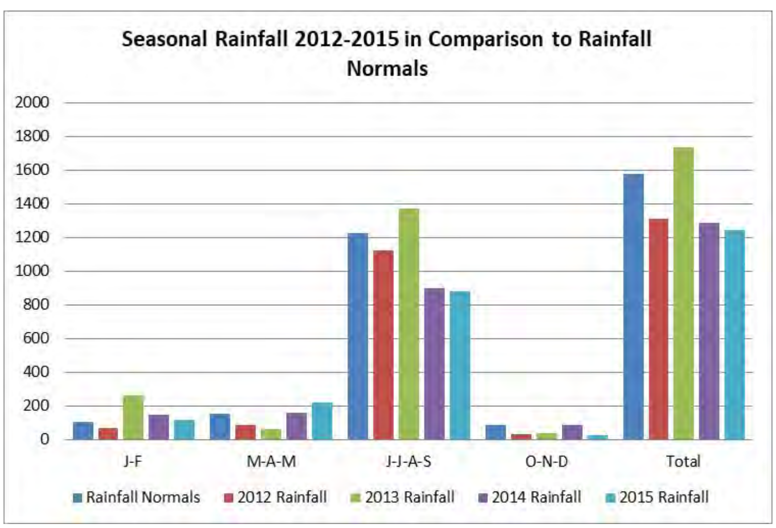


Figure 8 - Difference between Monthly Rainfall Normals[12] and Actual Monthly Rainfall in Uttarakhand



[11] Almora received no rainfall in October and November and only 0.4 mm in December (2016); Bageshwar received 3.3 mm in October followed by no rainfall in next two months; Champawat received no rainfall in November and December, it received 19mm rainfall in October

[12] Excess is when departure from Normals is 20% or more; Normal is when rainfall is -19% to +19%; deficient when departure from normals is -20% to -59%; scanty when departure from normal is -60% to -99%; -100% means no rain

The rainfall normals were crossed on five occasions, three in winter months, one in pre monsoon and one during monsoon period for the period 2012-2015. Uttarakhand as a whole receives 1580.9 mm of rain. 2013 monsoon rainfall is 12% excess from normal rainfall, winter rainfall for this year exceeded by whooping 146% from the normal. The four year trend indicates increasing winter rains over two month period (Jan-Feb) and decreasing post monsoon rainfall, when winter is about to set in.

According to our analysis[13] the two day rain storm (16 -17 June) over the state was caused by the disturbed large scale atmospheric conditions as a consequence of the interaction between the westward moving monsoon low and the eastward moving deep trough in the mid-latitude westerlies.

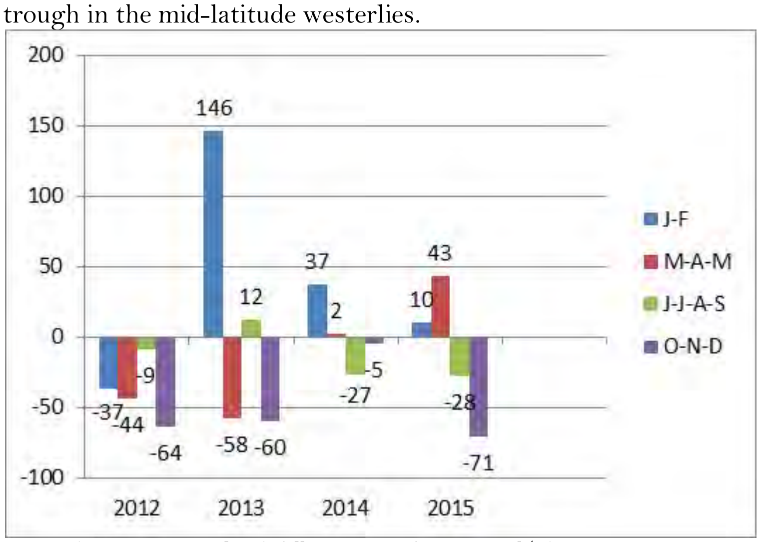


Figure 9 - Seasonal Rainfall Departures from Normal/s in percentage terms
Note: J-F (Winter), M-A-M (pre monsoon), J-J-A-S (monsoon), O-N-D (post monsoon)

Year 2012 shows a declining rainfall trend from normal whereas the winter and monsoonal rains show rainfall in 2013 as above normal (blue and green bars). In the preceding monsoon year of 2012 the monsoon rains were lesser than 9% of normals whereas succeeding monsoon years of 2014 and 2015 have had almost 1/3rd lesser rainfall during the monsoon season. It is pertinent to mention here that rainfall recording and confidence to conclude the spatial extent and quantum of rainfall depends on the spatial distribution of weather stations/weather monitoring parameters. The district averages thus leave a huge variation in rainfall received in lower, middle and upper regions.

As per the Indian Meteorological Department (IMD)[14], the rainfall in the State between 15 June and 18 June 2013 was measured at 385.1 mm[15], against the normal rainfall of 71.3 mm, which was in

The study concludes that spatially coherent decreasing trends were observed in terms of annual mean maximum temperature in the Indo-Gangetic plains with significant decrease in Punjab and Haryana. The maximum increase in annual mean maximum temperature was observed in Himachal Pradesh where the rate of change is +0.06 ^{0}C/year

The rate of decrease in annual mean minimum temperature is highest in Uttarakhand (-0.03 ^{0}C/yr). The highest decrease in mean maximum temperature in monsoon season is observed in Uttarakhand (-0.04 ^{0}C/yr)

Even though decrease in monsoon rainfall is spatially coherent but not significant in most of the states of India, it is still a concern for the rain-fed agriculture and water resources of the country.

Himachal and Uttarakhand have shown significant increase in mean maximum temperature in most of the months, +0.08 ^{0}C/yr (January & August) and +0.03 ^{0}C/yr (January, November & December) respectively.

Highest decrease is found in Uttarakhand in June (-0.06 ^{0}C/yr) in mean minimum temperature.

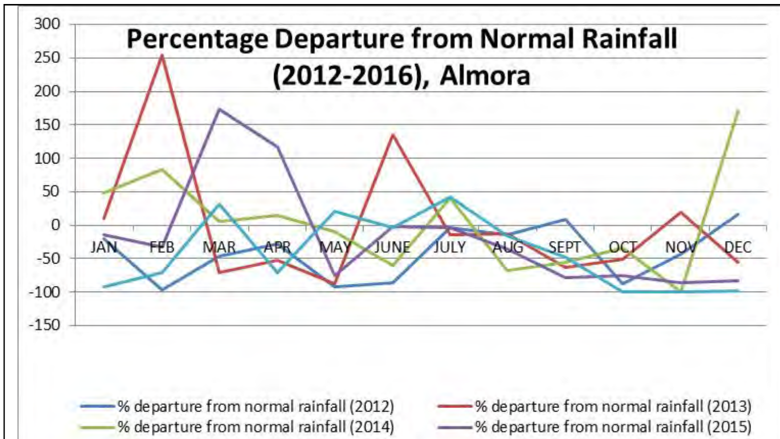
Significant change in winter months rainfall is found in January, it is decreasing in HP (-0.69 mm/yr). The highest significant decrease in monsoon months rainfall in July is in HP (-1.72 mm/yr) and few other states.

[13] IMD Met Monograph No.: ESSO/IMD/SYNOPTIC MET/01-2014/15
[14] http://nidm.gov.in/PDF/pubs/India%20Disaster%20Report%202013.pdf
[15] The seasonal monsoon rain in 2013 was 12% in excess to normal (144 mm)

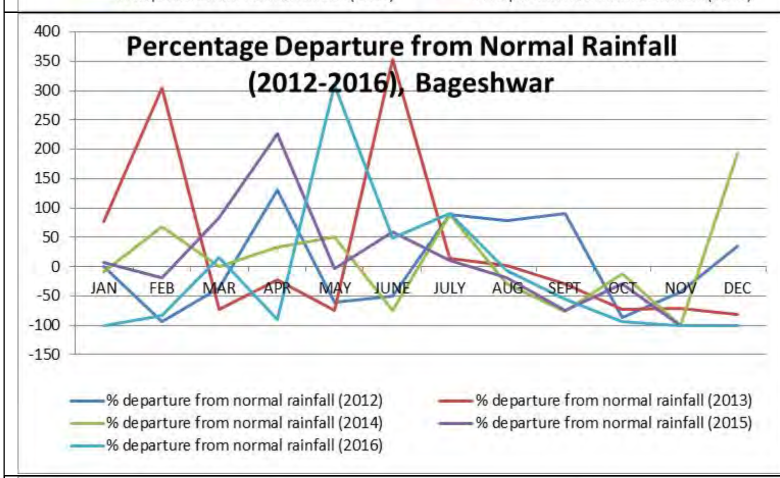
excess by 440%. Thus, it can be inferred that the disaster was the result of extra precipitation in a very short duration of time, which resulted in heavy water discharge in various rivers and streams.

June, is when the monsoon arrives during the last week but due to several weather disturbances and conditions, many concluded early arrival of monsoon on 16 June 2015 in the WHR. Advance process became very rapid between 13 and 16 June as the monsoon swept the rest of country in about 4 days, the process which normally takes 20-30 days. This was the exceptionally rapid advance as the monsoon covered the whole country in about 16-17 days from Kerala to West Rajasthan. For the season 2013, the onset and advance of monsoon over the entire country just occurred in one step between to 1st June to 17th June without any temporary hiatus anywhere.

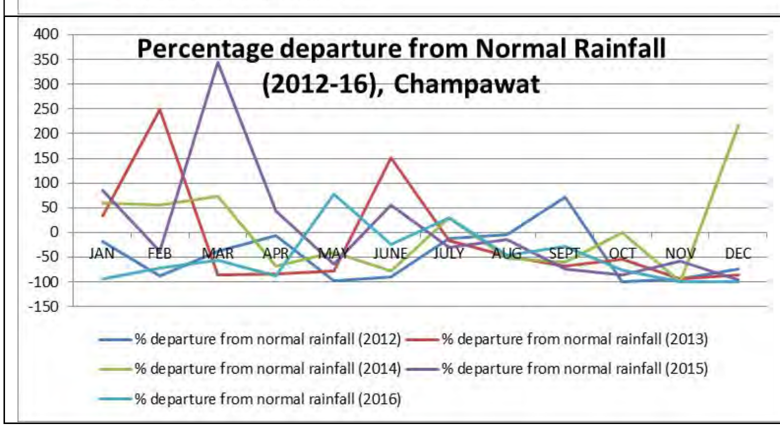
Figure 10 - District Wise Rainfall Trends



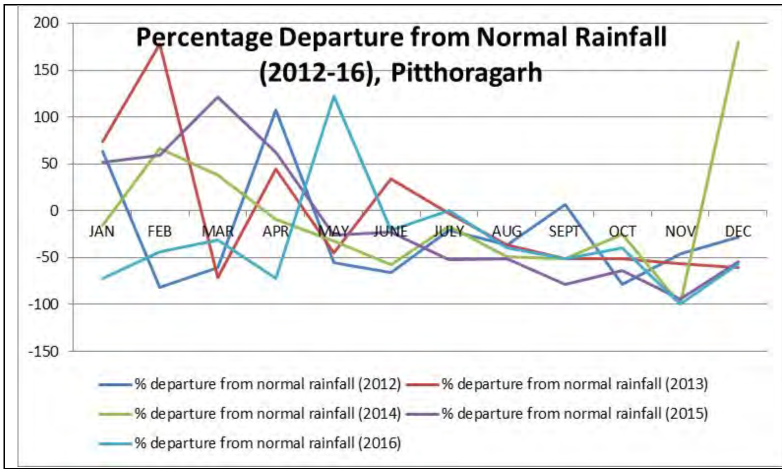
A dip from mid monsoon is seen across all the years with an exception in Nov. 2014. Year 2012 was all below normal rainfall. Pre monsoon rainfall in 2015 (march & april) stands out as excess rainfall registered for two months followed by a weak monsoon.



June 2013, April 2015, May 2016 show high excess rainfall months in these three years. More concentration of rainfall in the pre monsoon and winter months. 2016 rains indicate early departure in august and that in 2012 showed revival in July through September.



All the years (2012-16) show lesser rainfall in August-September period barring 2012 and the trend continues for post monsoon period too. Three out of the five years, show below normal rainfall in June and July.

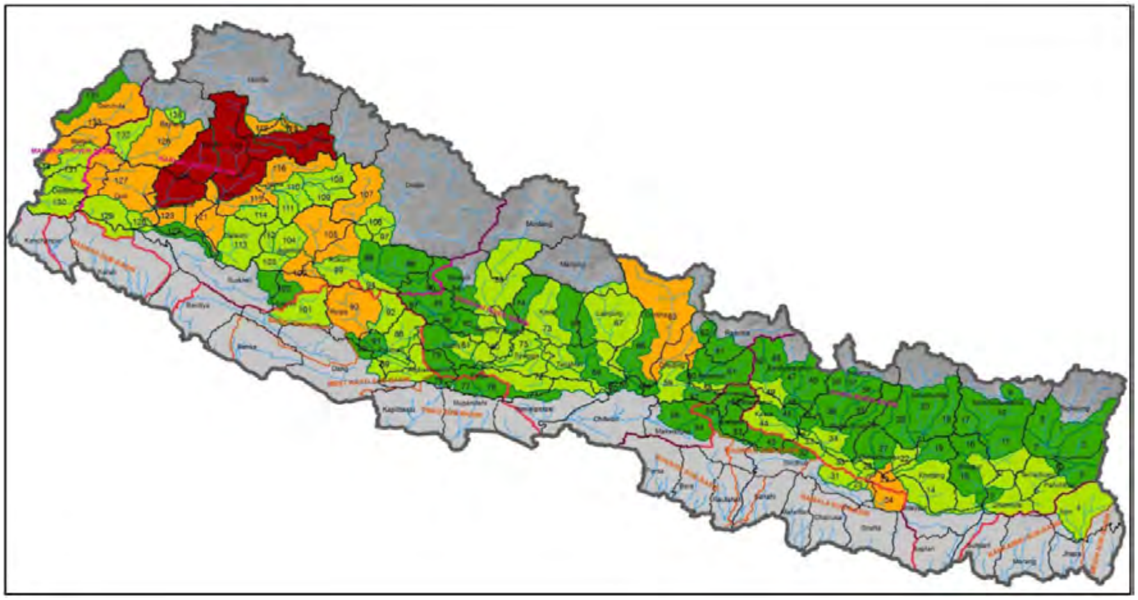


There has been consistent drop in rainfall from June onwards (barring June 2013), abruptly high rainfall in December 2014. Comparatively some increasing trends seen in winter and pre monsoon rainfall. Rainfall in Jan-Apr period of 2015 shows increasing trend.

District Pitthoragarh	• In 3 out of 5 years, an increasing trend has been seen in winter rainfall • Except June 2013 rainfall which was 34% above normal, rest monsoon rainfall is less than normal • Except December 2014 which witnessed 54 mm rain, rest of the post monsoonal rains are way below normal
District Champawat	• Winter rains showed an increasing trend from 2013 to 2015 in January and it exceeded 2.5 times normal in February 2013 • In march 2015, rainfall exceeded by over three times but in rest of the months of year it remained lower than the normal • Departing rains showed declining trend with the only exception of 2012 when it was 71% above normal. June rains exceeded by 1.5 times from normal • In the post monsoon period, there has been lesser rain than normal except December 2014 when it exceeded twice that of normal. High fluctuations were seen, from 217% in 2014 to -100 in 2016
District Bageshwar	• The highest rainfall in winters is observed in 2013 (February) at 189.1 mm, a positive departure of 304% from normal rainfall during this period. • Pre monsoon rainfall has been inconsistent in the District, 50% of the times rainfall in this period exceeded normal. Highest being 191.4 mm in May 2016, an increasing trend with 310%. April, which is the harvesting season has also seen fluctuating trends, with 3 out of 5 instances reporting increasing rainfall trends from the normal (see table) • The June 2013 rainfall is exceptionally high (599.5 mm which exceeded by 353%) whereas August too, has seen fluctuations but these are modest. September rainfall is decreasing over the years. • There is a net decrease in post monsoon rain in October-November period whereas some revival seen during December for 2012 & 2014. Almost no rainfall in 2015 & 2016 in the post monsoon season
District Almora	• In 4 out of 10 instances, winter rains exceeded normal and it exceeded almost 2.5 times in 2013 • In 6 out of 15 instances, rainfall is excess of normal. Exceptionally high rainfall during this period in March 2015 at 129.4 mm (173%) • Rainfall trend has been decreasing, especially in August & September whereas June & July rainfall has been moderate. Highest for these reference years (2012-2016) being 310.5 mm (135%) in June 2013 • There is a declining trend of rain in post monsoon season. Only December received 56.9 mm rainfall in 2014 which was 171% above normal. Almost no rainfall received in 2016 post monsoon period.

5.3.3 Climate Change and Vulnerability Mapping in Watersheds of Nepal

The entire middle Himalayas of Nepal has been subdivided in 135 watersheds, out of which watershed numbers 130, 131, 133, and 135 falls in Sarda/Mahakali river basin, as shown in figure. Climate Change and Vulnerability Mapping in Watersheds in Middle and High Himalayas of Nepal was conducted in 2012, aimed at building climate resilience of watersheds in mountain eco-regions. This mapping was done by International Water Management Institute for Department of Soil Conservation and Watershed Management (DSCWM), government of Nepal and it was published by Asian Development Bank.



For this purpose, three sets of indicators were identified - for sensitivity assessment of watersheds, for risk/exposure assessment of watersheds and anthropogenic indicators for sensitivity assessment of watersheds, as shown in the table below. On the basis of above indicators and parameters, let us look at the prevailing scenarios in the watersheds of Sarda river basin in Nepal.

Indicators considered for sensitivity assessment of watersheds

S N	Parameters	Direct Indicators/Indices	Proxy Indicators/Indices
1.	Ecology		Land Use & Land Cover
			Area
			Protected area coverage
			Area
			Topography (slope, aspect)
			Area
			Drainage density
			Area
			Dominant climate
			Area
2.	Human		Population
			Area

Indicators considered for risk/exposure assessment of watersheds

S N	Parameters	Direct Indicators/Indices	Proxy Indicators/Indices

3.	Temperature and rainfall	Mean seasonal temperature trend	
		Mean seasonal rainfall trend	
4.	Landslide and flood	Death	
		Injured	
		Property loss	
		Occurrence	
		Positive annual rainfall trend	
5.	Drought/ flood risk index	Daily precipitation	Population pressure on forest land
		Food surplus and deficiency	
6.	Human ecology		Human poverty index
			Accessibility
7.	Physical ecology		Surface soil erosion
			Mass wasting

Anthropogenic indicators considered for sensitivity assessment of watersheds

S N	Parameters	Direct Indicators/Indices	Proxy Indicators/Indices
8.	Socio-economic	Human development index	
		Human poverty index	
		Gender development index	
		Human empowerment index	
9.	Infrastructure	Road length	
		Area	
		PSTN landline phone	
		Population	
		Electricity consumers	
		Population	
10.	Technology	Irrigated land	
		Area	
		Terraced	
		Area	
		Existence of intervention	
		Number	

Assessment of watersheds in Sarda River Basin in Nepal is shown in the table given below

S N	Indicator/Parameter	Watershed No. 130	Watershed No. 131	Watershed No. 133	Watershed No. 134	Watershed No. 135
1.	Ecological Sensitivity	Moderate (0.360-0.460)	High (0.460-0.615)	Very high (0.615-1.000)	Low (0.000-0.360)	Low (0.000-0.360)
2.	Human Sensitivity	Low (0.000-0.352)	Low (0.000-0.352)	Low (0.000-0.352)	Moderate (0.352-0.587)	Low (0.000-0.352)
3.	Rainfall & Temp Risk	Moderate (0.415-0.598)	Moderate (0.415-0.598)	Moderate (0.415-0.598)	Moderate (0.415-0.598)	Moderate (0.415-0.598)
4.	Human ecological risk	Low (0.000-0.487)	Moderate (0.487-0.676)	Low (0.000-0.487)	Moderate (0.487-0.676)	Low (0.000-0.487)
5.	Physical ecological risk	Very high (0.762-1.000)	Moderate (0.268-0.515)	Very high (0.762-1.000)	Low (0.000-0.268)	Low (0.000-0.268)
6.	Landslide/Flood Risk Exposure	Low (0.000-0.184)	Low (0.000-0.184)	Low (0.000-0.184)	Low (0.000-0.184)	Moderate (0.184-0.343)
7.	Drought and Food Risk/Exposure	Low (0.000-0.446)	Moderate (0.446-0.632)	Low (0.000-0.446)	Moderate (0.446-0.632)	Low (0.000-0.446)
8.	Socio-economic adaptation Indices	Low (0.000-0.430	Low (0.000-0.430	Low (0.000-0.430	Low (0.000-0.430	Low (0.000-0.430)
9.	Infrastructure adaptation capability Indices	Moderate (0.098-0.233)	High (0.233-0.368)	High (0.233-0.368)	Low (0.000-0.098)	Low (0.000-0.098)
10.	Technology-adaptation capability sub-indices and	Low (0.000-	Moderate (0.299-	High (0.497-	Low (0.000-	Low (0.000-

	their weightages	0.299)	0.497)	0.694)	0.299)	0.299)

In conclusion, the quantification of local climate change impacts and vulnerability assessments are imperative for the design of adaptation measures. The use of such assessments will allow the various adaptation intervention programs to be targeted to areas where the risks of catastrophic climate-induced impacts are highest. Therefore, the final vulnerability map and various other assessments in the study are expected to provide necessary information to the government for developing a scientifically justified road map for the planning of effective watershed management interventions to build climate resilience in the mountain watersheds.

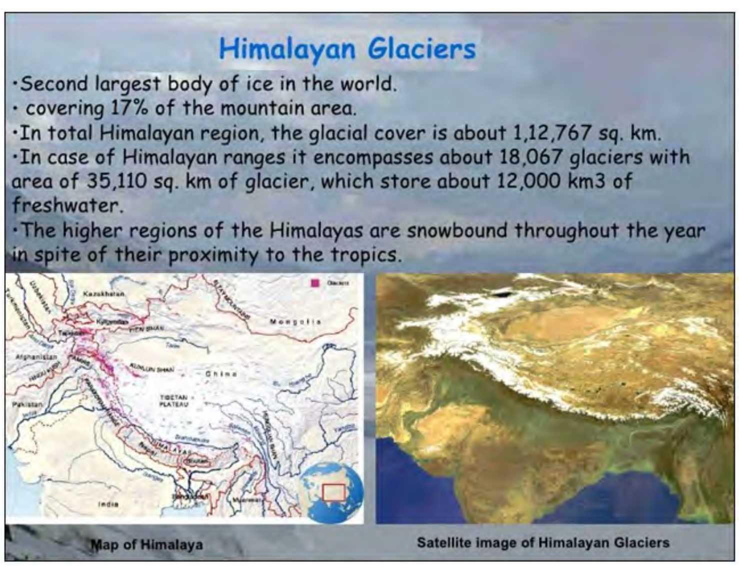
5.4 Glacial Retreat

Most of the world's "reference glaciers"— those 200-plus that have been under observation over the past 60 years by the Switzerland-based U.N. World Glacier Monitoring Service—are now sloughing off ice faster than it accumulates, and have begun to record significant losses.

The Himalayas are considered to be among the most vulnerable to climate change. The 20th century witnessed a consistent warming of the Himalayas. Studies show that the Himalayas have warmed at a faster rate than the global average. The Himalayan glaciers, as noted above, are retreating at a faster rate than the global average. Advanced blooming, migration of species, and changed timings of hibernation and breeding suggests that the climate in the Himalayan region is changing. The northward movement of species and tree line is also widely reported. An increased frequency and intensity of extreme weather events is also noted in the Himalayas. Cloud bursts intense episodes of rainfall in Uttarakhand and Nepal in June 2013 and delayed but heavy rainfall in Jammu and Kashmir in September 2014 are some of the indicators of climate change in the Himalayas. The August 2017 cloudburst in the Vyas valley affected the whole upper Tawaghat-Malpa region extending across river Kali. The impacts of climate change in Himalayas have local, regional and global implications.

It is apparent now that the glacier retreat rate has accelerated in recent times as compared to the 1970s. The valley glaciers and small glaciers are retreating fast. For instance, the Imja glacier retreated at an average rate of 42 m per year in the period from 1962 to 2000. The retreat rate increased to 74 m per year during 2001 and 2006, when it became one of the fastest-retreating glaciers in the Himalayas. Some basic information on Himalayan glaciers is shown in figure below.

Figure 11 - The Himalayan Glaciers



Source: Open access internet

During a glacier retreat, there is a high probability of formation of new lakes, as well as merging and expansion of existing ones, at the toe of a valley glacier. In the Dudh Koshi sub-basin of Nepal, the total number of lakes has decreased by 37%, but their total area has increased by 21%, corroborating increased melting of glaciers.

Glacier Retreat in The Mahakali Basin

The Mahakali basin has around 435 glaciers of varying size covering an area of 842 km^2 which is almost 5.5% of the total basin area upto Banbasa barrage. The ice reserves estimated is around 50 km^2.

The upper reaches of Darchula district in Nepal and Pitthoragarh district's upper reaches comprising of Vyas, Darma, Munsiyari, Chaudans are glaciated zones in the basin. The Darma Ganga or the Dhauli flows are supplemented by the snow melt it receives within its catchment. The Api Himal on the other hand in Nepal portrays similar features. A study conducted by ICIMOD[16] in 2014 discusses some key features of glaciers in the Mahakali basin in three parts. It provides an account of glaciers, decadal changes etc. The range variation of these glaciers is from 3694 to 6850 masl, mountain type glaciers at higher altitude than the valley ones. The study concludes that there were 164 glaciers in the Napalese part of the basin, an area of 113 Km^2 and the estimated ice reserves of about 7 km^3.

Other aspects covered by the report are as under;

- The majority of glaciers (93%) were mountain type and 7% were valley type but these large glaciers contributed 50% of the total glacier area and 64% of the estimated ice reserves.
- Regarding the decadal glacier changes in Nepal's Mahakali basin, the study concludes that the number of glaciers increased by 26% (34 nos.) over the 30-year period, with the greatest increase between 2000 and 2010.
- The glacier area decreased by 29% (46 km^2) and the estimated ice reserves by 36% (4 km^3), with the greatest change between ~1980 and 1990.
- The majority of glaciers in the Mahakali basin had mean slopes between 20° and 50°, and most commonly between 30° and 40°, with the greatest area for slopes of 20–30°. There were no glaciers with slopes of less than 10° or more than 60°.
- The Mahakali basin has an elongated north-south orientation, and the majority of glaciers have a west facing aspect. Briefly, the number of glaciers increased for all aspects, except north, east, and south, which showed very small reductions. In contrast, the glacial area decreased for all aspects except northwest, which showed a marked increase, with the greatest losses for the west aspect.

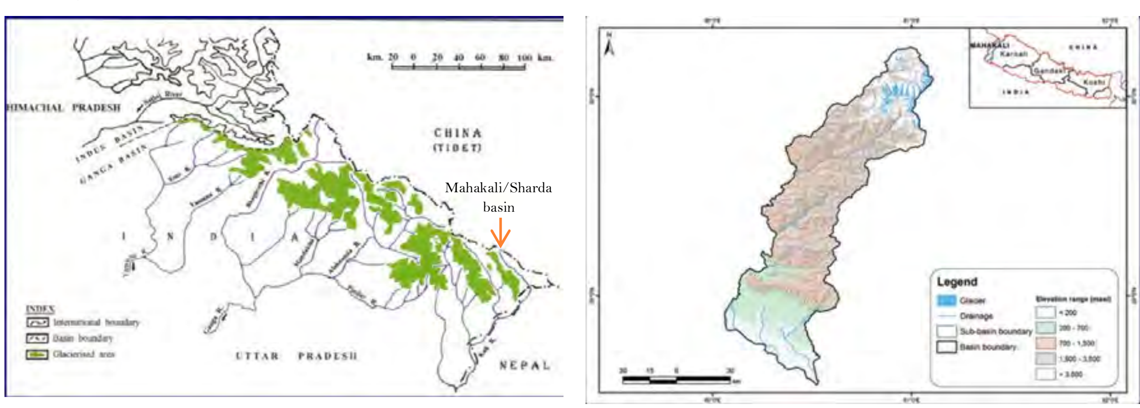


Figure 12 Glaciated area in Mahakali Basin shown above in India [left] (Gangakosh, NIH Roorkee) and Nepal [right] (ICIMOD)

[16] Glacier status in Nepal and Decadal Change from 1980 to 2010 based on Landsat data

The Indian part of the Mahakali basin has 271 glaciers covering an area of 729.42 km^2 and ice reserves of 43.77 km^3 with mean glaciation level at approximately 5200 masl. Milam glacier (located NNE of Nanda Devi, 7816 m) and many other subsidiary glaciers make up the Goriganga, the Namik and other smaller glaciers contribute and make up the Eastern Ramganga; the valley and mountain glaciers in the Darma valley make up the Dhauliganga. The other glaciers are Nui, Lebong, Rama, Baling, Gunna, Burphu, Nagling, Pancha Chuli group of glaciers on the Goriganga and the Lassar Yankti divide and upwards of it is Rajramba, Chiring We.

The glaciers are receding and the snow line is modulating. An overview of glaciated zone of Mahakali basin from 1984 to 2016 is shown through an array of time stamped images taken from Google Earth (January 2018) to see a wide perspective of stable years followed by recession in snow coverage. The Mahakali basin boundary is shown by blue line and two places 'Dantu' in the Dhauliganga basin and 'Munsiyari' in the Goriganga basin are marked as reference points. One can notice good snow cover from 1984-1998 (a stable period from 1984-1992, after which moderate reduction is seen till 1998). After 1998, there is consistent reduction seen in the snow area in the upper zones of Mahakali basin barring 2002 and 2008 which is relatively better than other years in the period from 1998-2016. Increasingly, the snowline has been shifting upwards i.e. from the valleys to the mountain tops/ridges and upper reach slopes.

The Himalayas are the youngest mountain systems, studies of glaciers in NW Himalayas in the Indus and Ganges basin have clearly indicated the changes due to climate change. The variations in climate affect the accumulation and ablation rate of glaciers. As many rivers are glacial fed, the flow and sedimentation characteristics coupled with climate change will determine the response of rivers. It thus also indicates requirement of a comprehensive approach towards development planning and policy interventions. Few of the images below will reveal the glaciated zone situation in Mahakali basin.

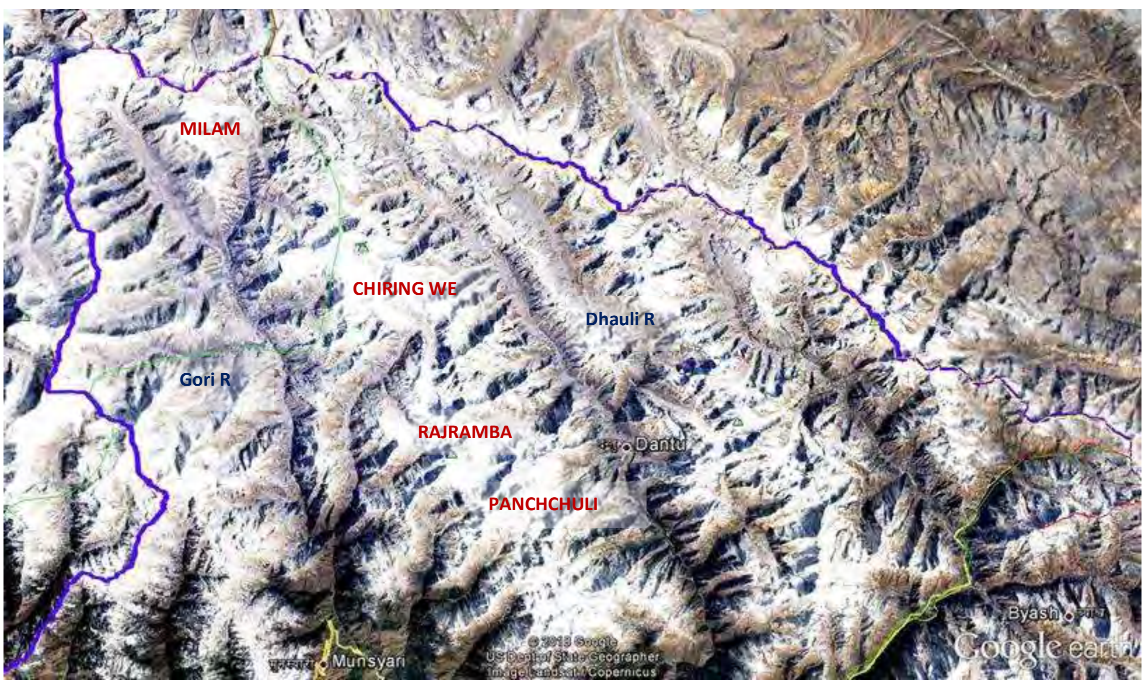


Figure 13 – Google Earth image of Glaciated zone of Mahakali Basin (Glaciers names in red)

Figure 14 – Time series of Glaciated zone in the Mahakali Basin – Melting ON!

December 1984

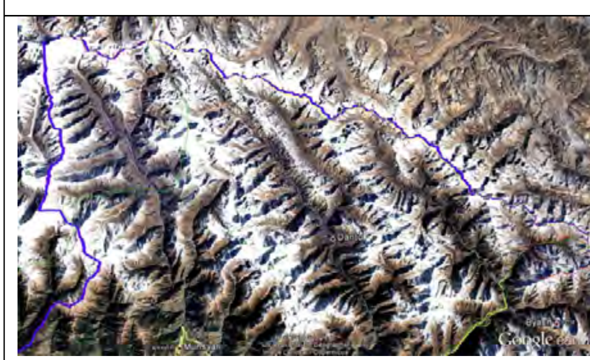
December 1987

December 1990

December 1992

December 1994

December 1995



December 1996

December 1998

December 2000

December 2002

December 2004

December 2006

December 2008

December 2010

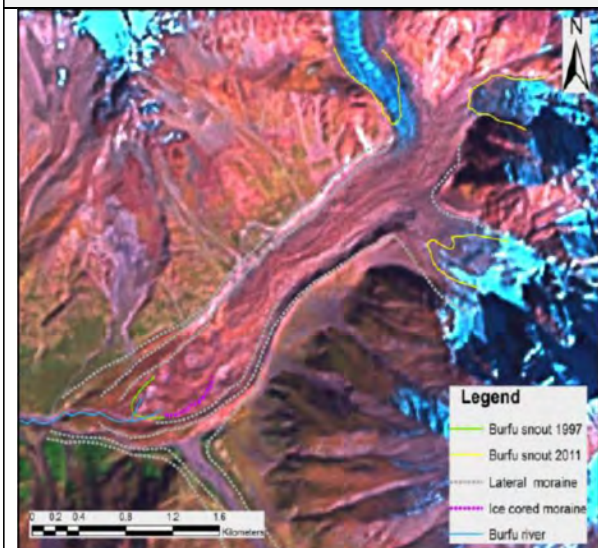
December 2012

December 2014

December 2015

December 2016

Burphu Glacier, Goriganga Valley

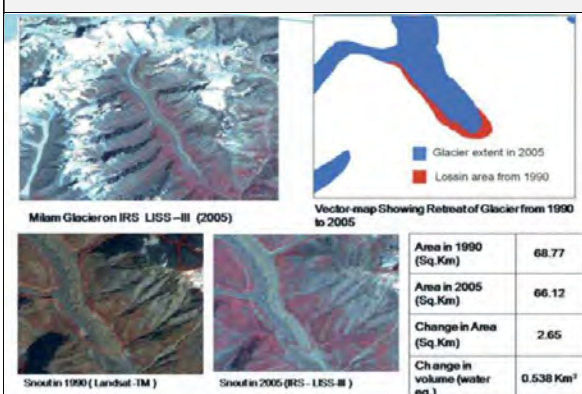


Burphu gad feeds the Goriganga. It is estimated that the retreat of this Glacier has been relatively high i.e. 69.66 m/year based on the observations from 1963-2011 during which it vacated the area of 1.43 km².

The authors point to the fact based on their visits that the higher reaches of the glacier have completely detached from the main glacier body and this is attributed to several factors like reduced winter precipitation (see in the sections on rainfall of this chapter), slope and aspect.

Image Source: IJCSMC, Vol. 3, Issue. 4, April 2014, Change Monitoring of Burphu Glacier from 1963 to 2011 using Remote Sensing [Rahul Singh, Dr. Renu Dhir]

Milam Glacier, Goriganga Valley



The glacier is a valley glacier having compound basin orienting towards SE from the Trishul peak. It is 16.7 km long and receives ice from two cirques on the Trishul peak and seven tributary glaciers in the Goriganga basin.

Image Source: Observed Changes in the Himalayan-Tibetan Glaciers, K. KASTURIRANGAN, R.R. NAVALGUND AND AJAI

Image Source: Current Science, VOL. 100, NO. 9, 10 MAY 2011, *K. Babu Govindha Raj*

The historical recession of the Milam Glacier reported by Cotter and Brown in 1907 and later by Jangpangi in 1958 illustrates that the glacier retreated 800 m (1849 to 1906) and further 620 m (1906 to 1957) respectively. The analysis of snout altitude derived from the toposheet (1954) and OSM map (1988) shows that the glacier snout was at an altitude of 3490 m and 3520 m during 1954 and 1988 respectively. The location of the snout in the satellite data of 2006 was at an altitude of 3580 m, indicating a vertical shift of the snout 90 ± 33 m in a span of 52 years. Features such as sharp bending of Goriganga stream channel at the downstream are clear indicators of the occurrence of moraines

Glacial Retreat Observed in other Glaciated Basins of NW Himalayas

Retreat of the Gangotri Glacier snout during last 220 years
Source: Jeff Kargel, United States Geological Survey, USA

Earlier studies on selected glaciers of Indian Himalaya indicate that most of the glaciers are retreating continuously since post-glacial time. Of these, the Siachen and Pindari Glaciers retreated at a rate of 31.5 m/year and 23.5 m/year respectively (Vohra, 1981). Gangotri Glacier is retreating at an average rate of 18 m/year (Thakur et al. 1991). Dobhal et al. (1999) monitored the shifting of snout of Dokriani Bamak Glacier in the Garhwal Himalaya and found 586 m retreat during the period 1962 to 1997. The average retreat was 16.5 m/year. Matny found Dokriani Bamak Glacier retreated by 20 m in 1998, compared to an average retreat of 16.5 m, over the previous thirty-five years. (Matny, L., 2000).

One of the best examples of glacier retreat is shown in the figure (left) where the position of Gangotri Glacier snout has been shifted about 2 km during 1780 to 2001 and is in a continuous process of recession.

During the period 1963-1997, Kulkarni and others found the retreat of Janapa Glacier by 696 m, Jorya Garang by 425 m, Naradu Garang by 550 m, Bilare Bange by 90 m, Karu Garang by 800 m and Baspa Bamak by 380 m (Kulkarni et al 2004). They further observed a massive glacial retreat of 6.8 km (178 m/year) in Parbati Glacier in Kullu District during 1962 to 2000. In their studies they observed an overall 19 percent retreat in glaciated area and 23 percent in glacier volume in last 39 years.

Based on the field survey carried out in 1999, the snout of Shaune Garang Glacier was marked at an elevation of 4460 AMSL in contrast to the Survey of India's 1962 topographic map, which marked the snout at an altitude of 4360 AMSL (Philip and Sah 2004). This indicates a vertical shift of 100 m and horizontal shift of 1500 m within a span of 37 years. These observations also suggest that global warming has affected snow-glacier melt and runoff pattern in the Himalaya.

The limits to climate change are numerous. In the Mahakali basin only a few prominent glaciers have some sort of time series information interpreted from remote sensing data. In the absence of meteorological data at micro levels, the correlation between retreat and meteorological events cannot be established with much accuracy – it requires this gap to be fulfilled by advocating for instrumentation in this glaciated basins. The google earth images and other interpreted glacier area images indicate the requirement of much greater need of meteorological information in snow bound areas to say with certainty the river behaviour and other characteristics, as it leaves its upper course and makes its journey downstream.

It is evident from the above discussion that climate change has already set in motion and will have adverse all-round impacts on livelihood and environment

Thus, the climate change in Uttarakhand will lead to widespread adverse impact and de-accelerate the economy in a more profound ways in not so distant future. The phenomenon of migration of 'environmental refugees' (distinct from economic migrants) has already set in motion in the state and in all likelihood is going to increase manifold.

6

Contents

6. REGIONAL CONNECTIVITY AND ENVIRONMENT

6.1 Introduction

Roads have always been the lifeline of people, especially in the hills where access to basic facilities is challenged by the nature of terrain and lack of accessibility and many a times limited modes of transport. The 'socially desirable' tag for roads is also reflected in the norms where population threshold becomes the criteria for proposing roads, more and more roads are opened for improving access to general public, trade, defence and reducing response time during disasters – broadly roads have become an indicator of measuring growth. Roads are considered important from the standpoint of security and strategic importance in the basin. But still many villages like Chuka[1], Thapliyalkheda (habitation part across Sharda River) on the bank of River Sharda have issues of inaccessibility along the border in Champawat district.

The modes of transport like air and rail remain restricted to a few urban centres[2] but now a more liberalised view is being taken on expanding rail links to upper valleys too. One of the major components of road building is the PMGSY programme for rural connectivity managed by the PWD whereas the border roads are maintained and managed by the Border Roads Organisation (BRO). River Kali/Sharda forms border between India and Nepal for some stretches.

Table 1 - Category of Roads and their Length in Kilometers, Uttarakhand

S. N.	Category of Road	Road length (in 2000)	Road Length (in 2016)
1	National Highway	526.00	2186.00
2	State Highway	1235.04	4521.07
3	Major District Road	1364.15	2151.81
4	Other District Road	4583.01	2651.40
5	Village Road	7446.23	19537.38
6	Light Vehicle Road	315.77	732.21
7	Bridle Roads/Border Tracks	3970.00	3186.00
		19440.2	34965.87

Source: PWD Website

After the formation of new state of Uttarakhand, there is a marked increase in length of roads, especially National Highways and State highways - the top hierarchy in the road network. Remarkably, the increase in village-roads is almost thrice during 2000-2016, demonstrating increased emphasis on connecting habitations. The impetus was provided by PMGSY, a scheme to link habitations whose launch coincided with the formation of three new states namely Uttarakhand, Jharkhand and Chhattisgarh.

6.2 Rural connectivity and Environmental Challenges

Road building in hills require environmental-sensitive approach so that roads connect people and not disintegrate the landform, ecology and environmental continuity of the region. In case of PMGSY, the objective is to increase linkages by maximising connectivity in the core network. The PMGSY scheme provides an opportunity to connect unconnected habitations in special category states like Uttarakhand. PMGSY is a 100% Central government sponsored scheme launched in December 2000 to provide all weather road to all unconnected rural habitations with a population of 250 persons and above in Uttarakhand. Below, a comparison of 3 districts falling in the Mahakali Basin is being made, showing large numbers of habitations still unconnected through an all-weather road – this reality also portrays challenges for impacts on environment and already established infrastructure.

[1] Few of the villagers shared that they travel in the mining vehicles which ply between Chalthi and Chuka on the riverbed of Ladhiya

[2] Naini-Saini airstrip (District Pitthoragarh) has been in the talks from almost an decade but there is no definite strategy on making it operational, its expansion was sought in 2016

Table 2 – Unconnected Habitations		
S. N.	**District**	**Eligible Unconnected Habitations**
1	Pitthoragarh	989
2	Bageshwar	416
3	Champawat	442
4	Almora	1334

Source: PMGSY portal

In the mountain-context it is perceived that in higher Himalayas, habitations are spread out and hence require more roads compared to lower Himalayas. For the three districts, per unconnected habitations, average population was 176 persons in Pitthoragarh, 228 persons in Champawat and 231 persons in Bageshwar respectively – as existed in 2001.

Table 3 - Habitation Coverage under PMGSY in Select Districts							
	2017-18		2016-17		2015-16		
District	Length of Road (in km)	No. of Habitations connected	Length of Road (in km)	No. of Habitations connected	Length of Road (in km)	No. of Habitations connected	Total Length (& habitations)
Pitthoragarh	39.3	5	224.85	12	131.83	7	395.98 (24)
Bageshwar	60.993	2	144.79	7	50.64	7	256.423 (16)
Champawat	41.475	5	44.75	1	111.07	2	197.295 (8)
Almora	103.075	3	188.6	6	94.519	11	386.194 (20)
Total	244.843	15	602.99	26	388.059	27	1235.892 (68)

Source: PMGSY online Portal, 2017

Of the total habitations[3] connected in the above districts, 43% are those habitations with population of 250-499, followed by 26.32% (less than 250 persons), and closely followed by 24.79% (population range of 500-999 persons). Of the remaining unconnected habitations[4] majority i.e. 96% of the habitations (of the total 2632 under these 3 districts) have population less than 250. All the three hilly districts are extremely vulnerable and susceptible to landslides and unconformities, adding to the whole gamut of environmental and geological challenges. The 1236 kilometers of rural road network added over the last three years connecting 68 habitations, mostly falls in the middle-high Himalayan districts.

Environmental Concerns

Hill side road cutting, muck dumping, slope stabilisation, proper demarcation and securing existing infrastructure are the most critical factors for a comprehensive environmental management of building roads in the hills. Most often departmental coordination is disconnected alongwith lack of clear policy on environmental safeguards. Roads and bridges are exempted from environment clearance process under the Environment Protection Act, 1976, however the project has to undergo the process of forest clearance. Uttarakhand has a high forest cover (61.43%), and it is very likely that rural road connectivity will demand more forests for non-forest use upon which the flora-fauna thrive and communities depend on forests for minor forest produce. Van Panchayats, for example are custodians of forests and many have been able to maintain the quality of forests but even these community institutions are devoid of any information regarding loss-assessment of van Panchayat land. Coupled with geological structures, many road alignments become chronic spots of land slips which recur in rainy season.

[3] 718 habitations; 182 in Pitthoragarh, 114 in Bageshwar, 318 in Almora and 104 in Champawat

[4] 2632 habitations; 989 in Pitthoragarh, 416 in Bageshwar, 924 in Almora and 303 in Champawat

Forest clearance process requires recommendations from the state government before awarding preliminary clearance (Stage I) with conditions attached to it. The final (Stage II) forest clearance is awarded, subject to fulfilment of conditions laid out in the preliminary stage. The value of such forests is benchmarked as per the assessed class & quality of forests and is termed as Net Present Value (NPV). Many of the middle Himalayan forests have a rich biodiversity and provide as well as regulate several environmental services. These forests also function as water storehouses, releasing water in the lower reaches even during the lean periods (off monsoon season). The loss of trees due to forest diversion ignores such functions and their loss is 'priced' as per their commercial value or the amounts so notified from one forest circle to another forest circle, the forest diversion requires compensatory afforestation over equivalent area of non-forest land and if such land is not available than afforestation has to be done on degraded forest land double the area of diversion. But to make these processes fail-safe, an upbeat institutional behaviour is basic requisite with the objective of maintaining environmental safeguards hand-in-hand with providing connectivity. Here is why;

PMGSY guidelines put the responsibility of the State Government/District Panchayat to ensure availability of land for works and a certificate of available land is required with land records to avoid disputes. Another important provision is to not start physical works unless necessary land is available.

Audit scrutiny in selected PIUs showed that two road works amounting to Rs 7.15 Crore were taken up (February 2010 & December 2011) without obtaining necessary clearance for using forest land. Expenditure of Rs. 2.84 Crore thereon was rendered idle as the necessary forest clearance was still awaited and works were held-up. Further, mobilisation/machinery advance of Rs. 35 lakh was paid (April 2010) to the contractor in one case despite the fact that necessary forest clearance was awaited. Out of Rs 35 lakh, Rs 10.50 lakh were recovered and recovery of remaining Rs. 24.5 lakh was pending (May 2013) due to non-completion of the work.

Table 4 - Audit Report (Social, General, Revenue and Economic Sectors) for year ended 31.03.2013

User Agency	No. of Road Stretches	Forest area diversion[5] (hectares)
Construction Division, Almora	48	181.1985
Construction Division, Askote	20	50.5531
EE TY Div. PWD, Berinag	14	71.68
PMGSY Lohaghat	11	54.379
Provincial Div, PWD - Bageshwar	46	126.2123
PWD	1	106.23
PWD Kapkot	39	123.908
PMGSY	54	327.7495
Total	**233**	**1041.9104**

Source: Forest Clearance Portal of MoEFCC
Note:

i. User agency as per records maintained on MoEFCC website

[5] Table 6 of Report No. 21 of 2013 'Compensatory Afforestation in India' shows divergence in figures provided by the Regional office of MOEF and State Forest Department on forest land diverted and non-forest land received. The RO indicated half the area diverted from that indicated by the state (9669.74 hectare) whereas RO indicated 3315.23 hectare of non-forest land received, the state indicated 'nil'. The para explaining Table 6 is quoted for reference "From the above table, it can be seen that there are substantial variation between the figures provided by the RO and the State Forest Department. In fact in not a single State/UT did we notice that there was convergence of data between the concerned State Forest Department and the Regional office of the MOEF. Not only does it highlight lack of a system of periodic reconciliation of data between the two authorities but also raises doubts on the reliability of the data. In the absence of authenticated data and non-production of proof of mutation/transfer of identified land in favour of Forest Department, it cannot be assured that the final clearances were given only on the fulfilment of all the stipulated conditions and the forest lands have been appropriately safeguarded.

ii. The above list largely includes road projects in the Mahakali catchment

After 2015, 233 road projects applied for diversion of forest land for road construction purpose, 37% of the area diverted is under PMGSY programme. Almost 10% of total proposed forest diversion[6] (above table) is for Tanakpur-Jauljibi road[7] along River Kali which is administered by the Border Roads programme of Ministry of Home Affairs. Almost 29% projects[8] have got in principal clearance (Stage I) i.e. they are granted with pre conditions to be fulfilled to proceed further whereas around 20% projects are at draft stage and another 43% are pending at various levels with the state, nodal officer and user agency itself. The CAG report of 2014 also portrays a similar trend of proposals pending at various levels but the most concerning issue highlighted is inability to furnish technical information from the state.

A Few Examples

Ladhiya valley lies between Mornaula-Devidhura ridge in North and Debguru ridge in the South and this valley is connected to Haldwani and Tanakpur via Dhunaghat and Champawat respectively. Undoubtedly, roads act as lifeline of people in the hills and over the last two decades penetration of roads has enabled linking interior areas and connection of villages to motorable roads has increased significantly. PMGSY has been a trigger for rural connectivity at village level and many people are all praise for PMGSY – people can move faster. As a result people have also moved to toks (hamlet) where they can grow diverse crops, says Kheemanand of Taand. The land near the River is used for growing rice and wheat and varieties like *manduwa*, *jhingora* are grown up as these are sown during monsoon months and hardly need irrigation.

6 MoEFCC in its letter dated 29.01.2015 cites MHAs concern on lengthy processes involved in grant of approval under the FCA 1980, creation of border security related infrastructure along the international border is getting delayed. Further according to condition (viii) State Government shall realise from the user agency funds for creation of compensatory afforestation over degraded forest land equal in extent to the area of forest land utilised for construction/widening of the roads. This relaxation is derived from the guidelines No.11-246/2014-FC dated 4th July, 2014 regarding special provision for creation of CA in lieu of forest land diverted for creation of strategic defence projects (including infrastructure and road projects) being taken up in the area located within 100 km aerial distance from the LAC by any user agency identified by the Ministry of Defence.

7 Pending at Regional Office [File No. 8-54/2014-FC]

8 Total 88 road works pertaining to Phase-VI to IX of State for connecting 48 habitations having population of 22,438 were pending on account of non-receipt of necessary forest clearances at various levels. Audit scrutiny of 20 out of these 88 cases pending for forest clearance showed that there were delays of 102 to 1821 days in preparation of forest proposals by the divisional officers. [Distribution of 88 cases - GOI:13, Forest Nodal Office: 7, DFOs: 23, Under Objection: 3, In-principle Sanction:22, proposal in hand: 10 & cancelled proposals by GoI:10]

Figure 1 – New and Proposed Road Networks in Ladhiya Valley

A new road circuit from Reetha to Tanakpur via Kulialgaon-Saal-Taand-Baram is now operational (January 2017) and light vehicles are already plying (road closes from time to time due to slides after rains) with a hope that the road will be black topped before the financial year ends. This cuts short the distance to Tanakpur by almost half, the usual route via Bhingrada-Dhunaghat-Khetikhan-Lohaghat-Champawat is around 150 kms. Connectivity is a boon or bane is debatable and is left to its utility for people but road building measures are conventional and open up chronic problems of land slips/landslides as an outcome of blasting and geological surprises encountered during road building. Uma Devi and her mother, being daily wagers are all praise for the new road being built as it will provide them much needed temporary relief especially in the wake of negligible employment opportunities here.

The elevation profile of Reetha Sahib to Taand stretch can be clearly defined in two legs – first from the bridge over Ladia near Kunialgaon and upto Macchiyar, and the second from Saal (lying between Macchiyar and Taand) to Taand – in both legs average elevation gain is about 200 m.

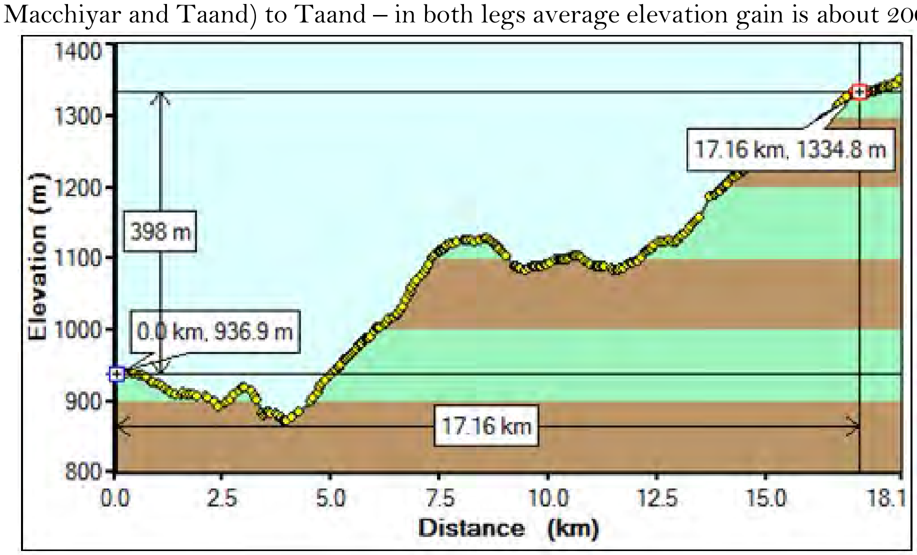


Figure 2 - Reetha Sahib to Taand Stretch Elevation profile

Two more links are likely to get operational very soon - one towards the left bank of River Ladhiya linking Ladhiya valley with Amori which is across the ridge in the Lohaghat–Korala valley and the second link will be from the bridge over Ladhiya between Kulialgaon and Chaura villages.

A road in **Chaudans valley** (Narayan Ashram to Jaikot) and Tawaghat to Thanidhar (Pangu) is leading to chaos – Jaikot is sinking. The road alignment from Tawaghat to Thanidhar (Pangu) is not based on technical feasibility and if such kind of road alignments are promoted in this region, it will worsen the problem of sliding manifold, says P S Garbyal. The cutting of several sharp turns by slashing the hill sides has resulted in damage of agricultural land of people. Similarly, village Busail's irrigation canal in Gangolihat Tehsil is damaged[9] due to construction of a road.

Sartola gram Panchayat is located along the confluence of **Saryu-Kulur Valley** in Gangolihaat development block. There are around 75 households in the village (Sartola and Nyolisera). Out of the total land, around 30% land of Nyolisera is irrigated. Canal which used to irrigate Sartola got damaged when Glasikot road was constructed; the canal has not been repaired so far and is an asset wasted. This is a warm valley and normally two crops are taken, sometimes three crops are also harvested. 35 families of Sartola have migrated due to issues with drinking water and health facilities.

Bhaisiachhana is a large Gram Panchayat with nine wards (Khairkhet, Bhaisiachhana, Budadhar, Kakadtola, Tilgada, Genaar, Kothgada, Guthli and Ramtola tok). It has a population of 1900 and is located at the border of Almora district with Pitthoragarh. Jaiganga and Jaigan are two tributaries which join Saryu in Seraghat. Like Kulur, Bhadravati, Jataganga, Narkul – Jaiganga and Jaigan are non-glacial rivers and are facing the challenges of climate change. Khairkhet among these villages was devastated in 2010 by the landslide (see picture) – 12 families of this village were moved out and took shelter in a school adjoining Jaigan gadhera and are forced to live on rent near Bhaisiachhana. Land and houses of Khairkhet and Budadhar are damaged, main drinking water source is Kochyani gadhera and the surrounding canals are not working due to drying up of source. Once it was a good agriculture belt providing livelihoods to families, now people are dependent on doing casual labour to sustain their livelihood.

Khairkhet Village, a km away from Seraghat

[9] Mohan Ram, Village Busail

A bridge collapse on river Kulur, the bridge collapsed probably under the weight of truck which is seen stuck on the bridge

A view of Saryu Valley, road construction activity is easily noticed here

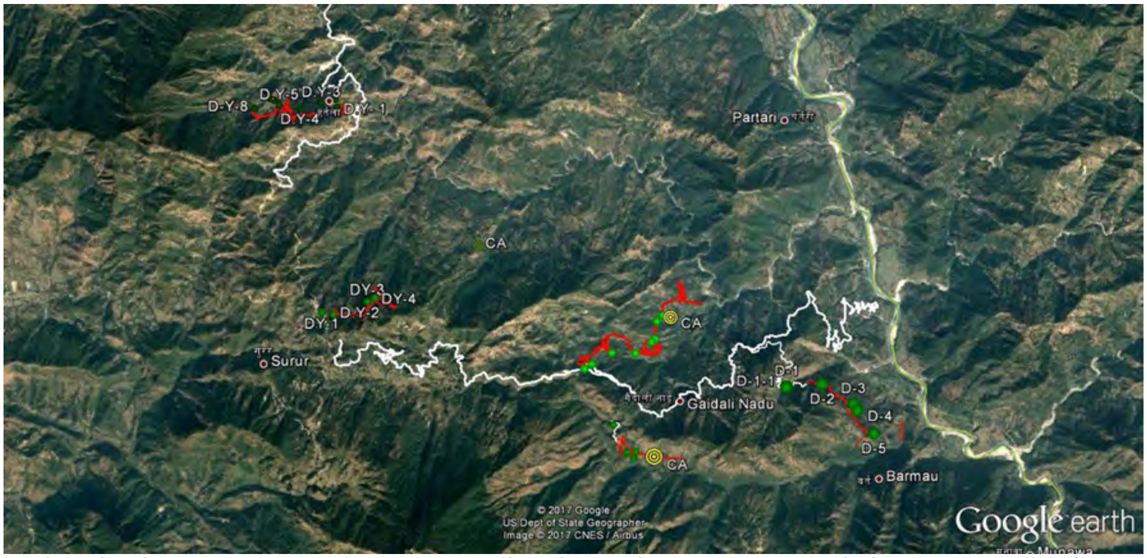
Enroute Askot, lots of debris flowing down the slope

Figure 3 – 8**:** A SERIES OF MAPS SHOWING PROPOSED ROADS IN THE MIDDLE AND HIGHER HIMALAYAN ZONES IN CHAMPAWAT AND PITTHORAGARH

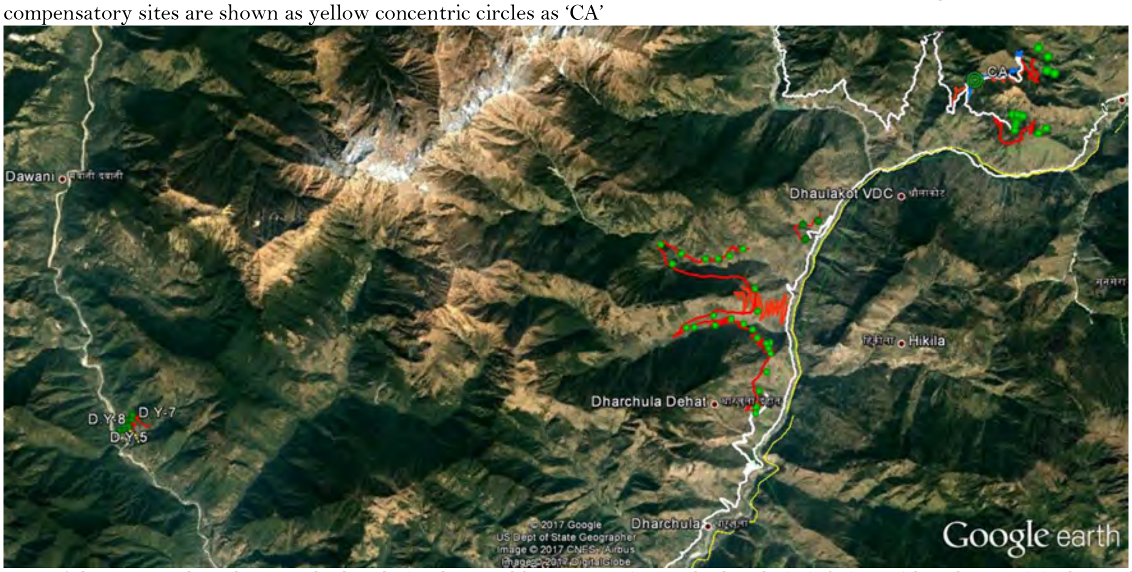
River Ladhiya is flowing from west to east. Few of the existing and proposed roads, majority of them under PMGSY. Most of the roads shown are in Chalthi-Reetha belt (in the SW direction) and Tamli belt (NW direction). Dumping sites for few roads are shown with dots

Proposed roads in upper part of Champawat. Lohaghat is a trijunction linking Khetikhan-Reetha Sahib-Pitthoragarh and Pancheshwar leading to traffic chaos, especially in the market area and the main arterial road. Dumping sites shown as green dots.

Proposed Tanakpur-Rupaligad-Jauljibi Road along River Sharda. Compensatory afforestation is proposed in Dharchula (see red polygons). Alignment of road is shown in red (Till Rupaligad) and dumping sites are represented by green dots.



Roads under the Askot Division of PWD. Proposed roads in red colour are seen with dumping sites marked. Few compensatory sites are shown as yellow concentric circles as 'CA'



Few of the proposed roads around Dharchula, the Road between Askot and Dharchula is being widened – muck is dumped along the slopes!

Enroute Darma - In 2013 Sobla was washed away on this stretch, some road section cutting has triggered landslides

Of the 34 road projects in pipeline, around 190.41 hectare forest land is destined for diversion for road construction, in addition there will be revenue forest and civil land. Of these 34 projects, compensatory afforestation in an area of around 80 hectares is envisaged. Here it will be relevant to mention that nowhere in India compensatory afforestation has succeeded in development of a forest and at best such efforts can be called mere 'plantations.' And this is the case when compensatory afforestation is strongly backed by ear-marked funds in the plan. The huge determinant in environmental impact for long term is the cutting of hill side and muck generated, a total of 37 lakh cubic meter muck is expected to be generated whereas around 65% is to be utilised (as stated in the documents) and the rest 35% or around 13.5 lakh cubic meters will be disposed in the dumping sites. Dumping sites in the hills has always been controversial, as there is hardly any free land or land which can withhold large quantum of soil and/or debris in hilly environments, eventually an ill-practiced environment management is rooted, making all the muck finds its way in the river. The total Net present value of forests ranges from around Rs. 7 lakh per hectare to around 9.35 lakh per hectare (higher density & class of forest fetches higher monetary value). By this account, the overall broad assessment for the chosen projects is Rs. 14.03 Crore - or Rs. 4.37 lakh per kilometer of road constructed; or Rs. 7.37 lakh per hectare of forest land diverted for the purpose. But it is worth mentioning from Table 10B[10] that 19,339.46 hectare degraded land was identified for afforestation by the forest department but in practice afforestation was done only over 4178 hectares of land. The report infers that in Uttarakhand Civil-Soyam land was received in lieu of the non-forest land.

For the identified road stretches, an average of 35 trees is lost per kilometer (a total of estimated 11,154 trees is lost/bound to be cut) and their valuation done by the forest department is Rs. 4.21 Crore. The valuation certainly keeps environmental services out of its ambit and merely prescribes a unit rate[11] which prevails as per the girth or size of the tree species. Many trees with girth of 10-20 cm are separated for rehabilitating elsewhere.

While comparing 15 projects each in Champawat and Askot Division, loss in forest land and trees is comparatively more in Champawat than Askot division which has projects spread in the upper reaches.

Road cutting in the hills is the biggest environmental impact – the frontal face of the hill once scaled down, makes it destabilised and makes it a chronic landslide/rock fall zone (discussed in the next section). Once alignment is finalised, the step to undertake cutting is a crucial environmental control step and require much attention in the initial two stages, as defined in the Environment Code of Practice – '*corridor prioritisation*' and '*project planning and design.*' Non-application of this code, results in implications on agriculture which is dependent on streams flowing through the hills and irrigates fields over the slopes and caters to household food security. Similarly opening up the face of hill create more frequent rolling stones instances down the slope, soil erosion which eventually damage the fauna as well as landform.

[10] CAG report on Compensatory Afforestation in India, 2013

[11] For instance, a 50-60cm girth tree of Pine is valued around Rs. 7000-8000 whereas Utis tree is around Rs. 3000-4000

Select Photographs depicting issues with hill road construction

Road Cutting: A hill opened up for extracting material for road construction

How long will this survive: A spring by the side of this excavation, the terraced fields are already short on irrigation infrastructure

View of Road link to Amori across the River as seen from Macchiyar Road – One can see the disturbance and slides

The same view (L) from Saal village at an approximate altitude of 1100m. The arrow indicates the existing dead end, the link is proposed overcome this.

A rock slump – 600m from Saal en-route Taand

Failed road edge lead to loss of trees - Preparation for protection work underway

Huge debris flow due to hill side cutting for road en-route Darma (white line indicating road level)

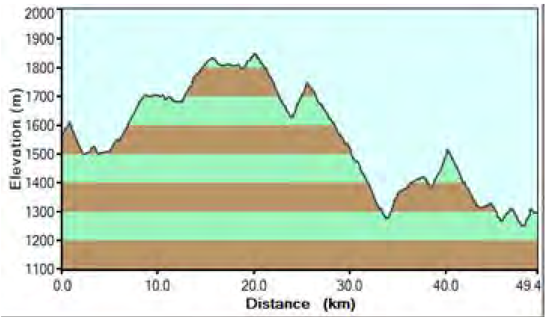
Road alignment along River Dhauli, sliding areas have increased

Slope protection work, Beyond Urthing

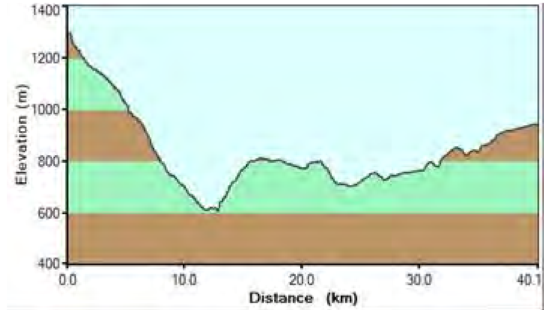
Enroute Dharchula, around 2 kms from Jauljibi

Kothera_Simalkeht Road enroute Gangolihat

Enroute Askote from Pitthoragarh, road construction underway just short of Harkhola village



Profile from Pitthoragarh to Askot, a stretch of around 50 kms. Around Satgarh is the heighest point seen and V shape near Harkhola



From Askot to Dharchula – From Askot to Bagadi Hat, the fall for this 12 kms is around 670 meters.

Road cutting for Thuligad-Rupaligad alignment underway, the hills constitute boulders, stones, soil and other aggregates having high potential of sliding

Machines at work just a few 100 meters downstream of Thuligad bridge. Circles show machines engaged in making way for road cutting

The site inspection report of Conservator of Forests of North Kumaon Division (Almora) reiterates the environmental problems associated with road construction and concludes the following (for the Thuligad-Rupaligad road as shown in the picture above);

Although construction of the proposed road is essential to safeguard the Indian border with Nepal and also much needed for the development of the people living in the area, the concerns of biodiversity conservation are equally important. I therefore, suggest and recommend following remedial measures;

a- As per the notification of MoEF issued on 14 September 2006 this project requires Environment Impact Assessment (EIA) which must be done to ensure mitigate adverse effects of the project on the eology and environment of the area concerned
b- An environmentalist should be engaged to supervise the works to ensure minimum damage to local flora and fauna
c- At the time of construction special care must be taken in cutting and disposing the debris so that there is no soil erosion and loss to flora and fauna.
d- Natural springs and water resources should not be disturbed during road construction

Another important issue which has been grossly misleading the whole clearance system is provisioning of No Objection Certificates (NOCs) on the pretext that no traditional and other rights are affected. The requiring agencies are furnishing certificates from the concerned Gram Sabhas/Gram Panchayat regarding the proposed forest land required for diversion. Mostly the content keepts its thurst *'that there is no encroachment/agricultural work by any tribal and non-tribal in the forest land required for the project. All villagers present in the meeting clarified that in the said forest land there is no encroachment or agriculture work being done by any tribal or non-tribal.'* But many trees and other resources under the van panchayats were to be diverted for the already discussed road stretches in the previous sections – there are rights and concessions entrusted in these and other forests.

Such an approach calls for a review as the Forest Rights Committee (under the Forest Rights Act, 2006) is enshrined with the powers and duties to assess, prepare and present the claims of right, if any. If the FRC concludes that there are no rights, the same has to be vetted by the 2 tier committees at the sub division and district level, the same process has to be carried out if the FRC concludes that there exist rights. The current process of granting NOCs is fast-tracked even when the process of FRA is trailing i.e. lack of awareness generation among people and no formation of FRCs at the habitation level or atleast at the revenue village level. Infact, Van Panchayats which are community forestry institutions, and many of them developed their forests much better than those maintained by the state. In most of the diversion cases, loss is also happening to the Van Panchayat forests and trees without the assessment whether such diversion is curtailing any rights of the user communities.

6.3 Road Building and Landslides

Road building and many other linear projects like laying railway lines, bridges, telephone lines, electricity lines, etc. are known to disturb the prevailing ecological equillibrium by destructing trees in forests. MoEF has issued specific guidelines for the implementation of linear projects in hilly areas, but it is a matter of common knowledge that policies for the good upkeep of environment face challenges of mis-coordination, poor implementation and systemic bottlenecks.

Analysis of a massive landslide in Pithoragarh on 1 July 2016, slope failure and mass movement incidents occurred at many places, as a result of heavy rainfall (160 mm) within 4-5 hours – Bastari and Didihat were amongst the worst affected areas. 160 families of 15 villages were affected by this calamity, as shown in table.

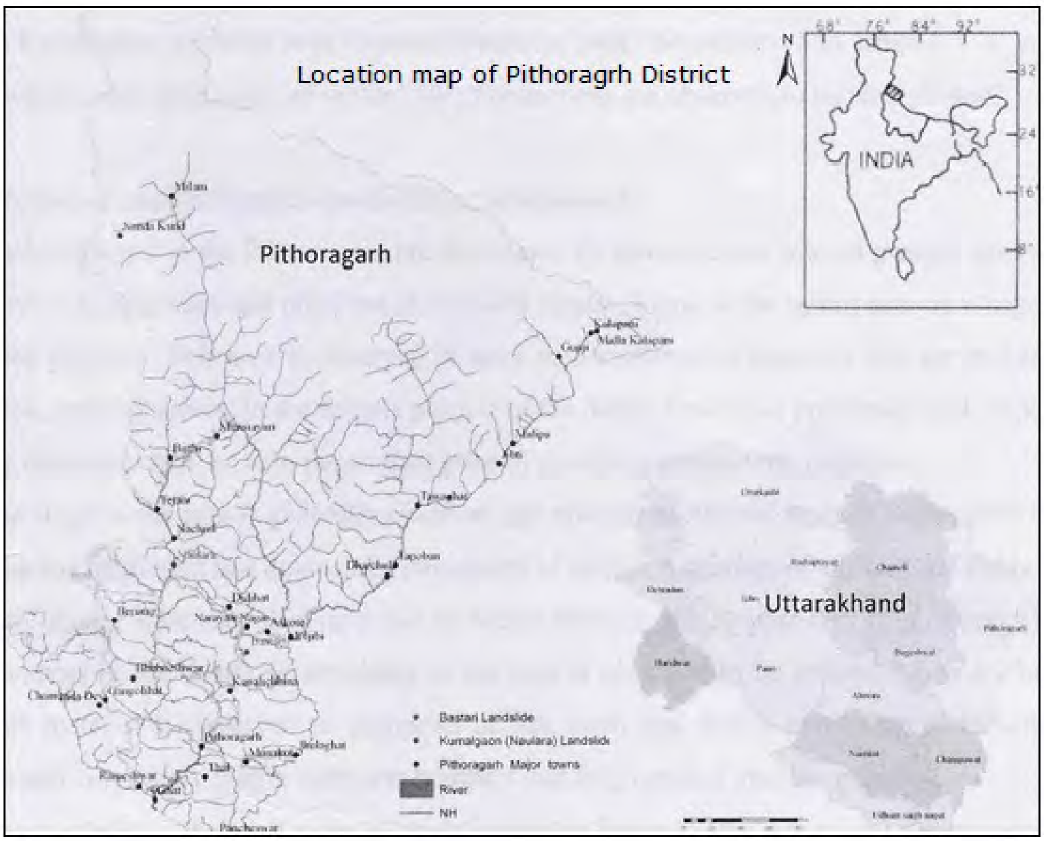
Table 5 - Village-wise list of families affected by slope failure on 1 July 2016 in and around Bastari

S N	Affected Villages	Affected Families
1.	Bastari	29
2.	Patharkot Malla	16
3.	Urma	47

4.	Patharkot Talla	11
5.	Ojha Malla	08
6.	Siroli	02
7.	Majhera	07
8.	Tal	01
9.	Sunakot	02
10.	Amthal	10
11.	Athkhket Dafila	10
12.	Kalasilla	01
13.	Naulra	05
14.	Pipli (pantsera)	03
15.	Didihat town area	08
Total		**160**

Source: Reference 4

Figure 9

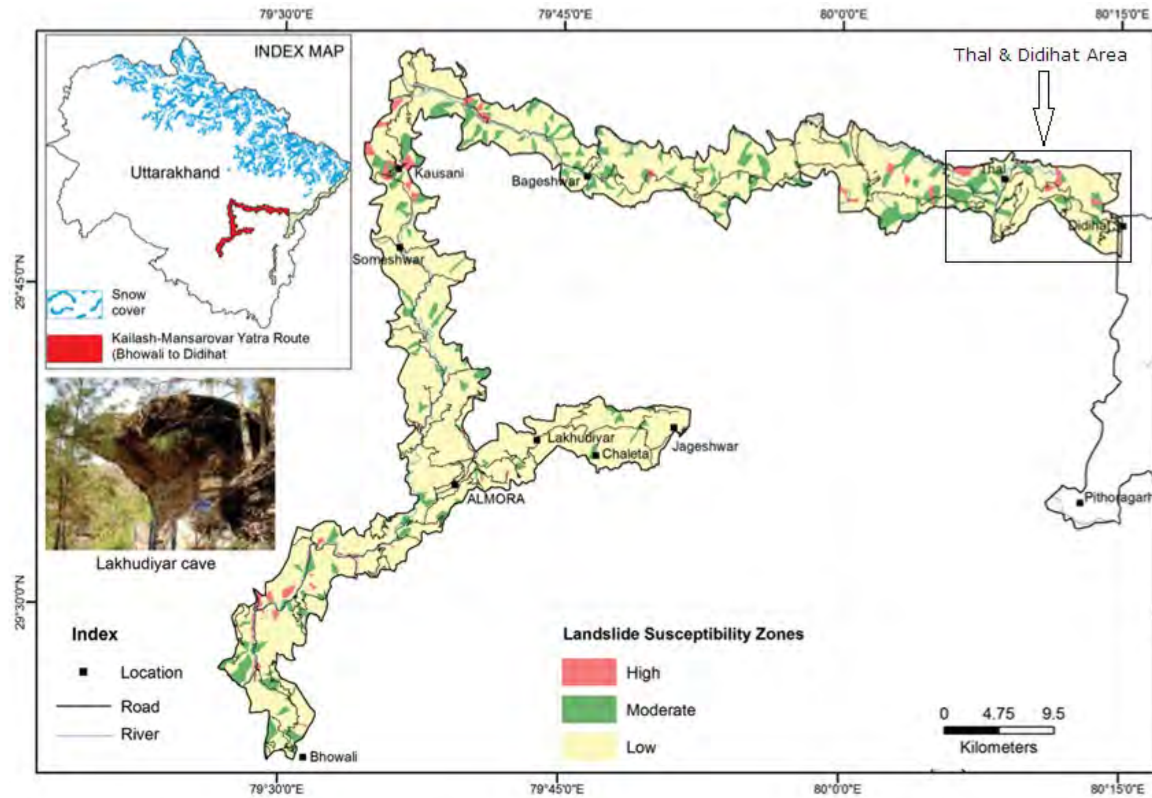


Source: Reference 1

Uttarakhand, by virtue of being located in Himalayan mountain range is susceptible to incidents of mass movement in large numbers. In this regard, Geological Survey of India has done exhaustive work and based on it, came out with a special publication on landslide of northwest Himalaya [1]. Didihat and Thal, both are one of the worst affected areas in 2016 monsoon, have already been identified as landslide susceptible zone. The area falls in the Kailash Mansarovar yatra route between Bhowali and Didihat. Both, Thal and Didihat has been rated moderate to highly susceptible landslide zone (Figure 10).

Pithhoragarh has a history of major landslides. On 14-15 August 1979, the villages of Sisna, Gasila, Beti, Syankuri and Juma lying on the right bank of the river Kali experienced the effects of devastating landslides after heavy rainfall. On the night of 8 August 2009, heavy rainfall followed by cloudburst triggered widespread debris flows in about 30 sq km area of Jhakula river catchment in Pithoragarh district.

Figure 10 - Landslide susceptibility map of Kailash-Mansarovar Yatra route



Source: Geological Survey of India 2016 (modified to show the area)

Landslide Susceptibility Model

The susceptibility model used to predict the spatial location of potential landslides is based on certain assumptions. It is assumed that landslides will occur in future under the same conditions and triggering factors that produced them in past. One has to take into account that geo-environmental conditions of an area such as land use or hydrological conditions may change due to human action. Conditions may also change when the source of a landslide is exhausted by earlier landslide or the morphology of the slope is changed and becomes stable. The local changes in the land use pattern, such as terracing of slope for cultivation or excavation for construction of new buildings can induce instability 'locally' and may increase or decrease the susceptibility of that slope. It is to understand that the susceptibility map is only valid under the geo-environmental site conditions taken as input in the susceptibility modelling. Any changes in the spatial distribution of the geo-environmental factors can affect the susceptibility of the area.

Geological and Geotechnical Aspects

Geologically the area (Thal Tehsil and Didihat Tehsil) falls in lesser Himalayas [2] and it has been suggested that rocks of Pithoragarh area [3] belong to two tectonic units – Almora Crystalline Zone and sedimentary zone of Garhwal Group. Rocks of Almora nappe thrust over quartzite and limestone of Garhwal Group along North Almora Thrust. Quaternary deposits (RBM) and Garhwal Group are observed in Thal Tehsil whereas granitic gneisses of Almora Crystalline are observed around Didihat area. The rocks exposed around Didihat area are riddled with numerous joints which comprise significant structural discontinuities, which in its own turn affect strength of the rock mass as well as the stability of the slope.

The Issue

It has been noted elsewhere that [4] – "*the villages affected by disaster incidents are traditional habitations where people have been living happily for ages… none can claim that the area has never in the past received this kind of rainfall. So it can be deducted that despite spells of heavy and prolonged rainfall these habitations were not affected by mass movement in the past.*"

It therefore becomes pertinent to examine the factors leading to this change in ground reality – is it a natural phenomenon? Or is there an anthropogenic role in triggering this mass movement? Or is it a result of changing ecological and/or environmental factors destabilizing the existing harmonious equilibrium between man and nature? Or is it simply a manifestation of abrupt change in land use patterns, especially in last one decade? These changes in land use may involve, construction activities, drainage pattern, road-building, forest cover depletion, agricultural land, and so on and so forth.

It has been found that in 13 major landslides on the aforesaid day, 11 landslides were in the close vicinity of roads and some directly on the roads (table 6), severely damaging the road. Among the remaining two landslides, one was on the bank of river and obviously heavy down pouring eroded the bank causing the landslide. And the remaining one was debris flow – result of mixing of loose regolith with huge quantum of rainwater.

Table 6 - Rain Induced landslides in Thal and Didihat Tehsil, Pithoragarh District

S. N.	Location of Landslide	Relation with road/ concrete building	Damages
1.	Deendayal Park (Ambedkar Ward)	Just below Didihat-Adichaura motor road	Deendayal Park was severely damaged; 2 houses partially damaged
2.	Lotpatta landslide (A W)	Just below Didihat-Adichaura motor road	Mid-part of Lotpatta village damaged (4 houses, temple, footpath, and cultivated fields damaged)
3.	Pamsiyari Road landslide (A W)	Newly constructed Didihat-Pamsiyari road	This road is severely damaged and 1 house downhill also damaged
4.	Dhmyikhan landslide (A W)	Debris slide	Footpath was damaged, 3 houses face threat of slope instability
5.	GIC Ward Landslide	Near motor road leading to Subhash Chowk	Foundation of Electricity pole, mobile tower damaged
6.	Milan Restaurant landslide	Downhill side of Didihat-Pithoragarh road	Huge debris accumulated along nallah
7.	DIET landslide	Road in front of DIET building	Road in front of DIET is threatened
8.	Sunakot village landslides	Near Didihat-Ogla-Bhagichaura motor road	1m wide and 2 meter deep crack in a house, 15 cm wide cracks in cultivated land
9.	Nonpapon landslide	Near Didihat-Sandev motor road	1.5 m thick debris covered a house & cultivated fields
10.	Bagjivilla village landslide	Near Chandrabhaga river	Landslide debris overran cultivated land & a house, a cemented water drain is damaged, debris flow at 3 sites in mid-village
11.	Patherkot Malla landslide	Near Didihat-Ogla-Singhali motor road	Landslide debris overrun agricultural fields & a house
12.	Ghatigad village	Thal-Munsiyari motor road	Landslide debris overrun

	landslide	(NH 309 A)	agricultural fields & NH 309 A
13.	Daphla village landslide	Thal-Munsiyari motor road (NH 309 A)	A double-storeyed house is severely damaged

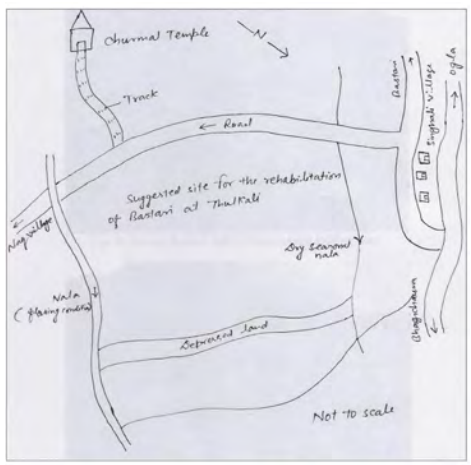
Source: Extrapolated from Reference 1

The use of explosives in road-building, coupled with cut and fill work has been a critical parameter in destabilizing the area around Bastari village. Today the Bastari village has become absolutely susceptible and vulnerable to the debris flow, owing to this onslaught. Therefore a plan for the rehabilitating the village from its present location to a nearby safe location (figure 11) has also been evolved in the report (ibid).

On the other hand, rapid unplanned urbanization in Didihat town has been found to be instrumental in destabilizing the hitherto undisturbed area as construction activities are invariably involved with massive ground excavation. It has been a causative factor in slope failure. It is further corroborated by numerous signs – absence of proper drainage network, overloading of debris slope, excavation and left-untreated such sites, construction over old landslide debris and finally the road-construction.

According to Nagar Panchayat Didihat, a total of 232 families were affected by the slope failure in Didihat town, out of which 101 families were in GIC ward alone. Among the remaining families 92 live in Tehsil ward, 32 in Ambedkar Ward and 7 in Shiv Mandir Ward.

Figure 11 - Suggested site for rehabilitation of Bastari village at Thulkhali



Source: Reference 4

Conclusion

There is a clear 'cause-effect' relationship witnessed in the calamity of 1 July 2016, wherein road-building and massive unplanned urbanization have been found to be twin factors leading to unparalleled slope failure in the area. This emphasized a more responsible, sensitive, eco-friendly approach while undertaking developmental activities in the Himalayan area in the future, to avoid such incidents. On the contrary, the renewed thrust on road-building in the name of increasing connectivity in the border areas which already enjoy procedural relaxations[12], ensures that number and frequency of such incidents, especially in contemporary times of climate change will increase manifold. There is an urgent need to rethink and ponder this issue in order to induce required policy level changes.

Under construction major linear projects in the basin

A. The Tanakpur-Jauljibi road

[12] http://pib.nic.in/newsite/PrintRelease.aspx?relid=105588

The 134.57 km road Tanakpur-Jauljibi road, at a cost of Rs 733 Crore was cleared by the government a few years back and preparations were in full swing. This proposed road, beginning from Tanakpur was to pass through Thuligad, Chooka, Tamli, Pancheshwar, Jhoolaghat, Askot and finally to Jauljibi. The road has a high-strategic significance and had been proposed to be constructed by Union Ministry of Home Affairs. Accordingly, the road along the Kali will cover 31 border outposts (out of 34) with Nepal in Champavat and Pithoragarh districts. The road will also benefit 33 villages in both districts.

The 43-km part of the proposed road, which will be constructed, falls between Thuligad near Tanakpur and Rupaligad near Tamli village, will cost about Rs 230 Crore." The process of e-tendering has been concluded on 22 September 2016.

Owing to uncertainty about the height of proposed pancheshwar dam, a substantial part of this road faces danger of falling in the submergence zone and hence final decision is pending. The work on the thuligad-roopaligad section has started – 12 km Kakaraligate-Thulighat section is being converted to double lane. Width of the road is increased from 5.5 meter to 7.5 meter. From Kakraligate to Thuligad, 3.8 hectares land for widening of 1 ½ lane to 2 lane has got FC in January 2016 whereas from Thuligad to Rupaligad 49.7 hectares land is expected for diversion. More than 6000 trees are expected to be chopped off in this section alone.

To ensure that these relaxations provided to the road sector do not deter the environmental consciousness and upkeep, all necessary precautions, be it the Indian Roads Congress guidelines or the G.O. of Government of Uttarakhand which puts critical issues in black & white[13] must be adhered. A thinking on bringing these safeguards in practice is must, whether it is the technology of road construction or muck management, cutting of trees and after that compensatory afforestation. The question will also be how to implement guidelines in toto and comply with conditions and most importantly how to unbundle the whole architecture of road building in the hills which is causing irreversible damages in the fragile ecosystem.

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7

Contents

7. STATE OF IRRIGATION IN SHARDA BASIN

7.1 Introduction

In context of geographical peculiarities and challenges of nature, hill agriculture has become more vulnerable owing to lack of irrigation, changes in the climatic cycle, social obligations, lack of preserved traditional seeds cum transfer of knowledge and presence of unconsolidated land holdings. Diversified agricultural practices coupled with joint holdings in the past provided some cushion to cope with these prevalent issues. The farmer managed irrigation systems have become few with the state gaining more control of the irrigation systems through several state and centrally sponsored schemes.

Irrigation – watershed management – community participation is interlinked aspects of an integrated system management but all three are driven by separate institutional frameworks. CAGs performance audit report (2008) on the Accelerated Irrigation Benefit Programme (AIBP) describes the situation very clearly;

It is the farmer who has a better understanding of his field conditions, who can manage the system better. In the current set-up, the farmers believe that the canals belong to the Government and that they are beneficiaries of the public irrigation system, with no role or responsibility for the upkeep of the assets. PIM[1] seeks to decentralize water management, create water users' associations (WUA) and turnover the operation and maintenance of downstream parts of the irrigation systems, distribution of water among users and collection of water rates to the users. The presence of WUAs was supported only by Government orders. There was no legal sanctity to the WUA and the roles and responsibilities of WUAs were not clearly identified. State Government issued an order (September 2008) to fix only the responsibilities of WUAs and the Department, in case of defective works. This approach of only clarifying duties without providing them any rights or resources to meet the obligations is an important factor to the failure of PIM in Uttarakhand. Despite the prominent role of women in rural economy, the representation of women in WUAs was only 9 per cent. The villages are populated more with women than men due to migration in the hill districts of Uttarakhand. 205 schemes in test-checked divisions were admittedly lying incomplete due to disputes between beneficiaries. The actual number held up due to disputes would be much higher. This point to inability of a weak WUA, without a legal basis, to enforce the majority decisions/ commitments of the WUA.

7.2 Broad Irrigation Outlook

Hill and terai agriculture-irrigation system is entirely different both in its nature and scale of operations. While sub surface flows in the terai are augmented and controlled by the rainfall, forests and snow melt in the upper catchment, the upper catchment itself has to derive most of its agricultural produce mostly through rainfed cultivation. In several districts, millets like jhingora (barnyard millet), Mandwa (finger millet) is grown, these are resilient crops but the area under them is reducing over the years. As per VPKAS[2], Almora – Almora leads the state in terms of area & production under finger millets (36599 hectares & 42796 tonnes).

Table 1 – Production of Few Millet Crops				
District	Finger Millet		Barnyard Millet	
	Area (ha)	Production (T)	Area (ha)	Production (T)

[1] *Participatory Irrigation Management seeks to decentralize water management, create water users' associations (WUA) and turnover the operation and maintenance of downstream parts of the irrigation systems, distribution of water among users and collection of water rates to the users.*

[2] *Vivekanand Parvatiya Krishi Anusandhan Sansthan*

Almora	36599	42796	14868	16733
Bageshwar	6137	8623	685	733
Champawat	6385	10989	1761	2612
Pitthoragarh	9086	13572	1258	1794

Source: VPKAS, Almora

Pitthoragarh: During 2008-2009, the irrigation available in the district included 410 km. long canal, (2,905) houzes, 1,410 km. guls, 172 hydrams (reaching water to a certain height). The irrigated area is 8.45 per cent of the net area sown. Of the total area irrigated 55.72 per cent or 541 hectares has been reported to be irrigated by canals and 7.18 per cent or 3056 hectares irrigated by other sources in the district. The total area sown under different crops were paddy 20,875 hectares, wheat 22,543 hectares, barely 3,529 hectares, maize 2,625 hectares, mandua 9,345 hectares, urad 675 hectares, masoor 3,745 hectares, peas 57 hectares, oilseeds (Lahi, Alsi, Til, Sunflower & Soybean) 2,001 hectares, potato 1,1163 hectares and tobacco 5 hectares during the year 2008-2009. The net area sown in the district is 42,565 hectares out of which 30,756 hectares has been use under multiple cropped area.

Table 2 - Status of Irrigation in District Pitthoragarh

				Planned Irrigation Potential			Actual Irrigated		
Blocks	No. of Canals	Length (km)	CCA	Kharif	Rabi	Total	Kharif	Rabi	Total
Vin	17	30.56	380	268	270	538	143	150	293
Munkot	11	50.90	508	469	469	938	122	137	259
Kanalichina	13	49.33	563	466	444	910	176	233	409
Didihat	32	63.26	664	498	487	985	178	197	375
Berinag	36	57.98	706	590	588	1178	266	266	532
Gangolihat	23	55.83	576	483	487	970	146	141	287
Total	132	307.86[3]	3397	2774	2745	5519	1031	1124	2155

Source: RTI, Irrigation Department
Area in hectare

During 2013-14, the net sown area is 41310 hectares whereas 78% of this cultivable land is double crop land which is largely located in the river valleys. If we look at the irrigation (created through schemes including rainfed), the gross area irrigated is merely 6130 hectares. The table above indicates the performance of 132 schemes which irrigated 2155 hectares.

In Pitthoragarh district, the planned cultivable command area (for six development blocks) is 3397 hectares from different schemes. The 132 canals listed in these blocks has the potential to irrigate around 5500 hectares but the actual irrigation utilised is only 2155 hectares, merely 39% of the created potential which either shows lack of planning or several other factors not considered during planning of schemes. Around 608 hectares irrigation potential is affected in the Dharchula division covering areas in the higher altitudes which face frequent landslides. 17 such canals were closed or partially working due to impact of heavy rains during 2016-17.

Almora: Almora's three development blocks under the catchment area of Mahakali has 123 canals to its name. The total length of canals is 313[4] kms including the branches and guls. Nine canals of

[3] *The total length reported in Statistical Booklet for Pitthoragarh is 490 kms.*
[4] *Total canal length mentioned in the District Statistical handbook (2014-15) is 621 km*

15.564 km are reportedly not operational due to lack of water availability at source[5] affecting cultivable command area of 158 hectare. Seven canals are damaged due to landslides in the Lamgara sub division of Almora in different Gram Panchayats.[6]

Table 3 – Irrigation in Almora

Block Name	No. of Canals	Length (Km)	CCA (hectare)	Created Irrigation Potential (Hectare)		
				Kharif	Rabi	Total
Takula	28	52.276	530	371.1	367.1	738.2
Hawalbagh	8	15.582	102	82.5	76.5	159
Bhaisiachana	17	71.06	554.2	378.7	348.1	726.8
Lamgarha	44	102.398	874	524.9	524.9	1049.8
Dhauladevi	26	71.953	587	374	305	679
Total	123	313.269	2647.2	1731.2	1621.6	3352.8

Source: Irrigation Department, Almora

The net sown area in 2014-15 was 78,000 hectares and almost half this area was sowed twice. The gross irrigated area is hardly 10,000 hectares. As per available data from Department of Irrigation, irrigation created by the canal network is 3353 hectare whereas only one-third is utilised (table below) and utilisable irrigation is declining from 1233 in 2013-14 to 1104 hectare in 2015-16.

Table 3.1 continued from above

Block Name	Utilised Irrigation (hectare)								
	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
	2013-14			2014-15			2015-16		
Takula	259	272	531	276	273	549	272	238	510
Hawalbagh	27	32	59	30	32	62	29	28	57
Bhaisiachana	103	86	189	96	48	144	60	65	125
Lamgarha	107	107	214	89	81	170	72	81	153
Dhauladevi	125	115	240	127	105	232	128	131	259
Total	621	612	1233	618	539	1157	561	543	1104

Bageshwar: During 2008-2009, the facilities of irrigation available in the district included 399 km. long canal, 968 hauzs and 1,179 km. long guls. The irrigated area is 23.98 per cent of the net area sown of the total area irrigated 50.18 per cent or 5,043 hectares has been reported to be irrigated by canals and 49.82 per cent or 823 hectares irrigated by other sources in the district.

The net sown area (2013-14) is 23000 hectare out of which 78% is double cropped. Gross irrigated area is merely 5000 hectares which constitutes 22% of the cultivated area. Total length of canals is 416 kms

Majority of the irrigation schemes existed before the formation of new state in the year 2000. Out of the 55 schemes implemented in Garur block of District Bageshwar, CCA of only 144 hectares is created after 2001. The difference between cultivable command area and the actual area irrigated widened in the schemes implemented post 2001 in all the three blocks. With looming crisis of climate change and shifting rainfall patterns, the agriculture sector is bound to observe changes in production cycle. But based on the analysis of data received from irrigation department the following is arrived at;

[5] *RTI Information, Irrigation Division, Almora*

[6] *Mergaon, Dadimi, SulChaura, Jhamar, Nirai, Unyuda, Dyli Ronela – Information as received from Irrigation Second Sub Division, Lamgara (District Almora)*

Table 4 – Irrigation in Bageshwar									
Block	**Pre 2001**			**Post 2001**			**Block level (overall)**		
	Sch.	CCA	Actual	Sch.	CCA	Actual	Sch.	CCA	Actual
Garur	42	1361	1368	13	144	156	55	2866	3048
Kapkot	41	902	804	9	218	129.4	50	2022	1737.4
Bageshwar	27	793	650.6	7	111	66.2	34	1697	1367.4

Source: Information received through RTI from Irrigation Department (2017)

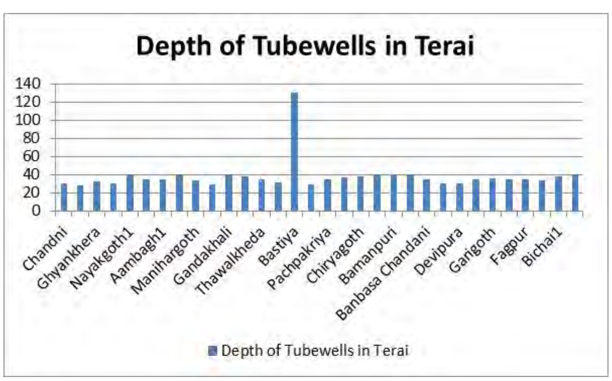
Note: i) Uttarakhand was formed in year 2000, so the categorisation of data has been done as pre and post 2001 to compare net addition in irrigation

ii) Area in hectares

Garur block fairs well in terms of irrigation realised – the other two blocks of Kapkot and Bageshwar have low irrigation realised in comparison to CCA. Atleast in Garur the irrigation is claimed to have been retained at the planned CCA level and has increased marginally. In pre 2001 schemes, the actual realisation in terms of CCA was better. The same is true for Bageshwar.

a) In Bageshwar block one canal is under construction for village Farsali whereas another 5 canals are proposed under PMKSY (Pradan Mantri Krishi Sinchai Yojana). The total CCA is 139 hectare and the proposed irrigation potential is over 179 hectares.
b) Only 4 canals viz. Khunoli canal (for village *Khunoli, Thakdal, Talla & Malla Sunyuda*), Bhangedi tank (for village Tadigaon), Pingalkot canal (for Kausani state) and Jaarti Tank have been reported to be non-functional due to drying up of water sources there by affecting CCA spread over 94 hectares
c) Five canals[7] are affected by landslides over a length of 5.6 kms and affecting 9 villages. The combined CCA of these canals is 103 hectares and 145 hectares is the PPA. The affected villages are Martoli, Jhakroda, Kajodi, Harbad, Naari, Naagar, Naugaon Rithayat and Fhusel.
d) Sunouli canal, pingalkot canal, jaarti tank and Bhagedi tank are abandoned due to drying up of source.

The three sub irrigation zones viz. Garur, Kapkot and Bageshwar have witnessed damages to the canals every year mainly due to blockages & breakages along the canal length. These damages are mainly an outcome of mix of anthropogenic and natural factors like road construction, inadequate siting and landslides respectively. Kapkot zone in the most affected. In 2012-13, the restoration cost for nearly 87 canals/schemes was estimated to be Rs. 4.03 Crore and an additional Rs. 2.1 crore for flood protection with almost 95% of funds expected for Kapkot alone. In 2013-14, the cost for restoration of canals was estimated at Rs. 3.15 crore whereas flood protection works worth Rs. 2.62 crore were required. In 2016-17, 44 canals/schemes were reported damaged for which a sum of Rs. 1.13 crore was required. The cause of damage to canals is destruction of canal head and filling up of canal with muck which points that either the head needs to be protected or redesigned in a manner that least damage is caused or side protection of hills is essential for strengthening of shoulders and avoiding loose material to fall into the canal



Champawat: As per district Statistics 2008-09 total net irrigated area in the district is 2,012 hectare and gross irrigated area is

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7 *Martoli tank, Kaloudi canal, Harbaad tank & canal, Dofaad canal*

3720 hectares. Out of this 28.18 per cent of the irrigated area is served through canals including guls and hauz and remaining 71.82 percent through tubewells in the district. The district statistics 2008-2009 also show that district had 231 km long canal, 1,517 hauzes, 979.51 km long guls, 58 hydrams and 18 Govt tubewells. The net area sown to the total area as per district statistics 2008-09 was 9.95 per cent i.e. 23,227 hectares out of which 13,596 hectares pertained to rabi. The net sown area has reduced to 17490 hectares (2013-14) and almost half of it is double cropped.

As per Lohaghat division, the length of main canals is 248.300 Kms whereas that of the guls is 32.700 kms, the estimated CCA of these canals is estimated at 2338 hectares. Large parts of Champawat district form part of the outer Himalayas, here too gross irrigated area is only 3140 hectares, largely concentrated in the terai region. Major irrigation is through state tubewells (see graph) followed by a network of canals running over 254.85 kms[8]. The graph indicates depth of tubewells ranging between 25-30 feet along the floodplains of River Sharda. Tubewell irrigation is the preferred mode in this lower part as there is no water allocation from the Sharda canal for these pockets but there is no organised data on electricity consumption for drawing up water. In contrast, the village Thapliyalkheda[9] which is bordering Nepal depends on water bought from Nepal for irrigating their fields.

Table 5 - Irrigation in Champawat

Lohaghat/Champawat Div.		Length (kilometre)				Irrigation Potential (hectare)		
Blocks	No. of Canals	Main Canal	Gul	Total	CCA	Kharif	Rabi	Total
Barakot	8	21.90	2.30	24.20	177	103.5	102.5	206
Pati	22	55.5	12.3	67.8	556.4	381.5	372.5	754
Lohaghat	14	37.67	1.20	37.97	388	263.6	259.6	523.2
Champawat	51	133.23	16.9	150.13	1216.5	843.3	822.3	1665.6
Total	**95**	**248.30**	**32.70**	**280.10**	**2,337.90**	**1,591.90**	**1,556.90**	**3,148.80**

Source: RTI Information, Irrigation Division Lohaghat

Around 21 canals which are abandoned, the major reason has been landslides coupled with road construction. Almost the whole canal is damaged indicating widespread damages to the canal affecting potential irrigation of 918 hectares.

Parewa Canal, on the right bank of Ladhiya across Reetha Sahib Gurudwara

Typical inlet point for a gravity canal along the river bed (Champawat District)

[8] *In the lohaghat division, out of 95 canals, 13 canals are closed and 20 canals to be abandoned. 12 closed canals affected irrigation potential of around 390 hectares due to drying up of source. To restore thirteen canals (Out of 95), the department estimates an amount in excess of Rs. 2.12 crore for revival of canals*

[9] *Detailed note in later Sections*

Abandoned canal on the Left Bank of Ladhiya River

Fishing on the right bank near Parewa

As no specific analysis is available on the state of irrigation, one paper which compares state managed and farmer managed irrigation systems in the Kumaon Himalaya is taken as the basis of drawing indicator/s as to measure the efficiency of the existing systems. But no separate farmer managed irrigation systems statistics were available to make a cross comparison. The descriptive note from the article is as below.

Canal ratio (CR) by definition is related to canal length and higher CR value means higher cost of construction and maintenance for irrigating unit area. Hill irrigation systems generally have large CR value than canal irrigation in plains due to topographic variations and hence, these small hill systems are costly to built and maintain. Alignment of canal plays an important role in variations of CR values. In case of state managed schemes of Kumaon Himalaya, CR value with respect to cultivable command area (CR—CCA) varied from a maximum of 0.158km/ha in Dhaulara (II) canal to a minimum of 0.053 km/ha in Binta canal. Canal ratio both for rabi and kharif crops is maximum for Sail Bugi canal (i.e. rabi = 0.383; kharif = 0.326 km/ha) and minimum for Chanoda canal (rabi = 0.108; kharif = 0.097 km/ha). CR-CCA in farmer managed canals varied from a mzimum of 0.356 km/ha in Barsil canal to a minimum of 0.049 km/ha in Sail (I) canal. Under both rabi and kharif crops seasons CR values were maximum for Barsil canal (CR-rabi = 0.364; kharif = 0.362 km/ha) whereas lowest values (CR rabi = 0.057; kharif = 0.049 km/ha) are recorded for Sail (I) canal. Comparing the average CR-CCA, CR-rabi and CR-kharif values of farmer managed schemes with that of state managed canals it was found that state (CR-rabi = 0.220 km/ha; CR-kharif = 0.168 km/ha) schemes were higher than that of farmer managed schemes (CR-rabi = 0.169 km/ha; CR-kharif = 0.161 km/ha). On the other hand, the CR-CCA values for state schemes were found to be much lower than that of the farmer schemes. This indicates that the state managed systems cover larger CCA with each km of canal length. Whereas, canal alignment in farmer-managed systems (having higher CR-CCA) may be more governed by site conditions. In terms of actual area irrigated, farmer systems are better (having lower CR-rabi and CR-kharif). The author goes on to compare CR of Sumatra (Indonesia) which is 1km/ha in hill irrigation systems whereas it is much lower in case of Kumaon Himalayas

By the same method, the average CR-CCA for the five blocks[10] (District Almora) is 0.12 km/ha whereas CR-kharif, CR-rabi for irrigation capacity created is 0.18, 0.20 respectively and irrigation utilised is 0.58, 0.60 and 0.3 for 2013-14; 0.61, 0.78 and 0.34 for 2014-15; and 0.74, 0.71 and 0.36 for 2015-16 respectively. This shows that there is deterioration in the irrigation utilisation which may be due to several reasons – CR values have been increasing from 2013-14 to 2015-16 thus indicating impediments in irrigation due to multiple reasons.

7.3 Brief Outlook of Schemes & Flood Protection Works

So far state, district and central schemes constitute the broad spectrum of irrigation sector financing and budgeting. The components under district and state sector are mainly construction/reconstruction of tubewells, construction/renovation of canals and lift scheme which are basically waterdrawal and water conveyance infrastructure creation schemes. For canal based systems, mostly naturally occurring springs are tapped. Most of the hill agriculture is rainfed and any delay in arrival of rain creates more risks for the farmer. Emphasis has been lessening on construction/renovation of canals and lift canals where the physical target reduced by 1830 hectare in the 12th plan period (2012-17) in comparison to the 11th plan period. Infact the emphasis in the terai belt has increased for withdrawal of water through tubewells which are highly energy dependent. The overall physical achievement in the irrigation sector in the 11th 5 year plan was

[10] *Takula, Hawalbagh, Bhaisiachana, Lamgada, Dhauladevi*

64,255 hectares for all the components whereas in the 12th plan the targets were fixed 79,842 hectares.

Irrigation department is entrusted with the duty of creating irrigation facilities, flood protection schemes and dig tubewells apart from managing the maintenance of headworks of power channels of power houses. This perspective is also reflected in the budget provisioning. Out of the total released finances of Rs. 42.15 Crore funds in the 2015-16 budget, only Rs. 5.68 Crore was spent (merely 13.5% of the released amount) under the various schemes in the State sector. Under the central sector, the overall amount allocated for flood protection schemes under the general, SCSP, TSP and reconstruction of CSS was Rs. 300 crore and Rs. 247.34 crore was spent as of February 2016.

The beneficiary oriented schemes have somehow made processes dependent on the government but unless localised O&M mechanisms are brought into the system, efficiency of schemes is reduced. When asked about the status of irrigation canal in his village, a young man from Beda (Pitthoragarh) told that it is broken at several places but the water is flowing. When asked who will repair it before it further gets damaged, he expects the department to repair it. This marked shift has distanced people from doing whatever little they could have in their capacities. In case of roads, where road intensity has increased and intended to penetrate further, protection of environment and the existing infrastructure (canals[11]) still seems to be a non-issue whereas damages are occurring.

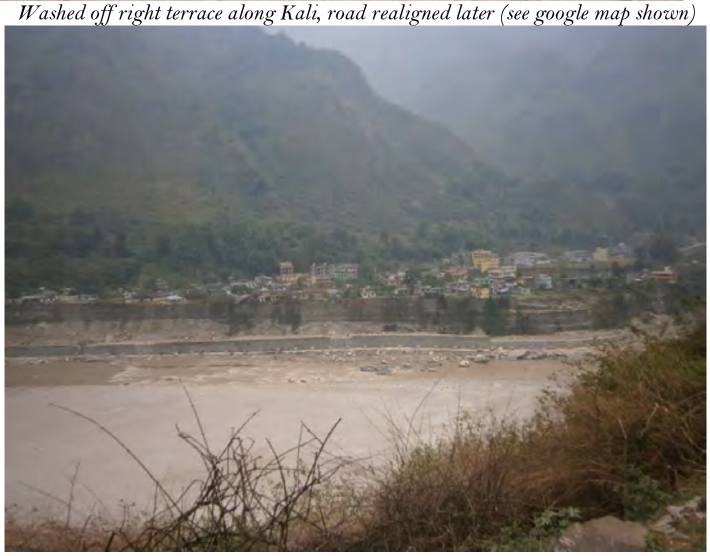
Under the Centrally Sponsored schemes, 14 flood protection schemes are in the Mahakali basin in the Kumaon region. The allocation for Pitthoragarh is Rs 9487.66[12] Lakh and almost 58% expenditure has been made. In 2013 and again in 2016 there was massive cutting by the flooded Sharda river near Baluwakot, Jauljibi and several other places. The right bank of River Kali between Baluwakot-Kalika got damaged in 2013 floods and in 2016 heavy rains, the road between Dhap and Kalika is realigned as is shown in the image below.

Figure 1 - With the Green circle – Kali meanders, the cyan colour represents the current alignment and the old alignment is in yellow coloured line. Similarly the meander near Baluwakot is almost a V pointing northwards, the main bazar is just abutting the river edge.

[11] *See*

[12] *Table under section 6.2.3 of Annual Report, Irrigation Department for the year 2015-16*

Washed off right terrace along Kali, road realigned later (see google map shown)



Darchula on the left Bank of Kali (above) and a road being made across Baluwakot (below)

Table 6 - Flood protection schemes in middle – higher Himalayan catchments		
S.No.	Scheme/Location Name	Total Cost (Rs. Lakh)
1	Flood Protection works on the right bank of River Kali for protection of Baluwakot	906.61
2	Flood Protection works on the right bank of River Kali for protection of Gothi settlement	916.35
3	Flood protection work in Jauljibi & Jhulaghat, River Kali	891.23
4	Flood protection works on the left Bank of Goriganga for protection of Madkot	951.34
5	Flood protection works on the left bank of Bhujgad River & Ramganga River (Baasgagad, Naachni)	1130.81
6	Flood protection works on the left bank of Kali to protect malla gothi & malla Baluwakot	937.8
7	Flood protection works on the right bank of Dhauli for village Khet and Village Dobaat & New Basti Seepu Talla on Kali's right bank	1035.58
8	Flood protection works on the left bank of Goriganga for protecting Bangapaani and Jauljibi	835.61
9	Flood protection works for protection of Village Khotila on the right bank of Kali	924.78
10	Flood protection works for protection of Nayakgoth & Thwalkheda villages, River Sharda	874.94
11	Flood protection works for protection of Brahmdev & Uchaligoth on the right bank of River Sharda	1218.87
12	Flood protection works on River Saryu, Kapkot	1248.71
13	Flood protection works for Khati village, Tallighat, Madalsera & Siselisera from tributaries of River Saryu	1009.68
14	Flood protection work of taxi stand in Dharchula, Right bank of River Kali	942.8

Source: RTI Information

A sharp meander near Kalika, a few meters upstream the road was washed away in 2016

On the left bank of Kali, terrace erosion is seen

Table 7 - Flood Protection Schemes in the Terai						
S. No.	**Name of Scheme**	**Name of River**	**Type of Scheme**	**Year Of Start**	**Year of Completion**	**Village/ Taluka Benefited**
1	Uncholigoth-Brahmdev FPS	Sharda River	Anti Erosion	1978-79	1978-79	Uncholigoth-Brahmdev
2	Nadhan Nala FPS	Nadhan River	Anti Erosion	1978-79	1978-79	Nadhan Nala
3	Thwalkheda FPS	Kiroda Nala-II	Anti Erosion	1978-79	1978-79	Thwalkheda
4	Nayakgoth FPS	Kiroda Nala-II	Anti Erosion	1978-79	1978-79	Nayakgoth
5	Kiroda Nala FPS	Kiroda Nala	Anti Erosion	1983-84	1983-84	Ghasiyara mandi, Tankpur Town
6	Ghasiyaramandi Nala FPS	Ghasiyaramandi Nala	Anti Erosion	1994-95	1994-95	Ghasiyara mandi, Tumrannigoth, Boragoth
7	Renovation of Kiroda Nala FPS	Kiroda Nala	Anti Erosion	1994-95	1994-95	Tanakpur Town

8	Ladhiya ghati FPS	Ladiya River	Anti Erosion	1994-95	2003-04	Dudhori, Naulapani, Sangtang, Kakhol, Chalthi, Jhalakudi
9	Kwerala Ghati FPS	Kwerala River	Anti Erosion	1994-95	2002-03	Chatkot, Belkhet, Betta, Amodi, Sera, Sajoli
10	Bamanpuri FPS	Huddi River	Anti Erosion	2003-04	2005-06	Banbasa, Bamanpuri, Chandani
11	Pachpakhariya FPS	Jogbura River	Anti Erosion	2005-06	2006-07	Pachpakhariya, Banbasa, Garhkot, Devipura
12	Anandpur-Chandani FPS	Huddi River	Anti Erosion	2009-10	2010-11	Anandpur, Chandani
13	Khirdwari-Talkhola FPS	Ladiya River	Anti Erosion	2010-11	2010-11	Khirdwari, Talkhola
14	Kathol-Kichel FPS	Sharda River	Anti Erosion	2010-11	2010-11	Kathol, Kichel
15	Furkiya JhalaFPS	Ladiya River	Anti Erosion	2013-14	2013-14	Furkiya jhala
16	Uncholigoth, Brahmdev FPS	Sharda River	River Training	2014-15	2015-16	Uncholigoth-Brahmdev
17	Thwalkheda FPS	Sharda River	River Training	2014-15	2015-16	Thwalkheda

Source: Flood Protection Schemes, E.E., I.D, Lohaghat

Irrigation department is the nodal agency for flood protection works, in the upper catchment river flows with high velocity through narrow gorges; the terraces abutting deep meanders are susceptible to erosion and cutting. While the river bed expands in terai, seasonal streams bring heavy boulders alongwith water. Large seasonal nallahs make way for erodible materials they bring along, especially during the monsoon season. Kiroda nallah is one among them which drains the lower western part of Lohaghat-Ladiya catchment before it falls into Sharda near Tanakpur. River training works thus become a consistent activity.

Figure 2 – The lower part of Sharda/Mahakali basin where the river reach widens, many rivulets are seen joining the river towards its right bank between Tanakpur and Banbasa

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Contents

8 OTHER EMERGING ISSUES IN THE BASIN

8.1 Village Thapaliyal Kheda, Tehsil Poornagiri, District Champawat

The Mahakali River constitutes international boundary between India and Nepal, in major stretches. There exists a peculiar issue of the village Thapaliyal Kheda, Gram Panchayat Sailanigoat, which is located on the Nepali side of the river Mahakali, whereas the Gram Panchayat Sailanigoat is located on the Indian side of river Mahakali (figure 3). Thus the village Thapaliyal Kheda is surrounded by Nepali territory on the three sides, whereas on the one side it faces river Mahakali. It will also be relevant to mention that the village Sailanigoth itself is bifurcated by the construction of Tanakpur canal (1992) in two entities on either side of the canal – Sailanigoth Malla and Sailanigoat Talla.

Figure 3 - Yellow line indicates road leading from Sailanigoth to Thapliyal kheda (see inset how the village is placed in the current setting)

Village Thapaliyal Kheda (Gram Panchayat Sailanigoth, Tehsil Poornagiri, District Champawat, Uttarakhand) is 10 km away from Tanakpur town where 40 families having a population of 200 people live. Except two families from Lohaghat, all hail from Manch, Champawat (25 km being the distance). The village (along with its agricultural fields) is settled over an area of 25 acre of forest land.

History of Settlement

Unlike the other forest settlements, established under the *Taungia* system, this village Thapaliyal Kheda has a different history of settlement.

[The *Taungia* system was devised by the then British Forest department during the colonial rule. In the early years of the century, erstwhile British Government introduced the policy of reservation of forests. For laying and protecting new plantations, often in place of the newly-exploited and clear-felled natural forest, labours were required. For the purpose of procuring cheap, in fact, free labour *Taungia* system was devised, more or less on the line of the *Begari* system (work without wage). Under this system, labour was brought and put in the middle of the forest in make-shift settlements and permitted to raise short-term rows of the plantation for few years. Once these trees grew to a certain height and were capable to grow naturally, then labours were shifted to new plantation sites. In 1946, the Government was hastily involved in more important work related to freedom of India and everyone forgot about these settlements. Thus they remained within the forest and continue to struggle for their rights. Government of Uttarakhand has not taken any initiative regarding 'Forest Rights Act' which has compounded their problems. There are 28 such forest villages under the *Taungia* system in and around Banbasa area.]

As already mentioned, the origin of village Thapaliyal Kheda is different, despite being a forest village. The ancestors of the residents of village Thapaliyal Kheda used to come here in winter with their cattle for grazing and returned to their native place in summer and it continued for a few decades. Subsequently, when the hilly areas remained untouched by development, about four decades back, these nomads decided to settle here permanently, in the hope that they will be benefitted by development in plains. But this hope soon crash-landed on the ground, as expressed by Suresh, a resident of Thapaliyal Kheda – "*We neither had road and electricity in hills nor here.*" Today, in contrast to this village, their native village Manch/Tamli Manch (from where they migrated) has road, electricity, police station, and an SBI Branch.

Issues Arising from Peculiar Physical Location

The villagers of Thapaliyal Kheda have been struggling with a plethora of problems since last forty years, as summarized below.

A. Loss of Land

Before the construction of Brahmdev Bridge in 1991-92, river Sarda was flowing towards opposite side, but after the construction of bridge started flowing towards this side and consequently significant chunk of fertile agricultural land was lost to river owing to severe erosion and submergence. Yet the forest department (government of Uttarakhand) didn't take any preventive action for future.

B. Crossing International Border on Daily Basis

Crossing international border on a daily basis has emerged as a major hurdle, especially if one is bringing some household paraphernalia. The process is typically too cumbersome and permission needs to be taken from NHPC. For example, if one has to bring some sand, bricks, cement, etc. from Tanakpur then he has to give an application to the HR Manager, NHPC office. It is scrutinized and signed first by HR Manager, NHPC, followed by sign of Gram Pradhan, then sign of NHPC official, finally CISF reviews and then the pass is issued. It specifically mentioned the number and quantity of items, details of the vehicle (like number, type, license, driver's name and his license's details), etc. If by some unexpected reason, the belonging couldn't be transported on specified date, new application needs to be submitted for issuing a fresh pass. Yet, one has to spent considerable time at check-post to explain everything to the guard – why each item is needed. Even bringing 5 kg salt of a bag of fertilizer is questioned. If allowed, we can bring the house-hold articles jointly and save a lot of money in transportation.

C. Inertia in Development Activities

The forest department has taken serious objection to any pucca and permanent construction in/around the village, on the ground that all the 25 acre land is technically 'forest land' and laying down road or erecting electricity poles will be a violation of provisions enshrined in Forest and Environment Act, so people are doomed to live in hutments, with only tin roof. Though 20 odd houses have managed to make brick and stone houses, they too have not been permitted to have pucca roof.

D. Existing Government Facilities

- In 2001, a primary school was opened under 'Education for All' (*Sarv Shiksha Abhiyan*) and *Aanganwadi* is also operational. There are two teachers in the school, but the shrinking number of students is a matter of concern. Presently, there are only three Indian students (three other students are Nepali). Though there are about 16 school-going children in village but they are studying in the boarding schools in nearby Nepali town – Mahendranagar – as villagers are not satisfied with the quality of education imparted in the primary school of village. Villagers are paying Rs. 600 (INR) per month for boarding school in Nepal.

- In the absence of electricity, in 2007 SSB has provided solar lamps in the village on subsidy so all 40 families has light in their homes. Each family paid Rs. 3000 for getting these solar lamps.
- During Parliamentary and Assembly elections, polling booth is established in the village so the villagers are saved from the drudgery of 10 km walk. But for Gram Panchayat elections and meetings, villagers have to go to Sailanigoth. There are 110 voters in the village.
- There is only one tube-well installed by the government and it is functional. It serves the domestic purposes only. Two other tubewells in the village are personal.
- Grazing is allowed by the forest department at a nominal fee of Rs. 100 per season. In fact, the receipts issued towards grazing fees are the sole basis for issuing Permanent Resident Certificate to these villagers. Only on the basis of this permanent residential status, Aadhaar card, Election Commission's voter Identity Card, etc. are issued to the residents here.
- There is no dispensary or medical facility – only the ASHA animator (Maya Devi) lives in this village.
- Ration cards have been issued but the fair-price shop is located in Sailanigoth so villagers have to cross river for purchasing edibles and other paraphernalia. There is no fixed time for opening of this fair-price shop and consequently villagers have to make several trips before being lucky to find the shop open.

E. Lack of Irrigation and Importing Water from Nepal

As there is no electricity in the village, irrigating agricultural fields becomes a major issue. Almost everyone belong to farming community, and beside main crops also grow vegetables. So villagers are importing water from Nepal, at a rate of Rs. 150/hour. The villagers inform friends across border to start pump (say at 5 PM to 9 PM), which is collected in a pool. People of both nations across the border are living in peace and harmony and till date no issue has emerged. Villagers say that water is available in plenty here (at a depth of 18 feet) and if electricity is provided they will install their own pump for irrigating fields.

F. Problems of Rainy Season

During rainy season, in the absence of a bridge, the village gets cut off from all sides and virtually becomes an island. Villagers merely wait for water levels to recede. In these times, school remains closed, essential daily goods are purchased from Nepalese markets at steep prices, floods in Sarda destroy crops, etc.

G. Other Aspects

- Mohan Singh Bohra, ex-Pradhan informed us that according to information procured under RTI, filed by a Champavat-based NGO a few years back Rs 33 Lakh and Rs. 3.8 lakh was sanctioned and allocated for construction of bridge and school building, respectively for Thapaliyal Kheda village, but nothing happened. This made Madan Singh Mehar, a local resident, to file another RTI to know what happened to this money. He was informed that all this 25 acre land belongs to forest department and hence no permanent structures can be constructed.
- Mohan Singh Bohra, ex-Pradhan said that he requested administration that for want of basic amenities they can be shifted from here or facilities be provided but nothing was convincingly affirmed. Mohan Singh Bohra and many other believe that being a border the community of ours is a natural check on the border and many also believe that had they not been here, there would not have been any forest left in the area.
- Villagers informed that 20 years back, there was a 30 feet no-man's land here but encroachments have taken place and today it has shrunk to hardly 10 feet.

- There is strong cultural affinity on both sides – Nepalese visit Poornagiri mela in India and Indian visit Mahendranagar Shivaratri Mela with equal zeal, vigor and enthusiasm.

What needs to be done?

The issue is compounded as forest falls under the Central Government. Further there are dozens of 'forest-villages' and any decision involving them requires a policy-level change, towards which both the state and central governments should be in consensus. Yet another aspect is that Uttarakhand government is dilly-dallying on the implementation of Forest Rights Act (2006), which enables forest-dwellers and tribals to reside within their natural habitats and fructify rights. Henceforth, the issue of changing status of 'forest-villages' into 'revenue-villages' (a long-standing demand of affected communities) is not so simple as it appears, rather it is deeply entangled in policy-inertia, bureaucratic red-tapism and political apathy.

Very recently (just a few days back) the Supreme Court has issued notices to six states including Uttarakhand, seeking the progress on implementation of Forest Rights Act (2006) and submit report within a month. For the time being, some administrative steps need to be taken up to ease the hardship of the residents of Thapaliyal Kheda (making transportation easier, simplifying process of bringing articles, providing basic amenities, etc.).

Few Glimpses of Thapliyalkheda

A mud house alongside farmland

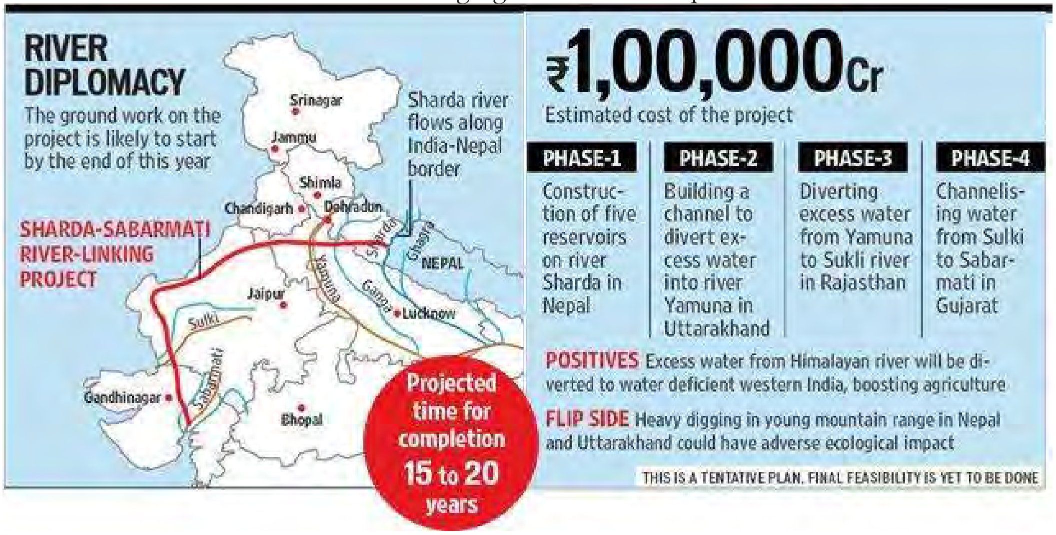
Sharda River after the Tanakpur barrage

Commonality across the village – a handpump, a solar panel

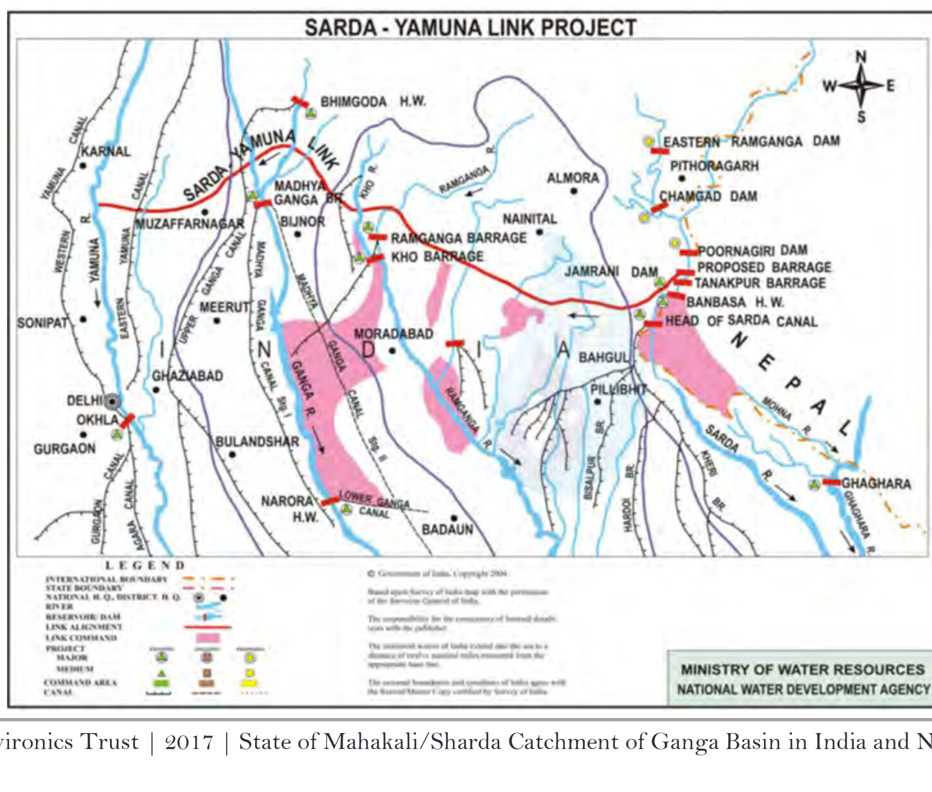
Harvested crop during the month of April

8.2 Sarda Sabarmati Link of Indian Interlinking Plan

India's ambitious plan of interlinking of rivers' has been a matter of grave concern for Bangladesh but Nepal too join it later protesting against Sarda Sabarmati link. In the first phase, India will develop five reservoirs on Sharda River. This issue is important from the people as well as environmental perspective as it will pass through the terai forests as well as many agricultural lands. The current apathy of Sharda canal is that people are not allotted water for irrigation, even those whose lands were acquired long back. Infact, ground water extraction is thriving in the terai region when the canal just passes by the agricultural fields. Such issues might emerge as water is becoming more scarce with the changing weather patterns and climate change.



As per the initial plan, excess water stored in reservoirs to be built on Sharda river will be channelled into Yamuna in Uttarakhand, from there to Sukli river in Rajasthan via Haryana and finally into Sabarmati, about 2,000 km from the main source. The cost of the project is estimated to be over Rs 1 lakh Crore over the next 15-20 years. Execution of such big multi-purpose hydel and irrigation projects in India has taken over 30 years and Narmada Valley project is one such example with work still going on after it was initiated in 1979.

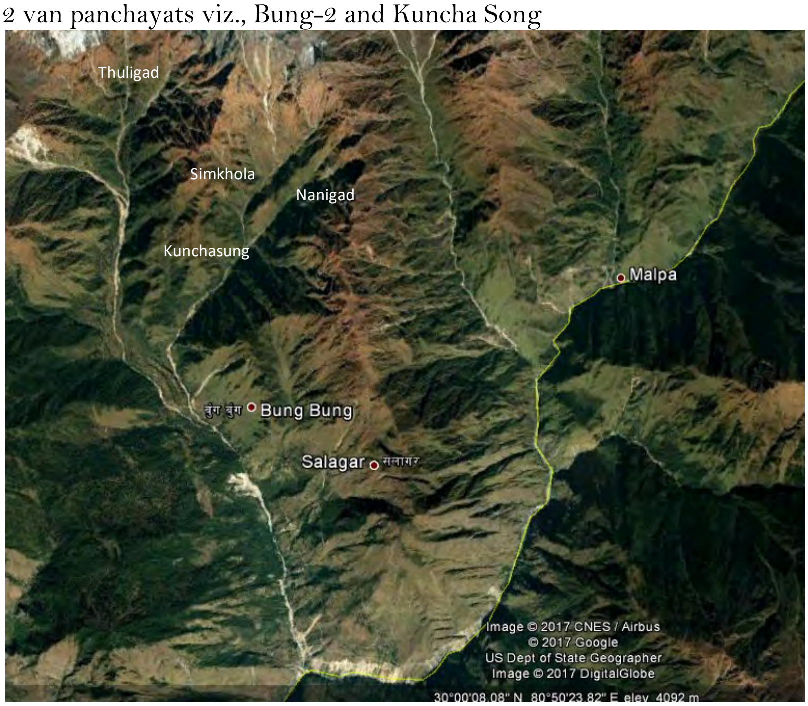


8.3 Disaster induced Impacts

8.3.1 Villages affected by Disaster

The vulnerability of this region attains proportion when the administrative processes are too slow or inconclusive. Following are few examples;

1. Gram Panchayat - Simkhola, Village Bung-Bung: Here 22 families are affected by high rains of 2013 & 2016. The incidents have been happening here from 1998, 2013, 2016 (cloud burst). All houses are damaged and a team of GSI has also recommended for rehabilitation of these villages Thuligad, Nanigad and Khatyabagad (Tangul Gram Panchayat). The incident happened on 13.8.17. The issue is that people have to be moved out from here and probably to a stable land. There are 2 van panchayats viz., Bung-2 and Kuncha Song



2. Of the 140 families of Gram Panchayat Jipti and its hamlets viz. Garba, Raksha Tal and Bugti/Syangri, around 76 of these families are affected. Houses have to be relocated after the cloudburst struck in the village. A reason was given that appropriate land could not be located so shifting the settlement is not possible. Infact people searched for 46 nali land @Rs. 1,32,000/nali but no furtherance of the initiative by the Government.

3. Sirdang is a village of 600 people where currently 300 people live. There is a risk from the nallah draining the area upstream of their village. The hamlet is in the glacial zone where villagers go every winter but that too is under risk (Gubangba) due to flowing water. People of Gubangba had requested government to shift them elsewhere but nothing has been done.

Yellow dots indicating villages/toks identified by Disaster Mitigation and Management Center as disaster affected

8.3.2 River Erosion In India and Nepal

Pitthoragarh town located at a higher altitude is highly susceptible to erosion by Mahakali as well as other rivers flowing in the area. In this regard, an effort was made to get an overall picture of the district in 2016 by procuring information from the district officials. This information was collated and synthesized in the form of a table given below.

Table 1 - River Erosion in Pitthoragarh District

S N	River/Nalla	Type of Impact	Village	Visible Impacts
I.	Gori River	Erosion	1. Jauljibi	Erosion & deposition on left flank of river
			2. Ghattibagad	Erosion & deposition on left flank of river
			3. Mori	Erosion & deposition on left flank of river
			4. Lumti	Erosion & deposition on left flank of river
			5. Chhoribagad	Erosion & deposition on left flank of river
			6. Bangapaani	Erosion & deposition on left flank of river
			7. Madkot	Erosion on left flank of river
			8. Devibagad-Madkot	Erosion on left flank of river
			9. Seraghat	Erosion on left flank of river
			10. Jimighat	Erosion on right flank of river
			11. Talla Dhapa	Erosion on right flank of river
			12. Talla Dummar	Erosion on right flank of river
			13. Bhadeli	Erosion on right flank of river

S N	River/Nalla	Type of Impact	Village	Visible Impacts
			14. Kainthee Band	Erosion on right flank of river
			15. Paikuti, Kandy Band	Erosion on right flank of river
			16. Mawani	Erosion on right flank of river
			17.Dawani	Erosion on right flank of river
			18. Talla & Malla Mankot	Erosion on right flank of river
			19. Talla & Malla Ghurdi	Erosion on right flank of river
			20. Fararkot	Erosion on right flank of river
			21. Umargada	Erosion on left flank of river
		Rising River Bed	1. Bhadeli	River bed is rising
			2. Kainthee Band	River bed is rising
			3. Paikuti, Kandy Band	River bed is rising
II. Kali River		Erosion	1. Jhulaghat	Erosion on right flank of river
			2. Dharchula	Erosion & deposition on right flank
			3. Dobat	Erosion & deposition on right flank
			4. Khoutila	Erosion & deposition on right flank
			5. Ningal Paani	Erosion & deposition on right flank
			6. Gothee	Erosion & deposition on right flank
			7. Naya Basti Malla/Talla	Erosion & deposition on right flank
			8. Malla/Talla Chharchom	Erosion & deposition on right flank
			9.Baluakot	Erosion & deposition on right flank
			10. Minority Settlement & Ghaati Bagad	Erosion & deposition on right flank
			11. Jouljibi	Erosion on right flank of river
			12. Kalika	Erosion on right flank of river
		Threat of Road Cutting	1. Baluwakot Bazar	Risk to Road and market both
			2. 1 km beyond Baluwakot market	Risk to Road
			3. 500 meter before Naya Basti	Risk to Road
			4. 1 km beyond Naya Basti	Risk to Road
			5. 200 meter before Joshi Khet (Kalika)	Risk to Road
			6. Joshi Khet (Kalika)	Risk to Road
			7. Gothee	Risk to Road
			8. Near Nigalpani bridge	Risk to bridge
			9. 200 meter beyond Elagad	Risk to road and NHPC tower

S N	River/Nalla	Type of Impact	Village	Visible Impacts
			10. 200 meter beyond Dobat	Risk to Road
			11. 2500 meter beyond Dobat	Risk to Road
			12. Chitalkot	Risk to Road
			13. Tawaghat	Risk to Road
III.	Madkaniya River	Threat of Road Cutting	1. Bhourabagad & Madkot	Erosion on right flank of river
			2. Dhaameegaon-Madkot	Erosion on right flank of river
			3. Devibagad-Madkot	Erosion on left flank of river
			4. Sana	Erosion on right flank of river
			5. Dobari	Erosion on left flank of river
			6. Ropar	Erosion on left flank of river
IV.	Ramganga River	Erosion	1. Naachni	Erosion on left flank of river
			2. Tejam & Chharet	Erosion on left flank of river
			3. Baansbagad	Erosion on left flank of river
			4. Devkuna Raton & Bhaintee	Erosion on left flank of river
		Rising river-bed	1. Rasiyabagad	River bed is rising
V.	Bhujgad River	Erosion	1. Baansabgarh	Erosion on left flank of river
			2. Dhameegaon	Erosion in left and right both flanks
		Rising River Bed	1. Baansabgarh	River bed is rising in the center of river

The following can be summarized from the above table, in Pitthoragarh district -

- Kali/Mahakali river is causing erosion at 12 sites and is threatening to wash away the road at 13 sites
- Gori river is causing erosion at 21 sites and leading to rise in river bed at 3 sites
- Madakaniya river is threatening to wash away the road at 6 sites
- Ramganga river is causing erosion at 4 sites and leading to rise in river bed at 1 site
- Bhujgad river is causing erosion at 1 site and leading to rise in river bed at 1 site
- There are two other rivers (Dhauli and Jakul) and few local nallahs (Elagaad, Taangagad, Queerijimiagad, and Barargad) which are also causing erosion and/or rise in river bed at one site each

Erosion and Devastation by Mahakali in Nepal

Nepal is ranked in 30th position in incidence of water induced disasters in the world. The country is also suffering from other disasters like earthquake, drought, windstorm, fire, epidemics, etc. Especially extreme high rainfalls during monsoon, topography, fragile geology massive deforestation and unsystematic village road construction are the main causes of water induced disasters in Nepal.

India Supported River Training Program (Bharatiya Sahayogma Sanchalit Nadi Niyantran Yojana)

The big to small sized rivers that flow through the Terai to India occurring floods and inundation problems during monsoon season are considered major disasters - destroying human life and property. Embankments have been constructed in some of the river based on agreement and understanding between Nepal and India. Joint Committee of Inundation and Flood Management (JCIFM) plays an important role to initiate the program in particular river. JCIFM is being steered by a high level team from DWIDP (Nepal) and Ganga Flood Control Commission (India) and along with the representatives from Ministry of Finance and Ministry of Foreign Affairs from both the countries. Ongoing projects are Sunsari, Gagan, Kamala, Lal Bakaiya, Bagmati and Banganga. By the end of the fiscal year the total length of the embankment constructed in the above rivers is about 188 km.

Fury of Mahakali in Nepal in 2012

The incessant rainfall in the mid and far western regions of Nepal affected 20 districts in Nepal with occurrence of floods in the major river such as Mahakali, Seti and Karnali. The discharge in the Mahakali River rose from 139,000 cubic feet per second to 440,716 cubic feet per second on 17 June 2013, well in excess of the flow of 398,000 cubic feet per second recorded in the 2012 monsoon. See the3 link below.

http://www.kantipuronline.com/2013/06/18/top-story/massive-floodsin-mahakali-river-6-killed-update/373456/

Some of the pronounced impact of these floods are listed below.

- The Mahakali river has swept away an entire settlement in Khalanga of Darchula District. Actually the full extent of the devastation in Nepal is yet to be known but the report shows the flood swept away 77 buildings and displaced 2,500 people in Darchula

    http://www.nepalnews.com/archive/2013/jun/jun18/news12.php

- The swollen river also has smashed a suspension bridge at Khalanga, the head quarter of Darchula and swept away the Kalagadh Micro Hydro project's power house and its transformer, two storied building of Resource Centre of District Education Office, and the District Hospital's morgue (Fig.4). While a few houses collapsed in Rigaune Tal, Brahmadev and Khalanga-2, Khalanga-5 has been worst hit.
- Six people were killed in Achham and Baitadi districts and eight people also were missing in Dhungaad. It is reported that 150 families have been rendered homeless in Dodhara and Chadani and around 30 families have been affected in Kuda. Four houses in Salyan have been damaged due to a landslide. In Kalikot district, 4 people were dead and 11 were missing and 27 families have been displaced. Flood in the Karnali River has affected many villages in the southeast region of Kailali, inundating large areas in Tikapur Municipality and the VDCs of Lalbojhi, Bhajani, Thapapur and Khailad. In Bardiya the floods have intensely affected the Rajapur Tappu region where 2,000 houses were inundated by the Karnali River. Approximately 600 families were at great risk in Khairichandanpur.

    http://www.ekantipur.com/2013/06/19/headlines/Monsoon-furyclaims-at-least-20-many-missing/373488/

Swollen Mahakali River smashes suspension bridge at khalanga, the head quarter of Darchula on Monday June 17, 2013

Left Bank of Mahakali River at Pipariya

Emergency works Mahakali River, Kanchanpur, June 2013

Left Bank of Mahakali River at Bhujela

Right Bank of Mahakali River at Dhakanaghat

Right Bank of Mahakali River at Dhakanaghat

Right Bank of Mahakali River at Shyaule Bazar.

8.4 Solid Waste Management – Growing with Urbanisation

Urbanisation and road penetration; product diversification and market penetration into rural hinterlands; packaging and cost effectiveness are parameters that have their goods and bads for the society and environment. Only the scale of problem seems to vary but the penetration of solid waste disposal methods is similar across the cities, towns and settlements – larger the population, larger is the spatial spread. Plastics have revolutionised the packaging industry but their disposal is an issue and all types of plastics cannot be recycled. The basin has largely a rural and a semi urban character and outskirts of these urban zones is marked by solid waste disposal on the valley side and eventually burning it off. The service level benchmarks for urban services is one way to measure service quality but their practice in the flat terrain and mountainous region requires some rethinking. The per capita municipal waste generation in the hills is relatively less than what is generated in the non-hilly urban areas; settlements detached from the urban zones have a relatively lesser problem in the beginning, thus no action. The problem is no less profound along the pilgrim and tourism circuits. Rivers eventually become the saving grace when the waste slides down the slopes and the process of seasonal cleansing continues.

Few of the photographs below portray the current state of affair.

Nainipatal – outskirts of Pitthoragarh Urban

Haze due to waste burning around Nainipatal

Near Wadda enroute Pitthoragarh

NH near Khotila-Dharchula

Champawat's backyard: Garbage on the slopes, burned [left]; array of plastic waste [right]

There are 11 urban local bodies in the Uttarakhand part of the Mahakali basin, the largest being Pitthoragarh which had a population of 56044 in 2011. There is likelihood that such waste streams will eventually choke the path of natural springs which make their way to the river and generate other public health safety issues.

With so much energy and effort spent to make articles/consumables reach the hills, it would be only prudent that local strategic plans are made in order to deal the problem at the micro level rather than addressing it in a business as usual approach. The density of population is relatively less in the region and mostly the houses themselves have spaces like kitchen garden or open spaces to contain and reduce the wet/dry bio-degradable waste.

Probably innovative approaches are required to deal with coverings, packaging of products which have low value but high volume viz. shampoo pouches, hair oil pouches, several eatables and many others. For sure, a financial solution would only promote the use of all these products, an amicable solution will emerge when dialogues with the communities with right facts are held and optimal decisions are arrived at with participation of those who are the consumers and citizens.

9

9. Key Points Emerging from the Basin

Basin as a hydrological unit is influenced by several processes that take place within the administrative boundaries which most often do not respond under a uniform procedure. But some of the issues which are common in the basin make sense to keep them flagged and create some precautionary steps or processes that do not disintegrate the basin environment.

1. The lower and middle Himalayan belts (700-1800m) are suffering a plathora of issues concerning livelihood security and production systems. Fragmented land holdings add to the problem. Wild attacks and lack of irrigation seem to be two crucial factors affected agriculture and productivity, the former cold belts have given way to warm environments, especially those belts which face the terai landscape. A dramtic shift in suitable agro-climatic array of livelihood options are required which have a hand holding of sorts to enable sustainability. The state climate action plan could be deeply looked into for making changes now. Experienced farmers can also guide the process and act as torch bearers. In many valleys, crop failures have grown due to variety of reasons – how a cross learning be made practical is an issue to be thought about, e:g at micro watershed level or a valley level, suitability mapping will probably lessen failures with traditional and scientific inputs.

2. Forest dependent communities in the basin have been protecting forests through their community institutions coupled with the religious beliefs that are assigned to the sacred groves and forests. In the major part of the basin i.e. Uttarakhand, the enactment of Forest Rights Act has still not taken a start which has a legal mandate to recognise the rights – individual, community, habitat. This process requires a new structure under the law which is probably being considered as a parallel to the existing Van Panchayats in the state. FRA provides for community rights as well as management rights of the said rights catchment! Forests are being diverted and with no such process of rights established, the harm is thus already done but how this should not grow further is an issue that require attention, atleast now. Whether institution of Van Panchayats or FRCs as suggested under FRA, their prime motive to protect rights and conserve forests should retained and strengthened.

3. Several communities who are settled in the bagad area (India and Nepal) from long do not have land records in their name due to no effective revenue settlement. Many of them seasonally migrate to their ancestral villages in the upper reaches and spend rest of the time in the bagad area or the valleys. These settlements are always on the verge of danger during monsoons or otherwise. Due to lack of right to land, the apprehension

of being categorised as encroacher or lack of support during disaster is high. Some steps may be required to correct this, like acknowledging habitat rights under FRA.

4. Communities in the basin, especially in the upper reaches, like the Darma-Malpa-Chaudans-Vyas valleys and similar valleys in Nepal are struck by one or the other disaster from time to time. Many communities look forward for rehabilitation in stable areas surrounding their existing locations. The rehabiliation policy of 2011 is a guideline for looking into post disaster rehabilitation but with large number of settlements affected, some mechanism has to be evolved for a faster relief. The current grant of Rs. 4 lakh for house construction for those who owned house has to be relooked and stable sites have to be marked. Scientific safer site selection and flexible policy will be beneficial for habitats affected by frequent disasters.

5. Connectivity in the basin is one of the major issues and this gives an indication that road construction is going to be one of the major activity for a long term. Many a times while creating a new infrastructure, ignorance in safeguarding the infrastructure that is essential and sometimes already being used is unaaceptable. Irrigation canals are hard to built due to drying up of sources and increase in capital costs and now with most under the state machinery, a sense of ownership is lost. Mostly canals follow the contours and are on hilly side at the road level or down in the valleys along the river reach. Road construction is essential for a variety of reasons but it should not become the cause of impacting important irrigation infrastructure.

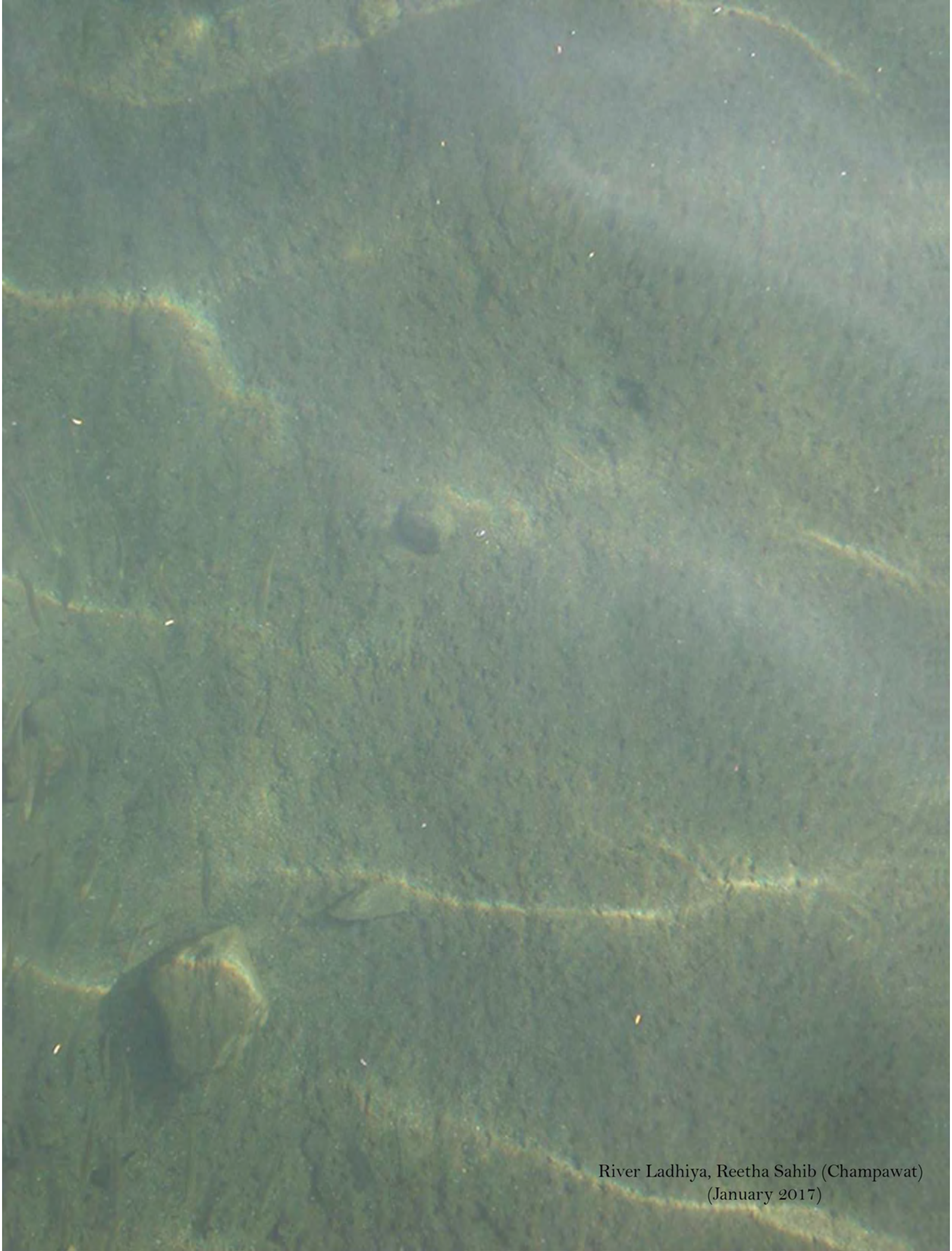
6. Land acquisition in hills for development projects like road, irrigation schemes and other allied activities may grow with increasing needs and in the process forest land is lost. The state has very less land with people (for example only 6-7% in Uttarakhand), any take away of land will induce displacement, migration as well as make certain land holdings uneconomical for a small farmer. The situation becomes severe as unconsolidated land holdings are in abundance. Thus prior to the process of land acquisition, requirement of Social Impact Assessment is must which rules out any acquisition which irreversibly harms the environment, deteriorate livelihoods and force people to migrate. The state should aid the process of identification of real risks and take caucious decision thereafter. Several projects initiated land acquisition proceedings under the 1894 Land Acquisition Act under the urgency clause but such projects were suspended because of the ecological risks they pose to the region, the one such case is Rupsiabadag Khasiabara in Gori Valley. Such acquisition process for the project bars any objections from the land owners (under the urgency clause) or those affected. With the project now in jeoparady, the status of such lands acquired for this

project (and probably many more) is not known such lands should be restored back in its earlier form.

As it seems, more and more infrastructure projects are destined to grow owing to strategic borders, tourism & pilgrimage expansion and thus will require attention for adequate safeguards for those loosing their land in this process. Acquisition for naini saini air strip was done long ago, its expansion sought in 2012-13. The 1894 land acquisition Act allowed the state government to acquire private agricultral land from several villages including Naini Saini, Sujai and Odmatha; acquiring 18.624 hectare from 946 farmers/owners. Local people had lost their land from a square meter of land to 3600 sq. meter, for which compensation assessment was Rs. 1000. But many people during the public hearing kept for air strip expansion in February 2013 raised the issue of incomplete payment of compensation to the affected, the promise of providing employment to one member of the family remained unfulfilled. Several villages had reflected the problem of access and rehabiliation to the authorities.

7. Within the basin several broadleafed forests and those which propagate soil health and store water are in abundance. Several smaller streams flowing down the slopes of such forests build the flow of river and these are the streams which communities relate to in their day to day life. While compensatory afforestation itself means a notional process to compensate for forestland diverted for non-forestry use, its success is dismal. But it will depend on the institutional mechanisms wherein community forestry institutions have control/right over their management to ensure survival and growth. Such catchments which provide high value ecosystem services like provisioning of irrigation waters to the downstream terai and plains require a rethinking on the process of securing the forests at first place and do a stringent due deligence based on the ecology of the area before diverting the forests for non-forestry purposes

8. Watershed level assessment of vulnerability and potential could present a picture of diverse resource set ranging from biodiversity richness to livelihoods, weak environments to increasing vulnerability. Lots has been invested for planning, especially under the State Climate Action Plan - this may also suggest a change in methodology or approach in a climate vulnerable model and enable planning through a lens of Himalayan paradigm and adaptation perspective.



River Ladhiya, Reetha Sahib (Champawat)
(January 2017)