

A River Pulse

A discussion paper on the flood-events in June 2013, Mahakali basin, Uttarakhand

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Himal Prakriti - A Trust for Nature*

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Between the 15th and the 17th of June 2013, the rivers of Uttarakhand pulsed. Again, like a slow heartbeat. Bridges toppled, big and small hydro-power projects were buried in boulders and sand, large swathes of road were torn away, and human habitations or establishments very close to the river were either swept away or severely damaged. Yes, there was heavy and incessant rain in the higher reaches of most river-basins during these days, but remember, these dates are barely the start of the monsoon in Uttarakhand, the Himalayan state in India immediately west of Nepal. Normally it takes a couple of months from June, well into the monsoon for the mountain slopes to be drenched and heavy with more water than they can hold, before they slough off, taking roads, fields and homes with them. It happens almost every monsoon here, some years more than others. This year, it seemed worse. It made international news .

But widespread media attention and dramatic television images apart, how extreme was the rain-storm event really? Was it just the rain that caused such damage and loss of life and livelihoods? Clearly, the high flood levels of the rivers indicate that there was indeed very heavy rain in some parts of the state. But was it really unprecedented, or even more than we have seen here over the past 20 years? The Indian Meteorological Department (IMD) has been quoted saying that this years rainfall was over thrice the normal amount between June 1 and 21, and over eight times as much between June 13 and 19. The highest figure quoted by IMD was 370 mm a day at Dehradun, suffixed by 'a record not seen for five decades'. They are also quoted as saying that in the week of 13th June to 19th June , the entire state of Uttarakhand received 847% excess rainfall, and that this has no precedent. This is an odd statement and makes little sense for an entire state.², and that this has no precedent. This is an odd statement, and makes little sense for an entire state.

For one, the IMD has only a very few stations scattered sparsely over the state, and what they have, are located in central district and sub-division office locations. Sure this makes for easy gathering of data, but is of little use for understanding any particularities, even at the sub-basin scale. The IMD

*Himal Prakriti, located in the Himalyan state of Uttarakhand, India was set up to promote nature conservation and sustainable livelihoods. More details are available on this Website

¹Image Credits - Map - Himal Prakriti, Pictures - E Theophilus, Weather Imageries - NASA

²<http://blog.orangehues.com/2013/07/nothing-natural-about-this-disaster.html#update2>

website shows just two stations for the entire Pithoragarh district³. In just the Gori sub-basin for example, rainfall can vary from 15 cm annually, (spread over ~28 rainy days a year, and not counting snow) in the higher alpine Trans-Himalaya reaches, to as much as 4 meters, yes meters, of rain annually (spread over ~152 rainy days a year, and again not counting snow) just 50 km downstream, in the Greater Himalaya where we live⁴. Therefore, statements such as 'the entire state of Uttarakhand received 847% excess rainfall', can be misleading. Excess rain for IMD is any rain 20% more than normal. Take for example, the 22 mm of rain recorded at Dharchula on 16th June. Had it rained 847% of this on that day, it would have meant just 186 mm, which is not very unusual for the area. While it may not have a precedent on those specific dates (in those specific and few locations where there are IMD stations today), it does not necessarily add up to exceptionally heavy rain. What they are really saying is that the monsoon was early.

It is hard to be precise about exactly how extreme this particular rain event was, because no met data is available from the actual ground stations in locations where there was the heaviest rainfall, that is the high-altitude alpine areas in the Greater and Trans Himalaya. The NASA Earth Observatory's satellite readings can give 'snapshots' of intensity of rain, but only for the the time that they are overhead. To judge how heavy the rainfall event was just on the basis of the extent of damage to human installations, or the number of people affected, is to ignore other contributing factors. It is for this reason that it is necessary to have a better-informed idea about the intensity of rain, and to see it in combination with the other magnifying factors.

If you live in the mountains long enough, you see that very high rainfall and ensuing flood events are common. Over the past 21 years that we have lived in the upper reaches of Uttarakhand, we have witnessed many flood-pulses of serious magnitude. In 1995 it rained non-stop for over three days and nights, a massive landslide sloughed off under the alpine village of Khilanch temporarily damming the Gori. The dam breached in stages, first sending the river flowing down dense and slow as cement mortar, and later, roaring livid down the valley, taking everything in its path⁵. Each and every bridge downstream is torn away, and much of the mountain path as well. We recall serious rainfall and ensuing floods in 1998 when an Indo-Tibet Border Police camp and the entire entourage of pilgrims to Kailash in Tibet get buried in flash-flood debris at Malpa in the Mahakali-basin, and many bridges get washed away in the Gori basin as well. Danseuse Protima Bedi, some of you may remember, was among those buried. In 1999, a huge landslide brings down most of Kultham village. We also recall two heavy spates between the years 2000 and 2005, one washing away Hurki village, and washing away road-sections as usual. In the deluge of 2010, many homes in Jimia village are washed away. During the monsoons of 2010 and 2011, there were very heavy rains in much of Garhwal as well, where we happened to be visiting high-altitude lakes, and then too, swathes of highway yielded to the river, leaving thousands of pilgrims stranded at landslides.

This year though, the death-toll from floods across Uttarakhand was unusually high⁶. Was this due just to the heavy rain this year or was there much more to it? Epithets such as 'Himalayan Tsunami' on television media convey a catastrophic weather event, beyond human cause, anticipation or control. If we look more closely at what actually happened in different river basins, and what was the nature of impact on landscapes and people there, we may learn something that could help avoid some and minimize other impacts in future. We will not go into a detailed analysis of all the affected basins here, because the focus of this piece is the Mahakali basin, and also because we have not investigated in sufficient detail about the other basins. Briefly however, based on information gathered so far, these are some of the patterns we can see.

The heaviest casualties and loss of life was in the Mandakini basin, at Kedarnath and downstream of it. Kedarnath is located just a half-hour stroll below the Chorabari glacier, and in geological terms, on

³The World Meteorological Organization recommends a precipitation measuring station density of one for every 100-250 km² for mountain areas. Pithoragarh district covers an area of 7,110 km² and has just two rain-gauge stations.

⁴This data is from two weather stations set up by us in 2004, in Milam and in Munsiri with data until 2006. The stations no longer exist.

⁵I describe this, because we witnessed and were stranded in this, as in many other flood events on the Gori river.

⁶The number of dead and missing during this event from different sources vary broadly between 600 and 15,000 people.

very recently vacated glacial-till. Rambara and Gaurikund, are directly below Kedarnath in a narrow valley. It is clear now that the catastrophe was caused by a Glacial Lake Flood Outburst (GLOF)⁷ from the moraine-dammed Chorabari lake, at the head of the overcrowded and haphazard temple and hotels complex, and the extremely overcrowded Gaurikund hotel and market complex directly downstream. From various analyses by ISRO, the Uttarakhand Space Application Centre⁸ and others⁹, it appears that there were two events in succession. One, the spate in one of the tributary rivers upstream of Kedarnath due to heavy rain, and a second, a landslide from the region of Kedar Dome, that further led to the breach of a push-moraine that had dammed the Chorabari lake and the ensuing outburst. Most of the people that are reported to have died or are missing in this year's flood events all over Uttarakhand were from these three locations. So were the many 'unaccounted for' migrant laborers from Nepal.

For those of you who have been to Kedarnath, it would be clear that the great loss of life here and at Rambara and Gaurikund downstream, was due to the extreme congestion of ramshackle construction, close to the river, to cater to the very large influx of pilgrims every year. When the outburst occurred, on the morning of 17th June, people at the various hotels and dharamshalas at Kedarnath, had no time to get away. However, it is known that some people at Rambara and Gauri kund downstream were informed of the oncoming flood outburst, and while many did not know or heed, there were many who scrambled upslope to get away.

I received a phone-call from Jai Singh Pawar, befriended during a trek past Madhmaheshwar in the Mandakini basin years ago. He was broken, having lost both his young sons who were at Rambara then. I asked him how it was that his sons did not get away on time, and he said that they did get away from Rambara, but that they, along with 'hundreds' of others who had fled with them, had died high on the alpine slopes while trying to cross over into the adjoining basin. They had probably died of exhaustion and hypothermia he said, because it had continued to rain throughout the day and possibly into the night of 17th June, and they would have been wet to the skin. Crossing over to adjoining basins even over difficult terrain, when the exit down from the basin they are in is impossible, is what local people normally resort to in such circumstances. We have had to do this on occasion. This crossing must have been very high, over an alpine ridge, where it can get close to 0° C at night, even in summer¹⁰.

At Hemkund Sahib, Badrinath, Yamnotri, and Gangotri, the crisis was not of people being swept away, but of a very large number of pilgrims being temporarily stranded at various points because paths had collapsed in landslides, and bridges had been washed away by rivers. A concentration of thousands of people in places not geared to feed and shelter so many would surely be the makings of a crisis. A subset of this dimension, is the manner, the scale and timing of pilgrimage influx to this area, as we are witnessing today.

Landslides are a common and frequent occurrence during monsoon months in Uttarakhand, but the urban pilgrim seems to have been lulled into a false sense of security while traveling here. Perhaps it is the commercial group-tour arrangements from door-step to door-step that makes them forget that they are traveling in the the Himalaya, where consequences of everything can be big; of weather-events, stupendous terrain, or just gravity. Uncertainty does not seem to be factored in at all. Even though this was early in the monsoon, a very large number of yatris travel here through the summer from all parts of India. Many of these are from tropical south India where they've never worn wool. While it is understandable that buying woollens just for a couple of days may be seen as wasteful, the lack

⁷Also known by its Icelandic name Jokulhlaup. There has been some hair-splitting recently over whether a glacial lake 'over-topping' leading to collapse can be called a GLOF, but as far as we are concerned, this is a pro-glacial lake formed by recent glacial action, and a marginal moraine collapse for any reason, would lead to a GLOF.

⁸Scientific Report. Satellite based observations of devastation caused by Torrential rainfall on 16th and 17th June 2013 in Kedarnath Dham and Mandakini valley of Rudraprayag district. Uttarakhand Space Application Centre. DST. Dehradun.

⁹<http://blogs.agu.org/landslideblog/2013/06/27/new-high-resolution-images-of-kedarnath-the-cause-of-the-debris-flow-disaster-is-now-clear/>

¹⁰<http://www.thehindu.com/news/national/other-states/uttarakhand-tragedy-64-bodies-found-in-kedar-valley/article5095993.ece> also confirms such deaths.

of sufficient insulation can be serious at high altitudes, where these pilgrim destinations are. The Kedarnath shrine, for example, is at 11,300 ft above sea level. Many rely on thin transparent plastic rain-ponchos available for 20 rupees at the road-head, to protect them from rain, to cut wind, and to provide some insulation. While this vapour-barrier works while you are walking, sweat can get very cold next to your skin when you stop, and lower body core-temperature drastically.

Since the majority of pilgrims today rush in and out of these destinations in vehicles, stopping only at hotels, eat-places and memorabilia shops enroute, they tend to come unprepared for any uncertainty. They will not step off the black-top of the road. And when there is a section that they must walk because the road goes no further, such as enroute to Kedarnath or Yamnotri, very many of them will climb onto the backs of wiry Nepali boys or onto ponies to be carried the distance¹¹. I speak not of the very old and infirm, but of the general urban yatri. Which is why, the need to step off the highway this year more than others even in the relatively safer places, to make their way over temporary paths that skirt the landslides, required the Indian Army to come in and assist. Or to be airlifted as 'survivors' from the actual destinations by hundreds of helicopter sorties. Depending on the size of the aircraft, this 'rescue' has cost the state anything between 50 lakh Rupees (for an MI 26 helicopter) to about 3 lakh Rupees (for a Dhruv) per hour of flying. Chief Minister of Gujarat, Narendra Modi's braggart show of exclusive favour to Gujarati pilgrims, driving them down in 80 Toyota SUVs from where the road was normal, and then flying them home from Uttarakhand's state capital and from Delhi in four state-chartered Boeing jet-planes, just squandered public money on a hollow pre-election stunt. It feels numbingly futile to even mention in contrast here, a man we met and spent a night with on a pilgrim trail in Garhwal in 1979, just a year following the even more catastrophic floods on the Alaknanda river. He had walked for months, all the way from his village in Madhya Pradesh, and would walk back, come hell or high water. Because every step made his pilgrimage, not just the destination¹². What pilgrimage has come to mean in urban India today, is a paradigm removed. In places where there is now such a massive flux of people, regulation of infrastructure, number of pilgrims in relation to facilities available, briefing for better preparedness for uncertainty, and early-warning weather systems are called for.

In order to understand a little more about the scale and nature of impact in our corner of Uttarakhand; the north-east of Kumaon and the upper reaches of the Mahakali basin¹³, we took a long walk down the Gori river-basin and then the mid-reaches of the Mahakali and Dhauri (the other tributary of the Mahakali), a few days after the flood-event. We also go looking for met data, flow data, any historical data, that might help us be more precise in our understanding.

it was in danger of breaching. Under normal circumstances they do not need his permission. He also confirms that he had refused, because the water level in the Mahakali main-stem was already flowing at danger-mark. NHPC went right ahead and opened their gates at full on the night of 16th June, without authorization or any prior warning to anybody¹⁴ but their own office-residence complex 20 km downstream, at Dobat.

¹¹There are about 4,500 registered mules and ponies that ply between Gaurikund and Kedarnath alone. Some credible estimates say that there are about as many unregistered mules as well. Various informal estimates say that between 9000 and 10,000 pilgrims visit the Kedarnath shrine every day during peak season. Friend Ravi Chopra of Dehradun during a visit to Kedarnath in 2003, actually counted and estimated that only about 15% of the pilgrims were carried by people or mules at the time of his visit. He also counted 80 helicopter sorties a day made by three companies. Even if 10,000 pilgrims are going up to the shrine while the another 10,000 are coming down on a given day, and setting aside even 20% of the 9,000 mules as hired for freight, the number of 'idle' mules as per the estimate are still puzzling. A mule carries between 60 and 80 kilos, which even at an overestimate of 5 kg per person per day, this would be food and provisions for around 25,000 people a day.

¹²While walking over a thousand kilometers on such pilgrimages would be rare today, there are a good number of pilgrims who walk the 14 km from the road-head to the temple and back. They are mostly the rural pilgrim, and predominantly from south India. Many ascetics still walk along the motor road, all the way from Haridwar, 300 odd km away in the plains, halting at the various river confluences or prayag.

¹³higher resolution map available at this

¹⁴NHPC never gives warning of sudden releases. There is a notice painted on a board at Tawaghat, the first river-side habitation downstream, that warns people not to go anywhere near the river, because water may be released anytime.

REFERENCE RIVER-MAP OF THE UPPER MAHAKALI

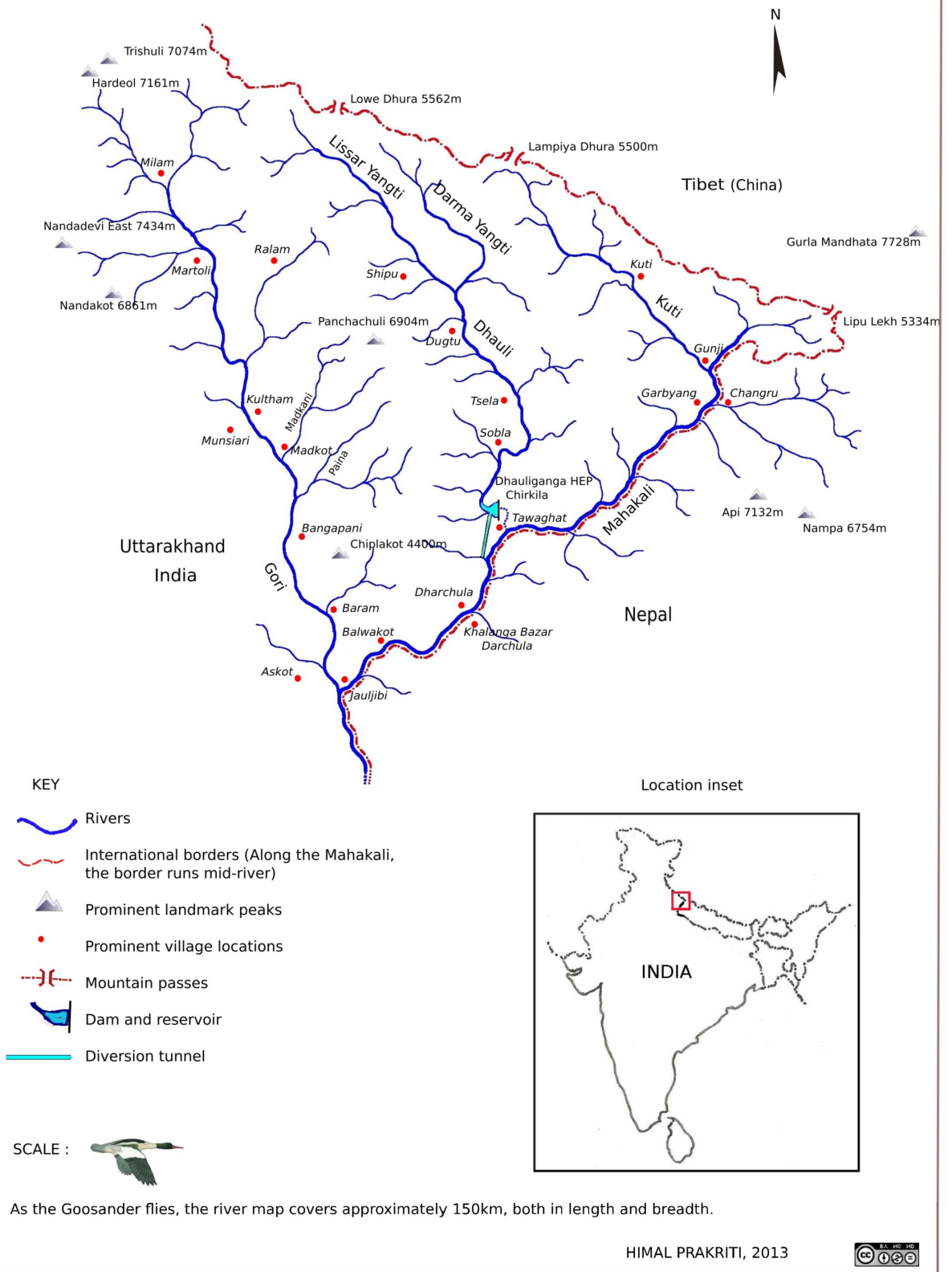


Figure 1: Reference River -Map of the Upper Mahakali

Days after walking down the Gori, we go to the Sub-Divisional Magistrate of Dharchula sub-division, Pramod Kumar, who is busy coordinating rescue and relief on a war-footing, but still has the courtesy to meet. On being asked by me regarding the sudden release of water by the 280 MW National Hydro-Power Corporation (NHPC) Dhauliganga Hydro-Electric Project (HEP) at Chirkila and the ensuing damage downstream, he confirms that he received an emergency call on the night of 16th June from the NHPC, asking that they be permitted to release the impounded water in their reservoir, because it was in danger of breaching. Under normal circumstances they do not need his permission. He also confirms that he had refused, because the water level in the Mahakali main-stem was already flowing at danger-mark. NHPC went right ahead and opened their gates at full on the night of 16th June, without authorization or any prior warning to anybody¹⁵ but their own office-residence complex 20 km downstream, at Dobat.

Was this really an emergency, or was this purely opportunistic on the part of NHPC to take this opportunity early in the season to flush their reservoir that had been filled almost to half with bed-load and silt? We went looking for clues and information. I went to the NHPC office complex at Dobat, and met Bhuvan Chand Joshi, their Public Relations Officer. After giving me the spiel on how safe, and how green this so called run-of-the-river (ROR) project was, constructed by no less than the Japanese, the Germans and the Koreans put together¹⁶, he admitted that their underground power-station was entirely flooded. Housed in a gigantic underground cavern about 100 meters long, four-storeys high at 40 meters and about 16 meters wide, river water had filled it right upto the control-room on the fourth floor. I had already been told by Kesar Singh Dhama, taxi owner of Dharchula, that on the 16th June itself, when he was ferrying the first batch of Kailash yatris to the road-head on their way up to Tibet, he had noticed the reservoir was filled high already with flood-waters, with large uprooted trees and other woody debris floating at the damsite. He confirms that water was being released, but only a small release, despite the dam being fuller than he had ever seen it.

I was also told by another employee of NHPC (who did not wish to be named) that what had gone wrong was that despite the high flows on the 15th and 16th June, the power-station continued with production of electricity as usual. In what seems to be an unbelievably short-sighted and poor design, the Tail-race Tunnel, from where water is released back into the river after having turned the turbines, is flushed into a tributary stream, the Ellagad. It was when Ellagad also pulsed, that it sent a train of bed-load debris down its lower reaches, effectively blocking the exit of the Tail-race Tunnel coming out of the powerhouse. The power house continued to take in water from the Head-race Tunnel intake, and to work their turbines, unaware that the exit for water had been blocked. It is only when the water blocked in the Tail-race Tunnel surged back up, burst through the turbine units and began flooding the powerhouse, that NHPC even know that something was wrong. It was then that the massive curved steel gates of the intake were slid shut, and the powerhouse evacuated. This was further confirmed by Joshi, PRO, who also said that the 'matter was under investigation' by their own team for organizational detail. The General Manager and the Chief Engineer of the Dhauliganga HEP had meanwhile been transferred out. It is not clear yet how soon after the powerhouse was flooded, that they opened the sluice gates at the bottom of the reservoir. Draining it was clearly beneficial for NHPC, but catastrophic for roads, bridges and habitations downstream, both in India and Nepal.

If you look closely enough, there are two separate events here. The flooding of the powerhouse, and the 'emergency' release of reservoir water. The powerhouse was not flooded because of too much water in the reservoir, but because it was in operation when its tail-race exit seven kilometers downstream, is blocked-off because of poor short-sighted design¹⁷. They are then forced to close the gates of the intake, and abandon the powerhouse where water has reached the control-room on the fourth floor. The intake gates are now shut, but the flood waters continue to fill the reservoir further. They have already allowed the dam fill to a very high level, and here is the other curious factor. The design of

¹⁵NHPC never gives warning of sudden releases. There is a notice painted on a board at Tawaghat, the first river-side habitation downstream, that warns people not to go anywhere near the river, because water may be released anytime.

¹⁶Kajima Construction Corporation Ltd of Japan, Daewoo Engineering and Construction Company of Korea, and Bauer Maschinen of Germany.

¹⁷How a tail-race exit could be planned on the Ellagad stream which is very steep and unstable, full of debris from a service tunnel, and highly 'flashy', is indicative of poor design and of lax design approval mechanisms.

the Dhauliganga HEP dam, is such that the dam has no provision for water to 'overflow' the dam safely, should undesired (even if foreseeable) levels be reached as they did this year. Or say if giant boulders block the narrow sluice gates at the bottom of the reservoir. Or in the real-time situation of what actually happened this year, the blocking of the tail-race tunnel leading to flooding of the powerhouse, hence requiring the shutting off of the intake, and losing the option of reducing reservoir levels more gradually and safely through two simultaneous releases. They then open the flood-gates. Clearly, one of two things have led to this decision:

One, letting the reservoir fill to a very high level is not out of the ordinary for NHPC; they do it every monsoon, as they had done on 16th June as well. It is not for many months in the year that they have enough water to run all four turbines. Despite the run-of-the-river label, Joshi confirmed that they were unable to let any water to continue to flow un-diverted in the river-channel during the winter-spring months (we have photographic evidence of this as well), or they would not have water to turn even one turbine! The mandatory requirement that every hydro-power dam in Uttarakhand be required to release at least 10% of the river's minimum flows at all times (as greatly insufficient as such a small flow is for downstream life), it seems neither a consideration while justifying the economics of such projects, and neither is it complied to here. The use of the term run-of-the-river here, is plain deception.

Their regular annual schedule for flushing the reservoir of bed-load and sediment is normally the 15th of July and the 31st of July every year. Here again, when the reservoir is full, and there is enough water to provide the pressure for increased and accelerated flow to flush the reservoir on a twice-annual basis. Both flushing schedules follow each other closely at peak-flow season, so that the flushing is as complete as possible, and there is enough of a monsoon season ahead to fill the reservoir up again before the winter-lean. The probable reason for preponing the flushing could be the chance of flushing some of the unusually high accumulation of bed-load debris that had come down in this year's flood. What this meant to the efficiency of the power-station is one thing, but what it means to all life in and along the river, is quite another.

Two, that the faulty design of the dam, both in location of its tail-race exit as well as no provision for over-topping, in combination with the carelessness of allowing the reservoir to fill to such levels at the start of the monsoon, was responsible for the 'emergency' catastrophic release.

The Dhauliganga HEP is located on the Darma-yangti river, re-christened the Dhauliganga river, just a couple of kilometers upstream of the confluence with the Mahakali at Tawaghat. In these two kilometers, the river flows (twice a year when it is allowed to, for a few hours) down steeply to the confluence which it meets at right-angles. With the Mahakali already in spate, coupled with the sudden release of more than 6 million cubic meters of stored water (Gross Storage Capacity), plus the flow of the river in flood (steadily increasing from 398 cubic meters a second on 15th June), as well as millions of tonnes of bed-load boulders and sediment, the damage downstream is clear to see. If you look at the fresh scour-level on the banks downstream of the dam, it is in places more than 15 meters higher than the flood-level flow of the Dhauli river. The river added thousands of tonnes of even more debris when, because of the flood level it reached, it tore through, plucking high at the talus-cones on either bank, and at every turn. At the confluence at Tawaghat, there must have been something of a back-flood for some time (a common flood phenomenon where the high-flowing main-stem creates a temporary water-dam), because the water-level seems to have risen very high, taking away the bridge that connects the entire Kuti valley and the trade route to Tibet, tearing away almost the entire village-market complex at Tawaghat, and destroying the road as well. The flood waters had clearly reached the top of the road because of the deposition of river-sand on it. When I walked this section days later, the river was only less than a meter below danger mark. Even so, it was flowing about 12 meters below the road! Further downstream, the destruction was more serious.

In order to understand the magnitude of this flood event, I ask Joshi of NHPC for flow-data of the Dhauli river between the 12th and the 18th of June. He goes off for some time and returns with a sheet of paper that has hand-scrawled 6 hourly flow volumes from 12th June, but stops short at 15th June. All the flow volumes between the 12th and the 15th were below 150 cubic meters a second (cumecs), and at 12 am, on the night of the 15th June it jumps up to 389.92 cumecs. This is just the

start of the flood. Joshi seems to balk right here, and says that they have not received data for the 16th June yet (the day I speak to him was the 8th of July), and that he may get it after a week or so. And anyway, he says, the powerhouse was abandoned from the night of the 16th June, so getting data beyond that would be out of question. It is clear that Joshi was unwilling to give me flow-data for the duration of the flood-pulse. He had only minutes before informed me of how automated the whole operation was, and that it was possible for them to even operate the power-house sitting in their Dobat office-complex itself. The real scenario will be clear when we get flow data for the 16th and 17th of June. Meanwhile, here is something to chew on.

According to NHPC, The Peak Flood Design for the Dhauliganga HEP is 3,210 cumecs, at a return interval of 100 years. That is the flow volumes that the dam is designed to be able to take without damage, at flood levels expected at least every hundred years. It is unlikely that flow volumes had reached almost 10 times the flow volumes of the flood on the 15th June at the damsite (389.92 cumecs), which is why Joshi omitted giving me the flow volumes for the next two days. NHPC gets its flow data from an automated level-gauge at the reservoir, so it did not require anyone to take readings manually, even prior to abandoning the station. If unprecedented levels had not been reached, there would be no excuse for the sudden release of water to flush their reservoir right then. If these levels had indeed been reached, then why had they held on to water in the reservoir right till the night of the 16th June? Please see the accompanying photographs, of the dam reservoir, empty of water. You can see at least two levels of cut-away terraces. The lower ones are alluvial terraces, consisting clearly of coarser gravels and cobbles deposited by the flowing river. The higher terraces, more visible high on the upper true-left bank in the photo, are remnant lacustrine (lake-bed) terraces, consisting of finer silts and sand, deposited by the stilled waters in the reservoir when it was full. This was the highest point of sediment accumulation in the reservoir prior to being flushed out. Clearly, at least 45% the reservoir was full of debris and sediment before NHPC flushed it. And if you look at the brown line on the concrete face of the dam, you see the level that the reservoir was allowed to fill upto, marked by the 'bath-tub ring' of floating bark and woody debris stuck there after draining.

Joshi tells me that when a delegation of people from Nepal came to NHPC to talk about the possible role that NHPC's sudden release of water might have had on the flood that devastated Khalanga bazar at Darchula, he had told them that to the contrary, the dam had saved Nepal from great damage. "See how much debris is still behind our reservoir!" This was bare-faced misinformation. There are two aspects being denied here. One, that great masses of debris were actually flushed out from the lower-end of the reservoir on the night of 16th June, leading to greatly increased flood levels as well as erosive potential downstream, especially on the Nepal bank at Darchula, which bore the brunt of flushed debris centrifuged on the curve. As is evident from the photo of the dam-site above, most of the debris that has been flushed, is from the front-end of the reservoir only. And two, that all dams and reservoirs, despite some being able to flush out debris from a section of the reservoir, do actually hold back a great deal of bed-load as well as suspended sediment in the upper end of the reservoir. They impede the very essential flow of sediment down to the oceans. More on this later, but look now at the geometry of bed-load debris in the stitched photo below. Distortions from the wide-angle lens apart, it clearly shows a gradual slope, and a filling up of the bed-rock channel to form a wide, sloping flood-plain. Had it not been for the dam, the bed-load would have continued to fill up the bed-rock channel downstream at about the same angle, slowing the entire flow of water and entrained debris. It would not have been washed down catastrophically all the way down to Darchula, without the force of an additional 6 million m³ of stored water released suddenly.

We go looking for other data. The Canal and Irrigation Department office at Dharchula let us have a look at their register without a fuss. The reading is taken once a day at 8 am, and is from a fixed gauge that has calibration of height above sea level in fractions of meters. We look at this year's data, as well as last year's. During the four days of heavy rain and during the flood-pulse, the water-level above the sea was 887.50 m above sea level (asl) on the 15th June, 888.60 m on the 16th June, 891.00 m on the 17th June and down to 889.50 m and on a decreasing trend on the 18th June onwards. The danger-mark is at 890.00 m asl, which was recorded as crossed only on the 17th June. The trend all through heavy rainy days in July hover a couple of meters below danger-mark. Other than the high



Figure 2: The Dhauliganga Hydro-power dam, after being flushed of bed-load sediment.



Figure 3: The Dhauliganga dam at eye-level. Note highest cut-away sand terrace on the true-left.



Figure 4: Stitched photo of the bed of the drained Dhauliganga reservoir.

point on the 17th June, last years trend was very similar.

While one could surmise from this that the flow levels were hardly enough to merit even a five-year high, it is a fact that after the release of water from the Dhauliganga Hydro-power Project, the water level in the Mahakali rose very alarmingly on the 17th during the day, tearing away the bank on the Nepal side, doing great damage there. The suspension bridge to Nepal at Dharchula barely survived, and had to be shut-down to traffic well before the waters rose right upto the steel ramp that pedestrians walk on to cross the bridge that day. This is at least 6 meters above danger mark. But data for that day and the next, were readings taken at 8 am only, after the 'horses' had already bolted. The whole stable of them from the Dhauliganga HEP at night, in the early hours of 17th June. Clearly, readings taken once a day are not very useful for alerting the civil authorities should emergency action be required at 'odd' hours. In other places, flood-level readings during the monsoon are required to be taken on an hourly basis.

We also take a look at the data from their rain-gauge at Dharchula and find, not surprisingly, that it had not rained here at all on 15th June, while the upper alpine reaches were deluged with heavy rain, leading to floods higher up and resulting in staggered flood-pulses in the river lower down over the next two days. On the 15th June there was no rain at Dharchula, on the 16th there was just 22 mm, on the 17th, 69.20 mm. It was on the 18th of June, when the flood in the river had subsided, that 107 mm of rain was recorded here. We then take a look at the rain-gauge data from Munsiri Tehsil. On the 15th June we get 25 mm, 16th June 44 mm, 17th June 25 mm and the 18th June 75 mm. Far from torrential, but steady and without let-up. These figures reflect nothing of the thrashing downpour that many friends reported, while they were camped out on the high alpine meadows, while collecting the aphrodisiac caterpillar *Cordyceps sinensis*.

The only other data we found in our attempt to get an idea of the volumes of flow in the various tributaries and the Mahakali main-stem, was discharge data mentioned in a report of ICIMOD¹⁸, Kathmandu, on the flood event. The discharge of the Mahakali at Tanakpur, down where the river meets the plain is reported to have risen from 3,936 cumecs to 12,480 cumecs on 17th June, well in excess of the flow of 11,270 cumecs in the monsoon of 2012. It can be misleading to extrapolate data from

¹⁸2013 Monsoon floods in Nepal and India: What happened and what could have been done. ICIMOD. 24 June 2013.

downstream for what may have happened in different tributaries upstream, because many different basins are involved. The unevenness of rainfall in mountain areas, temperatures at different altitudes (determining how much falls as rain, and how much as snow), wind direction (leeward-windward) and so on vary greatly, even within sub-basins. Estimating volumes contributed to the main-stem based only on relative size of watersheds can be speculative. However, since it is technically kosher to use such extrapolations while calculating and specifying Peak Flood Design for dam structures, let us see what we can gauge from this.

As per the dam design in the EIA for the Rupsiabagar-Khasiabara HEP by NTPC on the Gori, a major tributary of the Mahakali, they have calculated a Probable Maximum Flood Design (PMF) at 4,500 cumecs every hundred years. They have done this based on a 10,000 year flood-value for a place called Pancheshwar about two-thirds way down the river to the plain. The 10,000 year flood-value for this location is statistically imagined to be 15,041 cumecs¹⁹. However, downstream of Pancheshwar, the Ladhiya and the Lohawati meet the Mahakali on the Indian side, and Surnaya and Rangun on the Nepal side, and these tributaries could, if the rain was widespread, add significantly to the total flows measured at Tanakpur.

Judging tentatively though, just from these figures, and from seeing the values at the same location of Tanakpur last year, the difference of flows at flood levels between 11,270 cumecs in 2012 and 12,480 cumecs of this year's high, do not seem like a long-term flood cycle at all. Remember, this is a big river, and even if not anywhere as prominent in our national consciousness as the Bhagirathi and the Alaknanda (both combining to make the Ganga), the flows in the Mahakali during those days, were equal to the high flows in both the Bhagirathi and the Alaknanda put together. Admittedly, these are still indirect, and somewhat desperate ways of gauging how 'unprecedented' the rains really were. Till we get more specific tributary-wise data, this is what we can see.

For details of the damage caused by the Mahakali and its tributaries during the spate between 15th and 17th August 2013, please read read the various reports here

Discussion:

The magnitude and nature of this flood-event:

So, was this flood unprecedented? In our view, not so. It really depends on the time-scale we are looking at. Long-term data from rivers apart, we know that all rivers have their rhythms of flow. These could be seasonal pulses of highs and lows every year, or they could be longer-term pulse cycles that can be seen statistically in shorter 10 and 100 year cycles, or longer 1000 or 10,000 year cycles. These are just convenient statistical frequencies for predicting magnitudes, and do not necessarily reflect actual frequency of flood occurrence. The much longer-term flood cycles however may have to do with their relation to the recurring advance and retreat of ice-ages, as we shall soon see.

We know that these longer climate cycles of warming and cooling are predictable, and are caused variously by the effects of the ellipticity of the orbit of the Earth around the sun (every 100,000 years), the wobble of the Earth on its axis (41,000 years), and the precession of the equinoxes (every 22,000 years). These are influences at the astronomical level. We also know that at the planetary level of just our Earth, phenomena such as continental drift, changing ocean currents, and global climate change have much to do with the intensity and frequency of floods. Recent studies of paleo-floods unearth evidence of flood-cycles in geological time-frames.

Depending on where one is located and the area's climatic regime, the recurrence interval of large floods may fluctuate from a hundred years to a thousand years in extremely arid regions, to several decades and even to several years in humid tropics, temperate zones, and cold-climate regions where

¹⁹These figures are from the EIA by WAPCOS. Any data from WAPCOS is to be viewed with great caution, but they are quoted here anyway, being 'official' figures that pass through clearance processes

regular snow-melt floods occur²⁰. The last two conditions are typical of the Himalaya, where you can also find some of the rainiest places on Earth. Floods in the Himalaya are therefore frequent, and as numerous studies have shown, can be at a scale unimaginable to us primates, with our short life-spans.

Three broad phenomena seem to be the major causes for floods in mountain areas. From heavy rainfall events, from glacier or moraine-dammed lake outburst floods (GLOFs) and from landslide-dam or human-constructed dam outbursts. Except the Kedarnath flood, which was caused primarily by a small²¹ glacial lake outburst, the rest of the rivers in Uttarakhand this year, experienced floods resulting from heavy rain and snow-melt. The sudden release of water from the Dhauliganga reservoir, I suggest, was similar to a lake outburst, as already described. For an idea of scale, let us look at just a few examples, of other floods that have taken place in the Himalaya in the recent geological past.

The floods that have shaped the Tsangpo gorge for instance. The Tsangpo river runs along the northern water divide of the Himalaya in Tibet, and bends down from South-Eastern Tibet, cuts through the Himalaya down the deepest terrestrial gorge on Earth, and enters the Indian subcontinent as the Brahmaputra river. A study by D. R. Montgomery and colleagues²² tells us that during the Holocene and following the last glacial, with warming weather and glacial advance in some areas due to an intensifying monsoon, the Tsangpo river was dammed by a glacier-tongue. This formed gigantic lakes in South-eastern Tibet, just before the entrance of the river into the Tsangpo gorge. One of these lakes is estimated to have covered an area of 2,835 km², and held 832 km³ of water. Radiocarbon dating of organic matter from lacustrine sediments tell us that somewhere between 8,860 and 9,870 years BP, this glacier-dam breached, releasing water with an estimated discharge of upto 50 million cumecs. This mega-flood was probably repeated within less than 10 year intervals, with repeated extensions of the glacier tongue and re-damming of the river. The erosive potential represented by such a tremendous flow down a steep gradient and a narrow gorge (from >2,900 meters altitude to <500 m, over a course of 200 km) indicate that these floods were likely among the most erosive events in recent Earth history.

A more recent example of glacial dam-burst is that of Chong Kumdan (Shyok river) flood in a high valley in Ladakh in 1929. The dam is said to have held back a lake of 13.5 km³. When it breached, it is estimated²³ to have resulted in a peak discharge of 22,650 cumecs, completely transforming the Shyok valley into a giant debris-filled mountain floodplain at over 3,300 meters above the sea²⁴.

Landslide-dammed rivers are another mechanism of catastrophic floods in the Himalaya, especially when combined with intense monsoon rains. The Alaknanda has been blocked several times by landslides triggered by intense rain, thereafter releasing catastrophic floods on breaching. Some of the better known examples are the flash-flood in 1803, which swept away one-third of Srinagar town. In 1868 the Alaknanda river swept away two bridges, killing 70 pilgrims who were sleeping on the riverbank at Chamoli. In October 1893 a landslide in the Birahi Ganga near Gauna village formed a 350 m high dam, blocking water that came to be known as Gauna lake. Following very high rainfall and debris flow in August 1894, the lake breached. This sent a sudden surge of water down the valley raising level of the Alaknanda by 50 meters at Srinagar, which is situated on a wide flood-plain 110 km downstream, destroying the entire town²⁵. Examples of major disasters caused by extreme rainfall

²⁰Strakel, L. Clustering of flood events in the context of increased Human activity. Department of Geomorphology and Hydrology, Institute of Geography, Polish Academy of Sciences, 11 ul.św. Jana 22, 31-018 Kraków, Poland. e-mail: starkel@zg.pan.krakow.pl. Address being given in the absence of publishing details.

²¹I say 'small' for Kedarnath, having seen this and all the other glacial lakes of any significant size in every glaciated valley of Uttarakhand; and this was relatively small. Approximately 150 meters long, and 15 meters at its deepest.

²²Montgomery DR et al. Evidence for Holocene mega-floods down the Tsangpo river gorge, South-eastern Tibet. *Quaternary Research* 62 (2004) 201-207.

²³By Gunn (1930) and Hewitt (1982), quoted in Peter Coxon, LA Owen and Wishart A Mitchell. A late Quaternary catastrophic flood in the Lahul Himalayas. *Journal of Quaternary Science* (1996) 11 (6) 495-510.

²⁴While traversing the Himalaya on foot in 1997, it took my friend Malika over an hour to walk across the Shyok flood-plain. Having walked already for over 6 months at a stretch, she was walking fast. This high mountain flood-plain is that wide.

²⁵Varun, Joshi., Kireet, Kumar., 2006. Extreme rainfall events and associated natural hazards in Alaknanda valley, Indian Himalayan region. *J. Mount. Sci.* 3 (3), 228-236. Also described in *The State India's Environment 3. A citizen's Report. Floods, Floodplains and Environmental myths.* CSE.

events over the past 50 years itself include the flash-floods of 1968 in the Teesta valley, in 1993, 1997 and 2000 in the Sutlej valley, in 1970 in the Bhagirathi, and as just described, in the Alaknanda in 1978.

Flooding caused by heavy rainfall events are small in comparison with glacial lake outbursts, and even landslide or constructional dam-bursts, but can still be considerable. For example the Teesta river in Sikkim regularly has peak discharges between 1,800 to 2,500 cumecs, but in 1989, an exceptionally large flood event caused a discharge of over 18,000 cumecs²⁶. Examples are very numerous, but they seem to lie low in our collective memories.

The flood-pulses in the rivers of Uttarakhand in June 2013 seem to have been caused by heavy rain in the upper alpine reaches, and in scattered locations elsewhere as well. The flow-volumes, (judging from what we saw and from very patchy data obtained so far), and the erosive force of these rivers in pulse however, seems to have been more than one normally sees with just heavy rain.

There is another dimension to this entire flood event. The heavy rainfall at the alpine reaches in 2013, were compounded greatly by another factor that would have been missed out by rain-gauges, even if there had been any at the appropriate places. This was the amplification of runoff during the heavy rain episode, way in excess of infiltration, over already saturated alpine soils due to snow-melt, following late and heavy spring snowfall.

Let us take a closer look at the upper reaches of the Mahakali basin where we live, and which also experienced serious floods. The three river basins on the very north-east of Uttarakhand, that form the highest glacier-fed tributaries of the Mahakali on the Indian side, are the Kuti Yangti river (~52 km long), the Darma-yangti river, re-named the Dhauliganga river (~75 km long) and the Gori river (~100 km long). The three basins together comprise an area of about 4,500 sq km, covering altitude gradients from 7,434 meters to 590 meters above the sea. But here is the crux. In a length of 140 km at most, these basins possess climate-types that range from hot sub-tropical to proper frigid arctic conditions. Most importantly, about 74%²⁷, or almost three-fourths of the terrain of these basins put together, fall above 3,500 meters above the sea. They are either alpine, above the tree-line and with snow cover for about six months a year (covering 63% of the land) or nival, even higher up, with year-round snow and ice (covering 11% of the land). Winter snows cover this entire 74% and more till spring, when the snow-pack starts melting rapidly. However this year, in the spring and early summer of 2013, as late as the 3rd of June, we had more snowfall on all these alpine areas, to as low as ~ 3,700 meters asl²⁸.

When the monsoon struck early with the heavy rain episode between the 15th and 17th of June, I estimate that ~45% of the entire land-area of these basins would still have been covered with snow, the lower half of this a shallow snow-pack. The density of new snow varies from 0.05 to 0.20 (water being 1.0), depending on the air temperature when it floated down. By springtime, the density of the snow-pack would have increased to 0.30 to 0.50, due to settling and compaction, melting and refreezing, and with spring rain. When a snow-pack's temperature rises to 0°C, and its liquid content is at maximum, it is said to be 'ripe'. Even without rain, 15th June being so close to the equinox, substantial heat would have been added for snow-melt, from direct sunshine, from long-wave radiation, as well as from the release of latent heat at the time of melting and re-freezing (during day-time thaws

²⁶Starkel, L., Froehlich, W. and Soja, R. Floods in Sikkim Himalaya – their causes, course and effects. *Memoir Geol. Soc. of India*, 41, 1998, 101-118.

²⁷From an altitude related climate-type classification done by us for the Initial Plan Document of the Biodiversity Conservation and Livelihoods Improvement Plan by PEACE. 2006

²⁸Certain ethnic groups of people who live at the mid and lower elevations in these basins during winter, traditionally migrate up to their alpine villages for summer following a transhumant cycle. Following them, over the past 10 years, are hordes of thousands of other people from the mid and lower altitude villages, who now go up to the alpine meadows to search for *Cordyceps sinensis*. This caterpillar-infected-by-a-fungus, is known to be an aphrodisiac, among other uses in Chinese medicine, and fetches the collector over 10,00,000 rupees a kilogram, and retails for three times the price of gold in Tibet and elsewhere in China. This caterpillar is dug out from alpine meadows above 4,000 meters altitude and above, just as the snows melt in spring. While the precise time of snow-melt at this altitude varies every year depending on the timing and heaviness of snowfall during winter, people usually move up in late April to begin collecting. This year, the spring of 2013, they could only move up a month later, in late May, because the entire area was under snow from the late and repeated spring snowfall.

and night-time freezing). At this time of year, even without rain, snow-melt can be as high as 40 mm a day²⁹.

The incoming warm, moist air of the monsoon, coupled with torrential rain on this ripe snow-pack for three days, would have accelerated melting and overland run-off very rapidly. Those of you who have been up to alpine meadows at this time of year, would have found the soils already soggy with snow-melt during day-time, and needles of ice pushing out of the soil at night, clearly beyond capacity to infiltrate more moisture. This combination of factors (rapid snow-melt, torrential rain, already saturated soils) results in greatly increased overland runoff, and is a common source of floods in other high mountain areas across the globe³⁰. This would most likely have combined and compounded here this year, to produce floods of such high intensity.

In the complete absence of ground meteorological stations at alpine altitudes where it rained the most, the closest locational data on rainfall intensity that we came across were two NASA maps. They are copied below for you to see. The first map, from NASA Earth Observatory³¹ is derived from multi-satellite images and is based on data from NASA's Multi-satellite Precipitation Analysis (MPA), which estimates rainfall by combining measurements from several satellites and calibrating them using measurements from the Tropical Rainfall Measuring Mission (TRMM).

Of the four darkest-blue spots (denoting >300 mm rain), the one farthest east, right next to the Far-west Nepal border, is the one over the Mahakali basin. Note also, that the second largest dark-blue spot is in Tibet, right over the transition of the headwaters of the Sutlej and the Karnali basins, which are classically cold-desert areas, but where maps also show heavy rain. This should put to rest any doubts about possible meteorological warfare by China through cloud-seeding, that are also being bandied about.

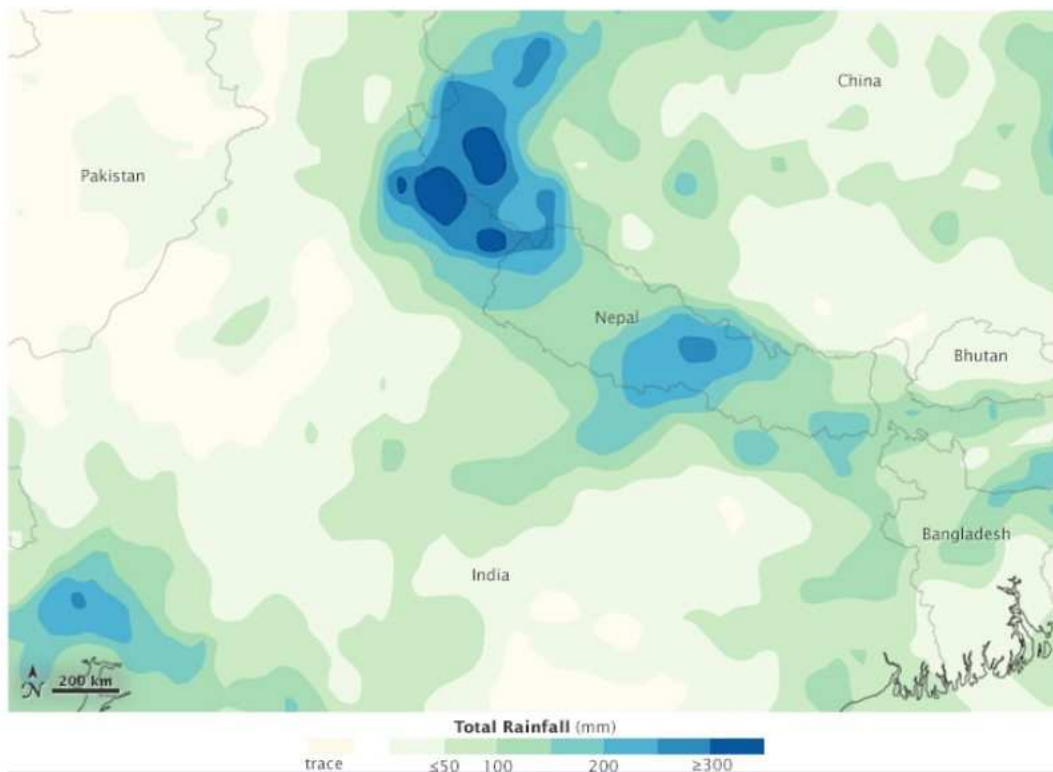


Figure 5: Image from NASA's Multi-satellite Precipitation Analysis June 14th-20th 2013

²⁹Church MA (1988) Floods in cold climates. In Baker VR, Kochel RC, Patten PC (eds) Flood Geomorphology. Pp 205-29. Wiley Interscience. Chichester.

³⁰Burt, TP. The Hydrology of Headwater Catchments. In Peter Callow and Jeff Petts. The rivers handbook. Vol 1. Blackwell Scientific Publications. Oxford 1992.

³¹<http://earthobservatory.nasa.gov/IOTD/view.php?id=81450>

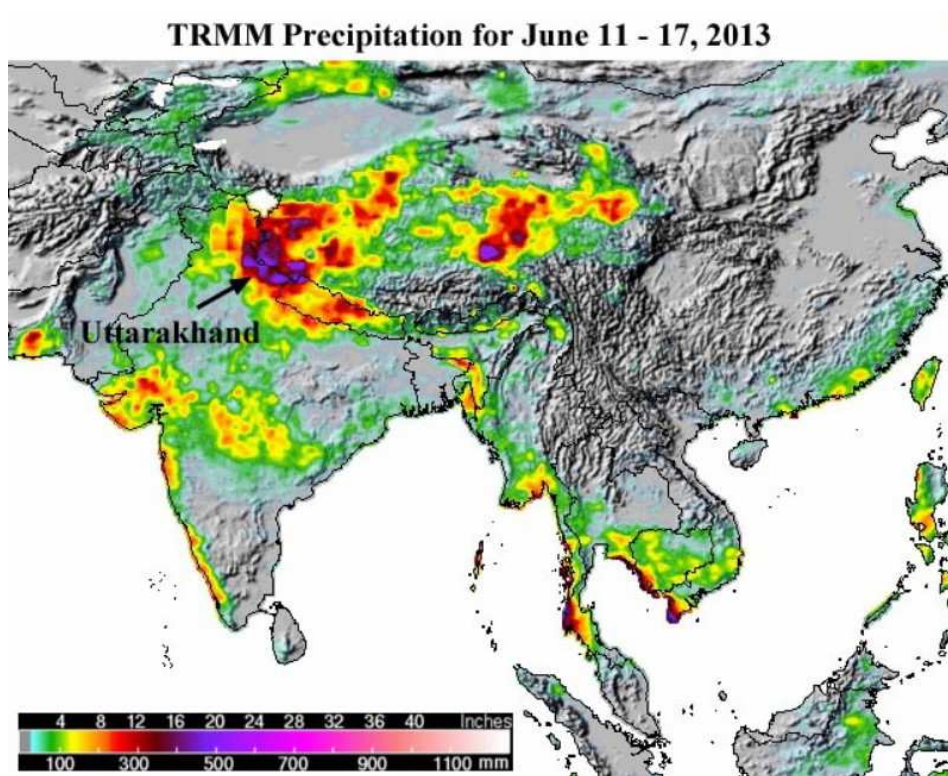


Figure 6: TRMM precipitation for June 11 - 17, 2013

The second map is also from NASA Earth Observatory's TRMM mission, and accessed from Jeff Master's Wunderground site³². What we understand from these maps is that the rainfall range that each colour represents is the total or cumulative rainfall received in those locations for the periods mentioned, which are a week each. In the first NASA MPA map, the areas in darkest-blue denote rainfall more than 300 mm, in one week. That is the top of the scale here, so we only know from the second map (NASA TRMM) where the scale covers much higher range, that some areas in Uttarakhand, including the headwaters of the Mahakali, received as much as 500 mm in places. NASA cautions that because these are estimates of rainfall over a very large area and based on when satellites pass overhead, these maps can miss pockets of heavier rain in smaller areas, or short periods of more or less intense rain. Even so, while this is heavy rain spread over 7 days, 'unprecedented' seems over the top.

Consider for example, a study by Varun Joshi and Kireet Kumar³³ that looks at extreme rainfall events across the Himalaya in recorded history. Among their list are the following. The town of Mandi and the Suketi valley in Himachal Pradesh (due west of Uttarakhand) experienced 250 mm of rain in three hours in the early hours on August 31st, 1960. Dharamsala, also in Himachal Pradesh received 387 mm of rain in one day on July 16, 1934 and 363 mm on September 21st, 1917. Haridwar, Dehradun and Kotdwar in Uttarakhand received rainfall of 495 mm on September 18th, 1880, 487 mm on July 25th, 1966, and 350 mm on August 27th, 1982 in 24 hours, respectively. In the Teesta valley in Sikkim, the highest rainfall recorded in 24 hours was 690 mm between 11 and 13 June 1915. The study also tells us that once every 10 years, the Ganga basin upto Haridwar sees rainfall events of 100 mm to 300 mm a day and daily rainfall of 200 mm to 450 mm once in 100 years.

A study of rainfall and related natural disasters in neighboring Nepal by Chalise and Khanal³⁴, says that 'rainfall events exceeding 300 mm within a 24 hour period, which disturb both slope and channel

³²<http://www.wunderground.com/blog/JeffMasters/archive.html?year=2013&month=06>,

³³Varun, J., Kireet, K., 2006. Extreme rainfall events and associated natural hazards in Alaknanda valley, Indian Himalayan region. *J. Mount. Sci.* 3 (3), 228-236.

³⁴Chalise SR and Khanal NR 2001. Rainfall and related natural disasters in Nepal. In. Tianchi, Li, Chalise, S.R and Upreti, B.N. (eds.), *Landslide Hazard Mitigation in the Hindu Kush-Himalayas*. ICIMOD, Nepal. Pp. 63~70.

equilibria on a regional scale, occur frequently in the country.’ Nearly 80% of all precipitation occurs during the monsoon (June to September), with 8% falling during the post monsoon (October to January), and 12 % falling in the pre-monsoon. Precipitation as high as 540 mm in 24 hours, with a peak intensity of 77 mm per hour, has been recorded. Within just a 10 year period, (from a very thin network of stations in Nepal) between 1981 and 1990, they record 29 rainfall events between 300mm and 400 mm, and 8 events of precipitation > 400 mm in 24 hours.

During the rains of June 15th to 17th this year, the real-time monitoring stations in Nepal reported³⁵ 80.4 mm of rain on 16 June and 221.8 mm on 17 June at Dipayal, which is in the Karnali basin, adjoining the Mahakali basin. Lower areas in the Mahakali basin such as Dadelhura, Dhangadi, and Birendranagar in the Far Western Development Region of Nepal recorded more than 150 mm of rainfall in 24 hours on 17 June 2013. None of this indicates that the rainfall during this period in Uttarakhand and Far-west Nepal was unprecedented. There were repeated references to cloud-bursts and multi-day cloud-bursts, in the media and others writing on the event. A cloud-burst really, is when the downpour ranges between 200 mm to 1,000 mm per hour!³⁶ The shorter duration high intensity precipitation in a localized area is more common, especially at high elevations, and in such a situation, between 100 to 250 mm of rainfall per hour may occur³⁷. We conclude from all the above, that the rainfall during the period in question was indeed very heavy, but by no means unprecedented.

The reason why one has gone to some length on the matter of attempting to track-down exactly how heavy the rain was, is because the Chief Minister of Uttarakhand, and the ‘entrained’ hydro-power lobby, have tried to make a case of ‘unprecedented’ rain for two possible evasive agendas. One, to dodge the issues of poor design and fundamental flaws in conceptualization and functioning of such hydro-power projects that have contributed to the devastation. And two, to evade the issue of the greatly enhanced erosive power of the rivers in spate, due to blasting of tunnels and dumping millions of tonnes of muck along rivers, as well as the mining of hundreds of thousands of cubic meters of sand and rock for the building of numerous hydro-power projects along all the major tributaries of the Ganga in Uttarakhand.

On the erosive power witnessed in the floods this June, and on disaster potential along rivers:

That many of these flood pulses were ‘flashy’ and highly erosive in nature, is attested to by the massive movement of bed-load sediment and landslide debris, the tearing away of all the steel bridges at the higher altitudes, and the severe damage to every hydro-power project in the Mahakali basin. Take a look at the photo below, of the 5 MW Himalaya Hydro Tanga Phase I dam, smashed by car-sized boulders that were transported during the flash-flood on 16th June in Paina gad, a tributary of the Gori. I had a close look at the boulder perched right on top, it was gneiss. I estimated the size to be about that of a small car, say a Maruti 800. At 2.7 tons per m³ for gneiss, such a car-sized boulder would weigh around 40 tons. This was being rolled around by water, right on top of the bed-load of a small tributary river!

I found the bigger picture on movement of sediments by rivers and erosive forces to be instructive in this context. The Ganga-Brahmaputra river system, which all the rivers in Uttarakhand are the western-most tributaries of, carries the largest load of river sediment compared to any other river in the world. It has done so for millions of years, notwithstanding the lopsided ‘Himalayan Degradation Narrative’ of deforestation caused by funky villagers. It is estimated that on average, the suspended sediment discharge of this river system is 1670 X 10⁶ tonnes a year³⁸. This is just the suspended wash-load of sand, silt and clay. Add to this an average movement of bed-load (coarser substrate otherwise

³⁵2013 Monsoon floods in Nepal and India: What happened and what could have been done. ICIMOD. 24 June 2013.

³⁶Deoja, B., Dhital M, Thapa B and Wagner A. 1991. Mountain Risk Engineering Handbook, Part I&II. ICIMOD, Kathmandu, Nepal. Pp. 875.

³⁷Varun, J., Kireet, K., 2006. Extreme rainfall events and associated natural hazards in Alaknanda valley, Indian Himalayan region. J. Mount. Sci. 3 (3), 228–236.

³⁸These figures on erosion rates are taken from the paper by Milliman JD and Meade RH, Worldwide delivery of sediment to the Oceans. The Journal of Geology. Vol 91, No 1. 1983.



Figure 7: Boulder bed-load upstream of the destroyed 5 MW Himalaya Hydro Tanga HEP on Paina gad.

sitting on the river-bed) of 734×10^6 tonnes a year. Suspended and bed-load debris together, carried and shunted into the sea on average is 2.4 billion tonnes a year. This can vary every year. In 1973, just the bed-load pushed into the sea was two billion tonnes. The accumulation of eroded debris from the Himalaya in the Himalayan fore-deep and what is now the Gangetic plain, is said to be at least 5 km deep.

Add to this the dissolved minerals in river water. We have some data from two tributaries of the Ganga, which I bring in here only to illustrate important flows that are seldom considered. There are also important similarities between the Alaknanda river basin and the Mahakali basin which we are focusing on; both immediate neighbors, and their basins representing similar geological transitions. An important study by Chakrapani and Saini³⁹ on chemical weathering rates in these two basins describes how carbonate rocks predominate in the Alaknanda River basin and silicate rocks predominate in the Bhagirathi River basin. When silicate rocks weather, they yield more suspended sediments to the river, whereas carbonate weathering results in more dissolved loads. Which is why the dissolved mineral flux of the Alaknanda river is much higher (1.80×10^6 tons a year) than of the Bhagirathi river (0.34×10^6 tons a year). The chemical weathering rates in these basins vary between 85 (for the Bhagirathi) and 155 tons km^2 a year (for the Alaknanda), which is much higher than the global average of ~ 24 tons km^2 a year. The study also shows that approximately 70% of HCO_3 in the Alaknanda and Bhagirathi rivers are derived from carbonate lithology and that over 80% of this dissolved chemical load is transported during the monsoon.

I have quoted these volumes here because they help me understand that a river is not just a channel of flowing water, but is as much the flows of very large volumes of dissolved minerals, suspended sediment and bed-load that are transported to the oceans. Nothing short of a re-cycling of the Earth's crust. What is the significance of this to our lives? Among other things, the following:

When silicate or carbonate minerals dissolve from weathered rock in rainwater we are told, carbon

³⁹G.J. Chakrapani, R.K. Saini, S.K. Yadav. Chemical weathering rates in the Alaknanda–Bhagirathi river basins in Himalayas, India. *Journal of Asian Earth Sciences* 34 (2009) 347–362

dioxide is drawn into the solution from the atmosphere to form bicarbonate ions. Rivers carry rainwater and bicarbonate ions (HCO_3) to the ocean, where they are used by calcifying organisms such as corals, foraminifera, molluscs and other shelled creatures. Most of the carbonate is re-dissolved in the deep ocean when these die and sink. Climate science tells us that both carbonate and silicate weathering and their dissolving in free-flowing rivers result in the build up of alkalinity in the oceans, as well as a decrease in atmospheric carbon dioxide concentrations. Over geological time periods this slow carbon cycle is said to be the most significant factor in stabilizing the Earth's climate⁴⁰.

Another study by Chakrapani⁴¹ and Saini tells us that among the human influences on sediment load patterns in rivers, none exert as much influence as the effect of dams and reservoirs along the river courses. They quote Vorosmarty and colleagues' estimates⁴² that 30% of the global sediment flux get trapped behind large reservoirs. Every reservoir traps significant amounts of sediment, even the diversion-and-storage dams of the so-called run-of-the-river hydro-projects. The stitched photo of the empty Dhauliganga reservoir illustrates this well. Add to this, the fact that water from entire rivers, the Mahakali being one such, are diverted for irrigating cash-crops and meeting industrial and irrigation needs in distant places, resulting in no water flowing down to the sea, other than during the monsoon months. Clearly then, dams for hydro-power projects combined with major diversions of river water for other commercial uses, seriously disrupt the stabilizing role of rivers in the carbon balance. What was that then about hydro-power being 'clean', even in the carbon sense?

A river is also what a river does. So what 'went wrong' this year? While floods may not be predictable on a short-term basis, are flood events in the Himalaya rare enough to take us by surprise?

For rural populations who have lived for long in major tributary basins in the Himalaya, this year's flood is not a surprise. They know that such floods recur with differing frequency, and they do not make their homes so close to the river. Therefore, if you look at the pattern of damage and loss due to this year's flood, you will notice that very few old village habitation sites have been affected. The places that have been most affected are the relatively recently built roads, and the shops, hotels and other commercial establishments that have come up alongside these roads. These roads, as described earlier, have been built by government, wherever possible on old flood-plains along the river. These flood-plains or bagad are old sandbanks, with layers of gravel and pebble. While one understands that roads inevitably become the locus of commercial activity anywhere, it is the alignment of the road that is misconceived in the first place. Such damage would not have been sustained, nor would people have been so cut-off, had the alignment been say 200 meters above flood levels, and along more stable rock-strata. Have not people, notable among them being geologist K S Valdiya, been saying this for long? To live so close to a mountain river, we'd have to do as a sand-martin does. Live in a 'hole' in the sand-bank (or very temporary shelter), and take flight every time there is a flood. Humans who live close to the river in the lower reaches of rivers in the Gangetic plain, do just that.

There are villages too that are not close to rivers and are also affected this year. They are mostly chronic landslide affected villages. But more on landslides soon. What about the builders of roads, and hydro-power projects? Was this unpredictable for them, with all their flood-cycle modeling and so on? Clearly not. There is much more going on here, ranging from short-sighted commercial interests inimical to local people's interests, criminal negligence, as well as widespread corruption.

It is appropriate now, in the context of this year's 'disaster', for there to be a larger public cognition of the disaster-potential of rivers per se, and particularly the highly hazardous nature of the entire enterprise of hydro-electric projects in the Himalaya. History has repeatedly demonstrated that impounded water can turn extremely hazardous for any habitations and infrastructure downstream. We have an immediate example of the small pro-glacial Chorabari lake above Kedarnath breaching this year. The flood was catastrophic for the pilgrim centre of Kedarnath, as well as downstream through Gaurikund,

⁴⁰The best brief explanation I have seen is here: <http://earthobservatory.nasa.gov/Features/CarbonCycle/page2.php>

⁴¹G.J. Chakrapani, R.K. Saini. Temporal and spatial variations in water discharge and sediment load in the Alaknanda and Bhagirathi Rivers in Himalaya, India. *Journal of Asian Earth Sciences* 35 (2009) 545–553

⁴²Vorosmarty, C.J, Meybeck, M., Fekets, B., Sharma, K., 1997. The potential impact of neo-castorisation on sediment transport by the global network of rivers. In: *Human Impact on Erosion and Sedimentation*. IAHS Publ. vol. 245, pp. 261– 273.

Rambara and beyond. The lame argument that the so called run-of-the-river projects don't hold much water, really doesn't hold much water itself. An example is the Dahuliganga HEP which is touted to be run-of-the-river, holds 6 million m³ of water; many times the volume of the breached Chorabari lake. Larger projects such as the Tehri dam hold 2,600 million m³. Dam failure is not a very rare phenomenon, either in India or anywhere else in the world. As recently as 1975, the failure of the Banqiao Reservoir Dam and subsequently other dams downstream in Henan Province in China, killed an estimated 171,000 people and 11 million people lost their homes. This is thought to be caused by a 2,000 year flood cycle⁴³. What if a 2,000 year flood were to take place along any of the Himalayan rivers where very large numbers of dams are being built? It would be a mistake to imagine that this is a remote possibility. River floods are both cyclical as well as caused by random and frequent events like formation and breaching of landslide-dams, caused by either rainstorms or seismic shocks and so on. While the Banqiao event was the most serious energy related accident so far anywhere, and doing more damage than the nuclear accident at Chernobyl, the list of other dam failures is long.

The intention is not to scare-monger, but following this year's flood, this requires to be put on the table. The Himalaya hold the largest ice-cap outside the two poles, comprising >5000 glaciers with a total area of 38 X 10³ km²⁴⁴. The Mahakali and all the other large tributaries of the Ganga are glacier-fed rivers. Just one tributary of the Mahakali, the Gori, has 32 named glaciers at its headwaters. We know that Glacial Lake Outburst Floods (GLOFs) are a clear and present danger in the rapidly warming climate and retreating glaciers. None of the government clearances given to any of these dams, have an assessment of GLOF hazards at all. Both ISRO's and ICIMOD's assessments of GLOF hazards based on satellite images, declared that none of the glaciated valleys of Uttarakhand were in danger from such lake outbursts. But you have the small Chorabari glacial lake collapsing with disastrous effect this year. In any case, assessments of GLOFs cannot be a one-time assurance. They require to be monitored and repeated frequently, because of the their constantly changing form and structure, made more rapid by warming climate.

The most dangerously impending disaster, in my view, from a glacial lake in all of Uttarakhand, seems completely out of public knowledge and consciousness today. Stand by the shores of Vasudhara tal high up and right on the glacier at the base of Kamet in the Niti valley, and you can see that this very massive glacial lake has extremely mobile and unstable banks of glacial-ice and moraine debris. The outlet is on the true-left bank, but was on the true-right only a couple of years ago. Another indication of its instability. The waters that are heavily silt-laden can be seen swirling in the lake, indicating flowing currents even far away from the outlet. If this glacial lake breaches suddenly, we could have a repeat of the floods of 1894 in the Alaknanda valley, not only wiping out Srinagar town again, but toppling three hydro-power dams enroute like dominoes, and multiplying the damaging potential all the way to Haridwar and beyond. Clearly, we need legislation ensuring that no infrastructure project along glacier-fed rivers, hydro-power in particular, be given any clearance without a basin-specific assessment of both flash-flood potential and foreseeable GLOF hazards as well.

Still on predictability. This has been said so often, that its import seems to be dulled. The Himalaya are a young mountain-complex, and as the discussion on river sediments shows, is subject to the highest erosion rates anywhere in the world. A large part of the sediment in Himalayan rivers is from slope-failure and massive landslides. While this is a 'natural' phenomenon, many studies have clearly shown that human interventions greatly increase landslides. Road building and hydro-power projects being the major causes. The study quoted earlier on sediment fluxes in the upper Ganga basins⁴⁵ cites a study by Wasson⁴⁶ that estimated that two-thirds of the landslides which occurred in the year 1999 in an area of 225 km² in the upper Ganga river catchment, were caused due to human activities such as road building, creating upto 45 X 10⁴ tons of loose debris. K S Valdiya estimated that an average of 40,000 to 80,000 m³ of debris is removed to build each km of mountain roads and another 550 cum

⁴³http://en.wikipedia.org/wiki/Dam_failure

⁴⁴G.J. Chakrapani, R.K. Saini. Temporal and spatial variations in water discharge and sediment load in the Alaknanda and Bhagirathi Rivers in Himalaya, India. *Journal of Asian Earth Sciences* 35 (2009) 545–553

⁴⁵G.J. Chakrapani, R.K. Saini. Temporal and spatial variations in water discharge and sediment load in the Alaknanda and Bhagirathi Rivers in Himalaya, India. *Journal of Asian Earth Sciences* 35 (2009) 545–553

⁴⁶Wasson, R.J., 2003. A sediment budget for the Ganga–Brahmaputra catchment. *Curr. Sci.* 84 (8), 1041–1047.

have to be removed per km every year to maintain them⁴⁷.

Hydro-power projects are perhaps the greatest contributors to landslides as well as flood damage, not just along their entire tunnel lengths, but all the way down the river-basin. They contribute in two ways. One, by destabilizing slopes along their entire tunnel lengths, and two, by dumping and stacking very large volumes of muck (euphemism for excavated debris) along flood-plains. Here is an idea of how much:

I take the figures from the shelved Rupsiabagar-Khasiabara HEP of NTPC⁴⁸ for a concrete example of dam design. We get this from a copy of their shockingly shoddy Environmental Impact Assessment (EIA)⁴⁹. Detailed Project Reports which have relevant details, are secret. We gather from the EIA that excavated material from tunnels for this project will be 1.6 million m³ or say 4,57,000 large truckloads (can't help think of carbon emissions here too). I spoke to a tunneling contractor for the railways, and was informed that for blasting granites and gneisses, they need to use upward of 1.5 kilos of explosives for every m³ of rock evacuated. This adds up to around 2,400 tonnes of explosives to be used for this one project. While the EIA speaks of seismic shocks caused by the use of such a large volume of explosives, they evade any mention of adverse impact, other than 'sound pollution', the most ephemeral of impacts. While the impact of such seismic shocks in one of the most seismic areas on Earth (Zone V) requires to be assessed appropriately, the actual impact on the surrounding areas is quite apparent. We see that in the Gori basin, where even exploratory tunneling has been done by hydro-power companies, springs and water-sources of villages above those tunnels have dried up. This could only happen if the impermeable rock strata was fractured, leading to leaching down of sub-surface flows. It is not for nothing that hydro-power projects use steel rods upto 15 meters long to 'pin' in place fractured rock around their buildings and structures near tunnels. We also see that numerous new landslides are initiated, while further destabilizing existing ones nearby.

Add to this the effect of tunnel debris stacked along rivers by hydro-power projects. Again, the Rupsiabagar-Khasiabara HEP would dump 1.6 million m³ of loose excavated debris onto either river-side forests taken away from nearby village communities, or on scarce river-side agriculture fields also appropriated from village communities. Consider the cumulative impact of the quarrying and debris disposal from the 8 large projects, and another 24 relatively smaller projects proposed and underway hydro-power projects in one short sub-basin such as the Gori, where these giant volumes of debris would be available to the river for 're-working' over subsequent flood events. The flood may not directly be human-made, but the multiplied destructive force would be.

The erosive force would be further compounded by mining of very large volumes of sand and rock required for each dam. The Rupsiabagar-Khasiabara HEP, for example, would require about 130,000 m³ of coarse aggregate, 50,000 m³ of fine aggregate and 115,000 m³ of sand for building the dam, the power house and other related buildings. This is apart from steel and cement, which are not 'local', but would be mined elsewhere⁵⁰. Rock for this project would be taken from two quarries on the river, and cobbles and sand would come right from the river bed. The Gori is a steeply descending river, and consequently has very few flood-plains where the river slows down enough for the settling of alluvion such as sand. Compare it with the stupendous Tsangpo gorge where the river descends from >2,900 meters altitude to <500 m, over a course of 200 km; the Gori descends from >3,500 meters to 590 meters altitude in just half the distance, a 100 km. Walking the entire length of the Gori we were hard-put to see where 115,000 m³ of sand could come from for this one project, let alone for the 32 other projects that would follow.

These hydro-projects will need to scrape clean all the sand deposited on the flood-plains and on slower curves on the river, and then mine downstream, along the banks of Mahakali mainstem as well.

⁴⁷Quoted in Agarwal, A and Narain S. 1991. Floods, Flood Plains and Environmental Myths. Center for Science and Environment, New Delhi.

⁴⁸The Project was refused Forest Clearance for diversion of Forest land for the dam, by the Ministry of Forests and Environment.

⁴⁹http://envfor.nic.in/sites/default/files/Rupsiabagr-Khasiyabara_EIA.pdf

⁵⁰18 years ago, at dusk on a sand beach on the island of Pirotan, the only marine Protected Area in India, we met a man from a cement factory in Gujarat, who told us that their 'raw material' was now scarce, as they had already quarried and 'finished' most of the sand beaches in the state, and were getting sand from other states now.

The Chief Minister of Uttarakhand, as well as the belligerent pro-dam notable Avdhesh Kaushal of Dehradun, have gone on record saying that the impact of the floods was made worse by environmentalists preventing sand from being mined from the river. The influence of the powerful sand-mafia apart, this is poor reasoning. While boulders and coarser bed-load moves down a steep mountain-basin episodically, during floods and like a jerky conveyor-belt, even filling up bed-rock channels, it is different with sand. Depending on many factors ranging from grain coarseness, magnitude of flow, shear-stress, to bed and boundary friction, sand is sorted and moved either as suspended sediment, or as shifting dunes, during high-flows⁵¹. Even at its slowest, a mountain stream is like a strong liquid breeze blowing down a river-bed. Take a snorkle down a clear pool slow enough to have coarse sand at the bottom, and you can see sand being 'blown', identically like from a sand-dune in a gathering desert storm. In high monsoon flows, depending on the magnitude of the flow, most of the sand would be swept up into suspension in the horizontal helix-like vortices of the river, or move in rapidly shifting dunes at the bottom, not impeding flows at flood levels at all. If anything, sand would contribute to channel stability by reducing bed-friction.

The other major concerns with such extensive sand mining is the loss of the 'sponge' that holds water for the riparian zone and intercedes with groundwater, of critical breeding areas and habitat for fish and other aquatic life in the first place, and well as the loss of access to the smaller volumes of sand required for home-building by local people living in the basin.

Lastly, on hazards, we seem to be ignoring entirely the great danger that impounded water poses during war. This is the ominous silence and secrecy that has presaged and followed major disasters before⁵², whether it was Chernobyl or Banqiao. For those of us who experienced even the air-raid drills and black-outs during wars with China and Pakistan during childhood, the possibility would not be entirely remote. Neither is this unprecedented. In 1943, the British Air-force deliberately bombed multiple hydro-power dams in Germany, causing catastrophic floods in the Ruhr and other valleys, killing and displacing thousands of people⁵³. In 1952, the US and South African forces under the name of the United Nations Air Command, bombed the hydro-electric complex of the Sui-ho dam in North Korea. Or the planning of Operation Eisenhammer of the Germans to wreck Soviet hydro-power stations during WW II. The hundreds of dams being planned and built on the headwaters in Uttarakhand, are just spitting distance, so to speak, from two international borders. Nine-pins again. Remember also that the recent Fukushima nuclear accident was caused by the effects of a seismic shock, notwithstanding the expertise of Japan on earthquake-proofing. Who needs a war, when most dams in the headwaters of the Himalaya lie in the same seismic category as Fukushima?

Counting the costs:

It is not far-fetched to say then, that the scale of dam-building in Uttarakhand is a serious issue of national security. At the Uttarakhand state level, this chimera of 'development' spells doom for its riverside civilization. If such a large number of hydro-power projects go ahead as per plan, almost the entire length of every river will be dry, due to the river being diverted into tunnels repeatedly. With their river snatched away, as well as more of their scarce agriculture lands and village forests appropriated for submergence and for dumping muck, what are villages dependent on these rivers for water and for food supposed to do? Those that do not leave as refugees to urban centers in the plains, will live under constant threat from, and bear the brunt of repeated floods like we have seen this year, made doubly dangerous by the destructive potential of muck stacked by the river-side, and more dumped in the river by dam-related road-building and mining.

The constant threat of dam-collapse will be an ever-present danger. Prime Minister Manmohan Singh's office is pushing for the relaxation of environmental impact assessment requirements and prior checks

⁵¹P A Carling. In-stream Hydraulics and Sediment Transport. In The Rivers handbook. Vol 1. Eds. Peter Callow and Geoffrey Petts. Blackwell Scientific Publications 1992.

⁵²<http://www.newyorker.com/online/blogs/evanosnos/2011/10/faust-china-and-nuclear-power.html>

⁵³In what was called 'Operation Chastise'. Also the subject of films such as The Dam Busters. For more detail see http://en.wikipedia.org/wiki/Operation_Chastise#Effect_on_the_war

for dams and mines at the behest of industry. The price will be unimaginably high, for what will amount, in principle if not in toothless law, to criminal collusion. At the end of the day, opting for hydro-power in such a big way is not even a Faustian bargain, because those who gain here, are not those who pay the price in the first place. At least not in the shorter-run.

What we are witnessing here, is the unraveling of the social fabric, the ecological integrity, and even the link between the two, the cultural heritage of Uttarakhand. Let me explain, and I cite particular examples from the Gori basin itself:

On social fabric. We have seen that the coming in of hydro-power projects into the Gori basin has decentralized corruption, and taken it to a new level altogether. Starting at the top of the chain are the bureaucrats and politicians. They are old players and were already in the game⁵⁴. Any Gram Pradhan or village council head in this part of Kumaon can tell you, that upto 40% of all village budgets, be it village infrastructure or labour employment, are required to be paid to the block-level officials who sanction budgets and releases. In the name of decentralized governance, you already have the broad-basing of corruption. This money is said to go all the way 'up', to departmental bureaucrats and further on to politicians. More is sequestered 'down' at the village level, by elected representatives and intermediaries in the chain. Quality of work be damned. The stage is already set for more.

Now here is the fine grain. When the NTPC⁵⁵ (a government corporation) and GVK (a private company) came into the Gori valley, they bought and bullied their way in. Both behaving similarly, and both known to the common village person as 'the Company'. First, the intermediaries and local politicians are co-opted. Look a little closer at these 'local' aggressive proponents of the unbridled build-up of hydro-power in the Gori basin and in the state. Is it a co-incidence that they are variously the biggest sand contractors, that their 'homes' are hired out for years to hydro-power companies as residential or office premises, and that hydro-power companies offer corporate-sponsored post-retirement positions in Universities ?

With the most powerful people on their side, their bully-force is multiplied. Then the next rung is co-opted through small contracts for transportation, maintenance, even hospitality. There are many villages and local people who are protesting the forcible acquisition of their land for the NTPC project. This forcible acquisition was ordered by the Governor, even before NTPC had been granted statutory clearances⁵⁶. Local informers seek favour by telling on those who are opposing the project. The tragedy of local people pitched against local people unfolds. People protesting are threatened physically, and local village-level elections are interfered with by both the goons and even the local administration. Locally, this is common person-to-person knowledge.

The local administration, who are also well looked-after at the NTPC guest house, hold a public-hearing⁵⁷ that is strongly protested to by many villages. Even so, the hearing is declared valid on the basis of signatures that a local food-contractor got even from the protesters, who signed acknowledging having eaten the lunch they were served during the proceedings. The contractor said he needed the signatures to claim payment from NTPC for catering. All this is orchestrated.

The local administration also travel with company officials to villages where land is to be acquired. We hear the villages being told that this is for their own good. That the river is flowing gold, and that it would be foolish to let it 'go waste' to the sea. That the Company would now bring them 'development'; schools, hospitals and roads! So we now need hydro-power companies, both state and private, to do what the government should have been doing all along. The message is repeated everywhere you look. Every government ambulance in Uttarakhand has the logo of GVK, the hydro-power company. Even dust-bins in public places have them. When one of the GVK Reddy brothers came down from the

⁵⁴Just a quick caveat here. I do not mean to say that all bureaucrats and politicians are corrupt. Corruption comes in many forms, and even so, there are notable exceptions.

⁵⁵The National Thermal Power Corporation. Despite the name, they are also into hydro-power and nuclear power.

⁵⁶Since the NTPC Rupusiabagar-Khasiabara HEP was finally refused Forest Clearance, the Project has been shelved. Even so, the people whose land had been forcibly acquired, still remain dispossessed.

⁵⁷Only because this is a legal requirement as part of the Environmental and Social Impact clearance procedure

sky⁵⁸ in a helicopter to Bugdiar, one of the dam-sites where exploratory work was underway, he had the path he would walk on along the river, screened off with shamiyana canvas, because he could not bear the sight of the river. However, since it was Diwali day, he dished out 500 rupee notes to everyone he met at the site, even passers-by. The message is repeated, of hydro-power companies as powerful benefactors, and of local people as 'beneficiaries' of largesse⁵⁹.

At many levels, you see truth and meaning turned on their heads to suit hydro-power companies. To cite just a few examples. There are three small and medium-sized hydro-power projects on tributaries of the Gori that are funded by the Clean Development Mechanism (CDM) of the UN. Simply put, money paid by corporations who are dirty (in the emissions sense), so that they can continue to be dirty. These CDM projects are the Himalaya Hydro projects Phases I and II on Paina gad, and the Madkani Hydro-power Company on the Madkani tributary. We've already discussed how 'clean' hydro-projects are, even in the carbon sense. While the first two have been seriously damaged during this year's flood, the third has abandoned a partly-built dam and have gone home because, surprise, they were suddenly in the submergence zone of a much larger hydro-power project coming up downstream. Just before they departed, cement and steel was available locally at half-price. They left, ripped-off and bankrupt.

The second example is of the de-notification of the river-portions of a Protected Area (PA), the Askot Wildlife Sanctuary, in the name of 'development'. The Forest Department of Uttarakhand, had notified a portion of the Gori basin, as well as the whole of the Dhauliganga and the Kuti Yangti rivers, as well as a portion of the Mahakali as the Askot Wildlife Sanctuary in 1986. While the Dhauliganga HEP, which is bang in the sanctuary, had strangely managed to slip past the need for special clearances and has already been commissioned, there are many proposed hydro-power projects on tributaries and river-stretches that fall within the Sanctuary. There are also large deposits of gold, silver and copper identified within and at the boundary of the Sanctuary near Askot, that are ready to be mined. It was UNDP's long nose that helped sniff them out in the first place. Since the de-notification of any land within a Protected area for such projects now requires clearances from the Supreme Court, the boundaries of the PA have been re-drawn⁶⁰. The ostensible reason here being that there are 111 villages within the Sanctuary, and because of restrictions for conservation, this was impeding 'development' in the area. What were they thinking when they included them in the first place? Not surprisingly, all the tributaries and river-stretches where hydro-power projects are planned, as well as the area near the gold-mine have been removed from the Sanctuary demarcation. The need for conserving rivers as an integral part of the ecosystem? It was the State Forest Department that pushed this proposal.

The last is the sell-out of some Universities and technical institutions to the hydro-power industry. The Water and Power Consultancy Services (WAPCOS) an EIA 'shop' with little scruples, and even less technical capability, is so well known that I need not say more about them here. But when even an IIT (Indian Institute of Technology), an institution that we as a nation are proud of, begins to throw science to the winds and mis-advise government in the context of hydro-power projects, it is alarming. The Alternate Hydro Energy Centre (AHEC), a department of IIT Roorkee, was asked by the Ministry of Forests and Environment⁶¹ (MoEF) to undertake a Cumulative Impact Assessment on the environment because of the multitude of hydro-power projects that were built and proposed along the two tributaries of the Ganga, the Alaknanda and the Bhagirathi. While it begs the question as to how an engineering department primarily devoted to designing hydro-power stations, undertaking

⁵⁸Until this year's 'rescue' operations, coming down in helicopters has been the preserve of the very rich and powerful, and has always been looked at with great awe. The many sorties sanctioned by government this year for rescue and relief, saw very many rural people take a ride of a life-time, some even feigning toothaches and so on.

⁵⁹It is another matter that Reliance Infrastructure Limited, an even bigger name has now elbowed out GVK on this project through a court-case. The court ruled that GVK's allotment was malafide, and that there was connivance by the state to dilute norms in their favour.

⁶⁰Govt of Uttarakhand Notification number 3239/ X-2-2013-19(1)2002 dated 25th July 2013. Dept of Forests and Environment.

⁶¹This was done only because of the specific recommendation for this by an unusually composed Forest Advisory Committee (FAC) that included Amita Baviskar, Mahesh Rangarajan and Ullhas Karanth. Non-official appointees, and each one a highly credible voice in conservation. Not surprisingly, the FAC that replaced them, comprised of some pro-dam appointees, even a hydro-power consultant.

research and advisory support for the hydro-power industry was considered competent by the MoEF to undertake such a biological assessment, it is clear that this was a deliberate move. IITs in general, and the one at Roorkee in particular, have earned their credibility in their particular fields. What comes out from an IIT, is not easily questioned. But the AHEC comes out with a document, dense with argot to indicate technical proficiency, but where they essentially said that it was fine to have all the hydro-projects on the Ganga, provided environmental flows were maintained. They reviewed all the current methods in use for arriving at e-flows, and came up with their assessment of minimum flows that should be allowed to flow through the various dams in these tributaries, using the Building Block Method. The upshot? In some places below dams, they recommended a depth of flow that would barely cover the back of an otter or a large Mahseer, let alone be habitat for their feeding and breeding range⁶².

If you travel along the Alaknanda, you will see writ large on giant hoardings 'No Dream Too Big', the slogan of the JayPee Hydro-power Corporation. Right now, it may seem like schadenfreude even to mention that their 400 MW Vishnugadh Pipalkoti hydro-power project dam was entirely buried and over-run with boulders and cobbles on the 17th of June this year, but the hubris of the slogan is naked.

The impression of all these on local people cuts deep. They see that hydro-power companies don't just come on their own. They come in an overpowering formation, a daunting phalanx of combined forces. The hegemonic discourse of development, forcible land acquisition by order of the Governor, the buying power of these companies, government officials in collusion, seeing their own elected representatives co-opted and turned against them and their future generations. And fear made physical in the pit of their stomachs, by the threat of violence from hired lumpen.

What is perhaps the most worrying in all this, is the deep erosion of the sense of community, the break-down of self-reliance, and the growing cynicism and hopeless.

The whittling down of the sense of community is visible more immediately in the form of people pitched against other people; where those who are losing their homes, their fields and their village commons are up against those who will gain from contracts and other inducements. In the longer-term, this is just a progression from the larger attempt to break-down communities' engagement with village commons and governance. This stems from other erosive forces such as the mangling of the *Van Panchayat* or Village Forest Council system by government. They have now been reduced to 'beneficiaries', beholden to government for permission for anything they do, in forests they and their fore-mothers and fathers have owned and managed for subsistence, for tens of generations. This is only one example.

The break-down of self-reliance is perhaps the most dangerous of all. Consider this. The entire upper reaches of the Mahakali, along the tributaries of the the Kuti Yangti, the Dhauli and the Gori, other than the military cantonment and town of Dharchula, are entirely rural. The villages' economic mainstay is agriculture and agro-pastoralism. They are communities that produce most of their own food requirements, and provide for themselves on a yearly cycle. How was it then, that when major road-sections were washed away this year, there was a crisis that threatened agrarian communities far from road-access with starvation within two weeks? Is this not the underbelly of collapsing agricultural subsistence made visible?

While there are many reasons for this, the coming in of hydro-power projects in a river-valley greatly multiplies the dissipative effects. Already fragmented land-holdings being lost to dams and related damage. Forest-dependent agriculture, such as all mountain agriculture is, being further stressed with forcible acquisition for dams and related mining and dumping, and by forest-depletion by thousands of migrant labour during the decades it takes for dam construction, because they have no other option. All this leading to a greater reliance on the Public Distribution System (PDS), which in effect means looking at food supply on a monthly cycle, and being entirely reliant on centralized supply from distant parts of the country. Any disruption in the long chain, means uncertainly and insecurity, even possible starvation.

⁶²For more on this, you could read a critique of the Assessment by AHEC, IIT Roorkee here.

The political ramifications of such critical dependence and loss of resilience are far-reaching. It teaches rural people to look to government, rather than their own communities to bail them out whenever something 'goes wrong'. The result? This year we witnessed the degradation and deep humiliation of village folk fighting each other for food and looting relief material. The plight of widows and the elderly was harrowing. People losing hope in their land and their communities, and asking to be 'relocated' somewhere in the plains. It is deeply worrying to think of what would happen in future if the government would not, or could not 'bail them out'. Say in a war-time scenario and inevitable disruption of the supply chain?

In conclusion then, where are we headed as a country, with our desperate quest for more energy at any cost? Is leaving behind silenced rivers, empty forests and dead oceans for our children really development? Not so long ago, we needed rivers to identify ourselves as a nation, and to define our living-scape even in our national anthem. Where the Yamuna and Ganga connect not just the Himalaya with the oceans, but also unite us as a people along its continuum. Free-flowing rivers as connectedness, shaping both the terrestrial and marine realms and sustaining all life in them. In one word, life-blood.

As we now thrombose, haemorrhage, and sell our rivers dry, there is another tragic loss we bring upon ourselves as a nation. The loss of meaning of life and death. For the great majority of people who have lived along the rivers of India, beyond the funeral pyre is departure at the river's edge. Gaston Bachelard⁶³ decribed this farewell at the water's edge as the most heartrending, and at the same time the most literary of all farewells. We as a civilization, need our rivers to pulse and to flow, even, in Bachelard's words, "for death to keep its meaning of a journey"

⁶³Gaston Bachelard. *Water and Dreams. An Essay on the imagination of matter.* Dallas Inst of Humanities and Culture.1999.