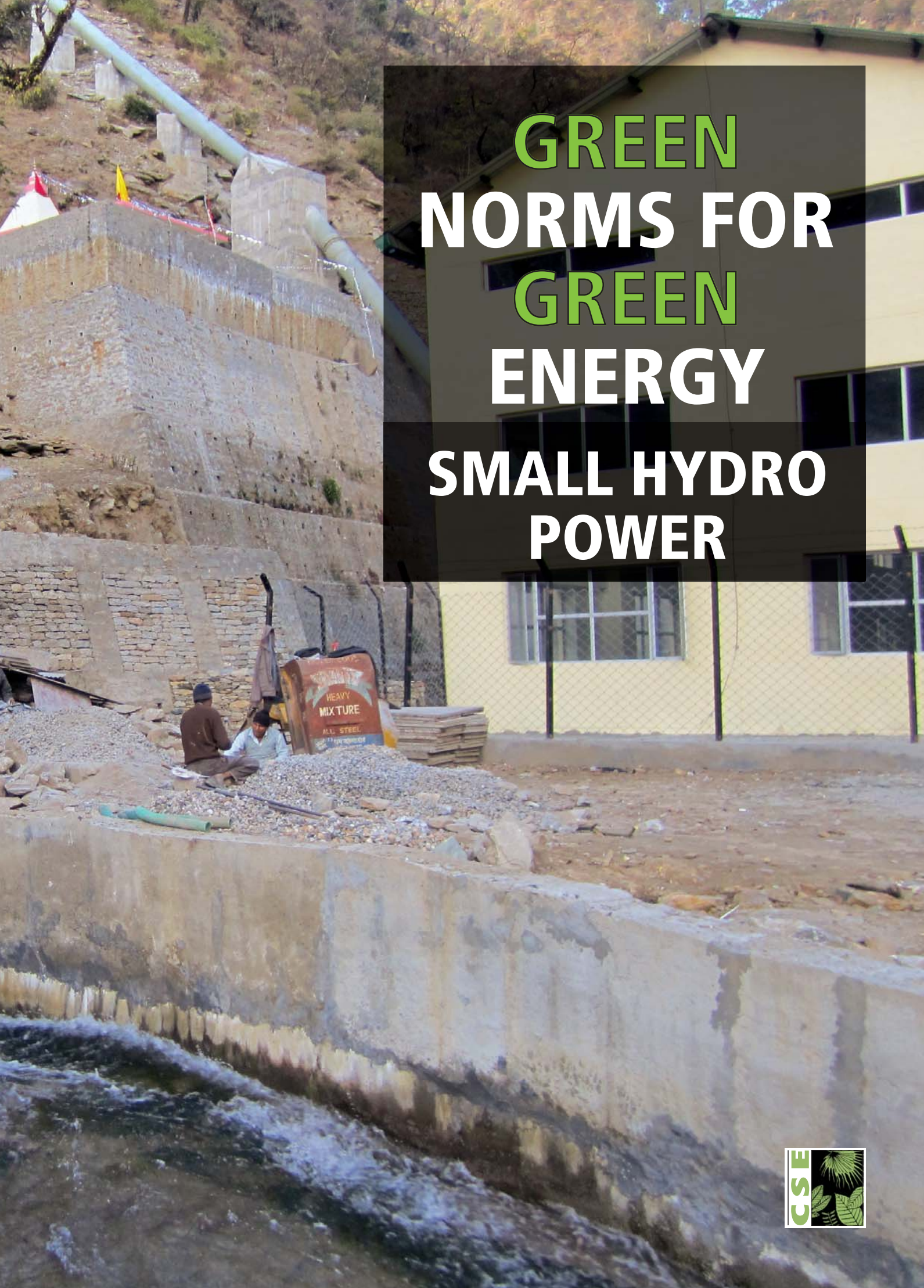

GREEN NORMS FOR GREEN ENERGY

SMALL HYDRO POWER

CSE

GREEN NORMS FOR GREEN ENERGY

Small Hydro Power

Centre for Science and Environment

- Research director
  Chandra Bhushan

- Researchers
  Jonas Hamberg
  Abhinav Goyal

- Contributors
  Kanchan Kumar Agrawal
  Aruna Kumarankandath

- Editors
  Souparno Banerjee
  Sheeba Madan

- Design and layout
  Anirban Bora
  Kirpal Singh

- Production
  Rakesh Shrivastava
  Gundhar Das

- Cover photo
  Abhinav Goyal

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Published by:
Centre for Science and Environment
41 Tughlakabad Institutional Area
New Delhi – 110 062, India
Ph: 91-11-2995 6110, 2995 5124, 2995 6394, 2995 6499
Fax: 91-11-2995 5879, 2995 0870
Email: cse@cseindia.org **Website:** www.cseindia.org

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SMALL HYDRO POWER

THE USE OF SMALL HYDRO POWER (SHP) IN INDIA GOES WAY BACK IN HISTORY, WITH THE COUNTRY'S FIRST SHP PLANT HAVING COME UP IN 1897. THE SECTOR HAS BEEN GROWING RAPIDLY: IN THE DECADE BETWEEN 2003 AND 2013, THE NUMBER OF PLANTS HAS DOUBLED. WITH GROWTH HAS COME SIGNIFICANT ECOLOGICAL IMPACTS, DESPITE THE SECTOR BEING DUBBED ENVIRONMENTALLY BENIGN. STRONGER AND MORE EFFECTIVE REGULATIONS ARE THE NEED OF THE HOUR

In India, small hydro power, or SHP, refers to a hydro power plant with a generating capacity below 25 megawatt (MW). There is no justification available for this. However, according to a 1982 document attributed to the Central Electricity Authority (CEA), a statutory body attached with the Union ministry of power, SHP has been categorised as a plant having a capacity under 15 MW.[1]

The capacity of projects that fall under the category of small hydro is further classified into small, mini, micro and pico. Micro and pico projects generate below 100 kilowatt (kW), are generally not connected to the grid and do not have a significant impact on environment. Hence, they have not been included in this study.

SHP is by far the oldest renewable energy (RE) technology used to generate electricity in India. The Sindrapong Hydel Power Station was set up in 1897 in Darjeeling (West Bengal) with a total capacity of 135 kW[2]. However, after independence (and till very recently), India's main thrust had been on large hydro power dams. But with growing resistance from local people who get displaced from inundated areas — as in the case of the Sardar Sarovar Dam on Narmada river — the attention has shifted

towards smaller hydro power plants using 'run-of-the-river' (ROR) design as well as towards canal-based projects. However, it is becoming apparent that these projects, especially those incorporating ROR design, do have environmental impacts that can rival large hydro projects when measured against the actual generation of the plants.

The total installed capacity of SHP projects in India was 3,632 MW in March 2013[3]. This is spread over 950 projects; hence, the average SHP project capacity is 3.8 MW (see Table 1: *Status of SHP in India)*. This does not include micro-hydel plants. The draft 12th Five Year Plan (2012-17) has, as its target, 2,100 MW of SHP capacity[4]. The total potential country-wide capacity is estimated at 19,749 MW, of which about 1,250 MW is under development.

TABLE 1 Status of SHP in India

State	Potential capacity (MW)	Installed capacity (MW)	Capacity under implementation (MW)
Andhra Pradesh	978.4	217.83	35.25
Arunachal Pradesh	1341.38	101.51	30.97
Assam	238.69	31.11	15
Bihar	223.05	70.7	17.7
Chhattisgarh	1107.15	27.25	140
Goa	6.5	0.05	–
Gujarat	201.97	15.6	–
Haryana	110.05	70.1	3.35
Himachal Pradesh	2397.91	536.905	182.45
J&K	1430.67	130.53	34.65
Jharkhand	208.95	4.05	34.85
Karnataka	4141.12	915.395	322.03
Kerala	704.1	158.42	52.75
Madhya Pradesh	820.44	86.16	4.9
Maharashtra	794.33	295.525	80.6
Manipur	109.13	5.45	2.75
Meghalaya	230.05	31.03	1.7
Mizoram	168.9	36.47	0.5
Nagaland	196.98	28.67	4.2
Orissa	295.47	64.3	3.6
Punjab	441.38	154.5	21.15
Rajasthan	57.17	23.85	–
Sikkim	266.64	52.11	0.2
Tamil Nadu	659.51	123.05	–
Tripura	46.86	16.01	–
Uttar Pradesh	460.75	25.1	–
Uttarakhand	1707.87	170.82	178.04
West Bengal	396.11	98.4	84.25
A&N Islands	7.91	5.25	–
Total	**19749.44**	**3496.145**	**1250.89**

Source: *State-wise Numbers and Aggregate Capacity of SHP Projects (Up to 25 MW)*, Union ministry of new and renewable energy (MNRE), document accessed by CSE in January 2013

Environmental impacts of SHP

SHP plants[5] have been, and to some extent still are, viewed as being an environmentally benign energy source, and are categorised by the Union ministry of new and renewable energy (MNRE) as a green and renewable technology. When compared to thermal coal power, SHP has no effect on climate change, its fuel source is inexhaustible and it does not contribute to air pollution. Water pollution by SHP is relatively low, and happens mainly during the construction phase. Compared to large dams, it inundates much lesser area and causes little or no displacement of people.

SHP can, however, exert multiple impacts on local environment and ecology. Because SHP is exempt from EIA in India, there are not many studies available which examine in detail either the project level impacts or cumulative impacts. The impacts which are perceived to be of critical importance are ecological (on aquatic flora and fauna), physical (on water quality, sediment carrying capacity, erosion, groundwater quality and recharge, climate, soil and geology), and human–induced (such as interference with drinking and agriculture water availability, solid waste generation and socio-economic factors).

SHP plants with a capacity close to the maximum limit may have dams (even when classified ROR) up to 10 metres (m) in height. SHP plants often re-route water through pipelines and tunnels to increase the pressure and remove silt, leaving long stretches of a river dry[6]. The river distance left dry by small ROR plants varies depending on the geography of the site as well as with the size of the project. For example, the 10-MW Madhya Meshwar SHP plant in Uttarakhand uses a 4-km long tunnel along the river.

Two other projects, Kaliganga I (4 MW) and Kaliganga II (6 MW), both in Uttarakhand, use tunnels of 400 m and 2 km length respectively. The desilting tank of Kalinganga II project starts form tail-race of Kaliganga I. This way, multiple projects on the same river can leave a longer continuous stretch dry.[7] The same scenario is true for SHP plants in the Western Ghats with the Nagarjuna Hydro Project leaving 1.7 km of river bed dry inside a mature and dense forest reserve.[8]

Hydro power turbines, dams and tunnels also have an impact on fish populations as many fish species migrate for spawning; this migration is effectively barred by dam constructions and dry

A 2-km long tunnel under construction, diverting the water for creating the necessary head at Kaliganga-II SHP plant

riverbeds. 'Fish ladders' — unblocked streams, either human-made or natural, running by the side of a project with 'steps' low enough for the fish to travel — give fish an alternative means to move up and downstream. They can be used or created to improve migration; however, in most cases, this has not been done. On the other hand, the success rate of fish-ladders is debatable[9], especially in tropical areas, where there has been little research on how fish travel as opposed to studies on salmon migration in the northern latitudes[10].

A single SHP plant has a relatively lesser impact on the surrounding area. However, since its output is also less, more plants are required to generate the same amount of electricity as one large hydro power plant. Therefore, the cumulative impact of SHP projects is most important. In an article published in Energy Policy, Dominique Egrea and Joseph C Milewski ask: *"Could the overall impact of a single 2,000-MW project be less than the cumulative impact of 400 small hydro power projects of 5 MW, because of the number of rivers and tributaries which will be affected?"*[11]

Four hundred SHP projects of 5 MW each have the potential to affect more tributaries directly compared to one large hydro power project of 2,000 MW. The location of the dam site is also important. A large dam needs a greater flow which can only be possible on major rivers. The World Bank, one of the largest funding bodies for hydro power projects, admitted in 2003 that the impact of plants placed downstream on large rivers is more severe than that of projects, including those that are small-scale, placed upstream on smaller tributaries[12].

Furthermore, if SHP projects are designed with reservoirs (and not actual ROR), the area needed for these reservoirs is much larger per MW capacity as compared to large hydro power projects. Theoretically, the volume of a reservoir increases cubically with an increase in surface area: a dam of double the size would hold four times more water, and therefore be more efficient. Similarly, the storage volume would decrease multiple times if the surface area is cut in half[13] (see Table 2: *Comparative sizes of plants and reservoirs).*

If measured according to impact per MW, SHP can — in certain scenarios — exert the same impacts as large hydro power (see Box: *Small vs large*). The environmental impacts vary widely depending on the site and the selected technology. For instance, canal projects which use no tunnels have no impact other than what the canal had from the start.

TABLE 2 Comparative sizes of plants and reservoirs

Size of plants (in MW)	Number of plants in survey category	Average size of reservoir per unit of power (ha/MW)
3000-18,200	19	32
2000-2999	16	40
1000-1999	36	36
500-999	25	80
250-499	37	69
100-249	33	96
2-99	33	249

Source: Robert Goodland, *How to distinguish better hydros from worse: the environmental sustainability challenge for the hydro industry*, The World Bank, 1995

Building a SHP plant leads to generation of rubble and wastes as seen here at the Adit tunnel of Kaliganga-II. Often, these wastes are dumped in pristine forest areas

SMALL VS LARGE

An analysis of diversion reach and head correlation of all ROR operational projects over Bhagirathi river basin reveals that the ratio of head in case of small hydro power projects is approximately 18 times that of a large hydro power project per MW of generation capacity. This leads to an increase in diversion length of the river by six times, whereas the annual generation is just 1.38 times. This shows that in case of a large number of SHP projects over a river basin, there are significant losses for the ecosystem; at the same time, the expected economic benefit is not achieved. SHP is touted to have less ecological impact at the cost of economic benefit, but in many cases the decreased ecological impact (as compared to large projects) is not realised.

TABLE A Comparison of various parameters on per MW basis for small and large hydro over Bhagirathi basin, Uttarakhand

Parameter	Per MW for small hydro	Per MW for large hydro	Ratio of small/large
Diversion length (m)	319.61	53.45	5.98
Head (m)	15.84	0.89	17.85
Annual generation (MU)	5.88	4.28	1.38

Source: Analysis done by CSE **Note:** m = metre; MU = million units

The Norwegian study

A Norwegian study did a comparative analysis of environmental impacts from 27 SHP plants (<10 MW) with three large hydro power projects. The results show there is a slight tendency of large hydro to have lesser degree of impacts than many small-scale projects.

The average environmental impacts from the large hydro power projects were compared with the accumulated impacts of the small-scale hydro power plants. The result shows that the following impacts were on a higher scale in small hydro in comparison to large hydro power plants. These are:

- Sediment transportations and soil erosion
- Changes in local climate
- Impacts on fish migration and spawning
- Recreation

TABLE B Extract of all reported environmental impacts from the 27 small-scale hydro power plants and how often the various impacts are reported

Type of environmental impact	Per cent of impacted cases reported
Reduction in water flow	100
Fish and fauna affected by the project	78
Areas with no prior and major encroachment (INON)	67
Anadromous fish present in affected part of river (not only by passed stretches)	56
Cultural and Heritage sites affected	44
Pipelines causing landscape encroachment/impacts	11
Changed water quality	11
Organisms living in or close to water/cryptogams by waterfalls negatively affected due to reduced flows	7

Source: Bakken *et.al*, Development of small versus large hydropower in Norway- comparison of environmental impacts, Science Direct- Energy Procedia 20(2012) 185-199

Access roads and transmission lines to and from multiple small plants increase the environmental impacts as they often need to be constructed through hilly and forested terrain, necessitating the use of explosives such as dynamite. The deposition of rubble, muck and silt from both construction and operations is also a concern; dumping sites are often located in pristine forest areas where they should be forbidden. Not returning silt to the river may also lead to a decrease in nutrients downstream — nutrients that are vital for both farming[14] and fisheries[15].

Cumulative impacts

Cumulative impacts imply the 'addition' of environmental effects due to various projects on the same river basin which share a similar topography, ecology and environment at large.

Karnataka's Nethravati river has at least 44 projects planned on it and its tributaries, but it is far from being the only one. In fact, in many cases, including Nethravati, one project can show the way for other developers by proving the feasibility of a project on that specific river, leading to multiple imitators.

Uttarakhand has two major river basins: Alaknanda and Bhagirathi. A total of 70 hydropower projects with a cumulative capacity of 9,580.3 MW are under operation, construction or development phases here. These includes 30 projects above 25 MW and 40 SHP projects.[16]

With most of the large Indian rivers already dammed, there is more focus being put on damming higher altitude tributaries. With multiple projects on the same tributary a river can run dry for many kilometres with only intermittent ponds behind dams before the water once again goes into a diverting tunnel and penstock.

The cumulative impact of SHP is not confined to the addition of multiple SHP projects in one area; the impact is also cumulative with many other development projects in terms of forest use and linear intrusion from roads and power lines. Such an impact is apparent in the Western Ghats where SHP projects are coming up alongside new highways, pipelines and roads. All the projects create barriers, especially for migration of wild elephants, which has led to an increase in human-elephant conflicts.[17]

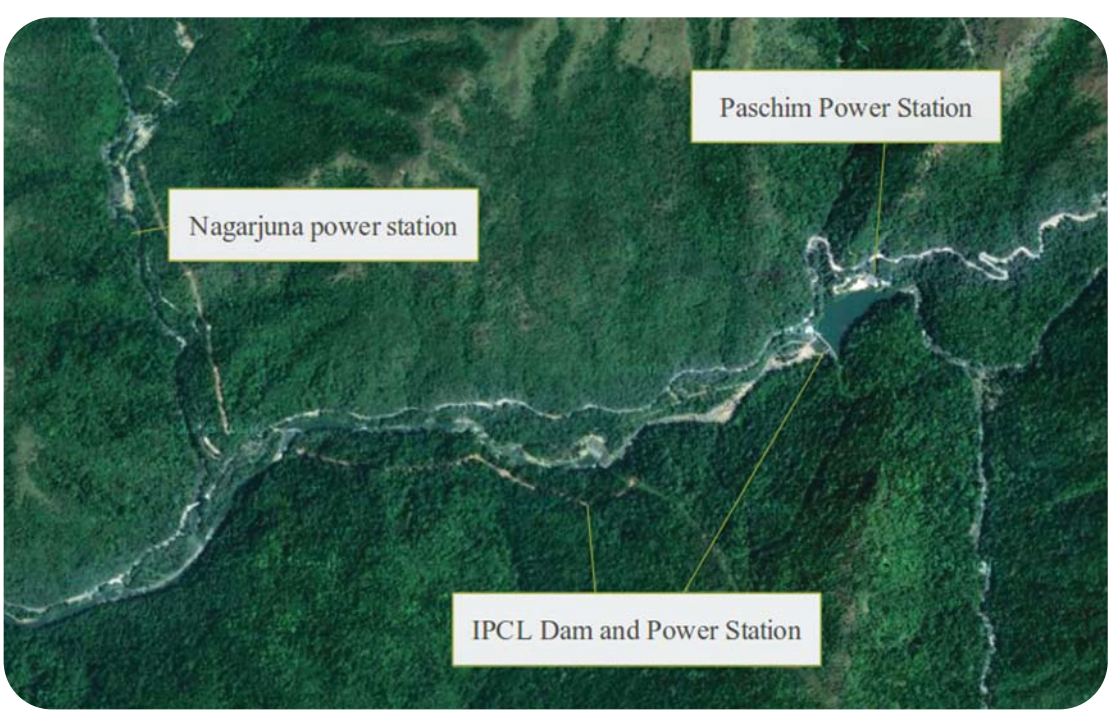
Cascading — head race of downstream project starting at tail race of upstream project — and that of not leaving adequate distance between two projects is at the core of this issue.

According to Devadutta Das, emeritus professor, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee: "Cascade operation of small hydro power stations poses environmental concerns, as it leads to almost drying up of the natural channel of the stream during low flow periods. Cascade planning for hydro power generation should be contemplated with due consideration of the environment. Such cascade developments should preferably be planned, if there is no habitation along the river stretch with riparian use of water and some smaller perennial streams join the river downstream of the diversion weir."[18]

The reason for this unplanned hydro power development is two-fold.

- First, the state governments conceive implementation of these projects as a means for revenue generation. Uttarakhand, for example, expects to generate an annual revenue of Rs 1,586 crore through selling of electricity, which it will receive by selling 12 per cent free electricity from the project developers, when all the projects are implemented (CSE analysis considering an average tariff rate of Rs 3.50 per kWh and 45 per cent CUF of power plants).
- Secondly, and more importantly, it is due to the sheer ignorance of the government agencies towards implementing river basin management plans which include ascertaining the water requirements for irrigation, drinking, industry and environmental needs. This lack of responsibility further stems from lack of past hydrological data which is necessary for performing river basin management analysis.

In the case of hydro power, planning becomes especially difficult because of the multiple agency syndrome: two different ministries share the responsibility of policy design and implementation based on the categorisation of projects as small or large. While policy formulation for the former is undertaken by the MNRE, the latter is overseen by the ministry of power (MoP).



Three SHP projects in close proximity on the Nethravati river in the Western Ghats. This leads to 'cumulation' of environmental impacts on the river basin

Ecological flow

Ecological flow is the concept of keeping enough water in the river downstream from a dam to sustain ecosystems and human livelihoods dependent on water from the river. So far, in India there are no country-wide rules on environmental flow even for large-scale hydro power projects. The concept is only adhered to at specific projects where it is part of the environmental clearance process. The implementation and enforcement, however, is haphazard at best.

- ***Himachal Pradesh:*** This is the only state that has introduced general terms for minimum ecological flow that hydro power projects, including SHP projects, have to comply with. The mandated minimum flow in Himachal is 15 per cent of the average of the three leanest months (generally between October and February).[19] But there is a concern with this measurement: the state's hydrology is affected both by monsoon and glacier melt-off and the river flow is highly seasonal. Therefore, 15 per cent of the lean flow will be a fraction of the high season flow.

  Take, for example, the Ravi river. At its head, the lean season (November to January) flow is only 22.6 per cent of the high season flow (July to September).[20] This would mean that for an SHP on a tributary with the same qualities, actual minimum flow in lean season will be mandated at 3.4 per cent of the high season flow (15 per cent of 22.6 per cent). Any computation of minimum flow would also need up-to-date and reliable measurements, something which has been difficult to come by so far for many Indian rivers.[21]

- ***Uttarakhand:*** At present, there is no regulation in Uttarakhand mandating a certain percentage of environmental flow in the case of small and large hydro power projects for capacities up to 100 MW. It is a generally shared belief among state authorities that 10 per cent of the lean flow should be left at any given point of time in the natural river stream. However, this is not adhered to due to technical and financial concerns.

- ***Karnataka:*** Although there is no specific mention of mandating ecological flows in Karnataka, the Karnataka Renewable Energy Policy 2009-14 says: "The Mini Hydro Project proposals which do not involve diversion of the water flow resulting in drying up the stream/river stretch will be considered for development."[22]

Impacts on riverine fish

The impacts of SHP plants, dams and the drying out of river beds on fish in rivers is, to a large extent, unknown. Professor Renee Borges from the Indian Institute of Science (IISc), Bengaluru, an expert on Western Ghats ecology states, "I can count the studies on the fish fauna in the Western Ghats on one hand, and there is only one recent one. We don't know what is there frankly."

What is known so far, is that there are 318 species of fish in the rivers of the Western Ghats, of which 136 species are endemic, 55 are endangered and 27 are critically endangered. Even more important is the fact that 128 species are "data-deficient",[23] which means that the status of these fishes is unknown.

Making it even more apparent that these rivers are biodiversity hotspots is the fact that new fish species are being discovered on a regular basis; last year, a new species was found in the Kumaradhara river,[24] which has SHP projects in development and operation.[25]

Another species of fish was found in the Barapole river, on the Karnataka-Kerala border in 2012[26] where a new SHP project was recently stopped because of its impact on the environment and due to resistance from the local community.[27] In Sita river, near Shimoga, Karnataka, where many new SHP projects were planned, two new species were found in 2010.[28]

The team behind some of these discoveries and locals in Karnataka and Kerala say that the knowledge of fish fauna in the Western Ghats is still limited.[29] With very little idea of even which fish species exist, information on their behaviour is even less exhaustive.[30] There is little know-how about how the different species of fish breed and if they migrate. If any of the fish species migrate upstream (or their larvae drift downstream), any dam such as those built for ROR SHP projects in the Western Ghats would block off the species completely and potentially kill it. If a species is not migratory, and like many of the newly discovered species exists in a small stretch of one river, a loss of a km or two of habitat due to drying out of the river as its water is diverted could also spell doom for the species.

In the Himalaya, large hydro power projects and other dams on major rivers have already stopped much of the migration of fish species such as the hilsa[31]. Any new SHP dams and diversions would have the same effect on local population as in the Western Ghats. The power plants in the Himalaya also leave the river bed dry and dams block any migration[32]. Hilsa exemplifies the fact that the fish in the river are not just important for ecological reasons, but also for survival of fisher-communities up and down the river and for food safety.

HOW MUCH IS LOST FROM ECOLOGICAL FLOW?

As pointed out by the Himachal Pradesh State Electricity Board in a court case (Himachal Pradesh Electricity Regulatory Commission vs M/s DSL Hydrowatt Limited), the minimum flow requirement has no major impact on generation from SHP. The developer was requesting a higher tariff, arguing, among other things, that the ecological flow requirement of 15 per cent (of lean season flow) cut generation to nearly nil in lean season, forcing a shut down of the plant. The Board, however, looked at the actual generation from the plant as opposed to projected generation. Projected generation was 0.393 million units (MU) — 0.432 MU for January and February — while actual generation was 0.94 MU and 0.92 MU (Financial Year 2009), which means generation was far above projections. All in all, the Electricity Regulatory Commission found that the cost of the ecological flow regulations was Rs 810.34 lakh over 40 years, or 8 paise per unit.

A trench-type diversion weir, with no provision for leaving a passage for the fish in a SHP project

According to the South Asia Network on Dams, Rivers, and People (SANDRP), 10.86 million Indians depend on fish from inland fisheries like rivers, tanks, ponds and wetlands for subsistence and income[33]. Fishing yields of hilsa, mahseer[34], carp and catfish have decreased or collapsed over the last few decades.

The yield of fish in the Ganga fell from around 50.3 kg/ha/year in the 1960s to 20 kg/ha/year in 1972 to 6.3 kg/ha/year in the 1980s[35]. Fisheries in smaller rivers where dams have been constructed have all shown a decline. However, no specific reasons have yet been documented for this decline in fish yield.

Based on 1997 figures, Indian rivers are estimated to yield 0.64 to 1.64 tonnes of fish per km although this may have fallen to 0.3 tonnes already. The higher stretches of the river[36] support traditional artisanal fisherfolk who fish for their own subsistence.

Since the dependence on small riverine fisheries is often for subsistence, the value of these fisheries is not accounted for in the economy.

It can be roughly estimated that a ROR dam that leaves one km of river bed dry could mean a loss of 0.3 -1.64 tonnes of fish for traditional fisherfolk each year. However, in reality, the impact is much greater as dams stop migration and fish may be killed in turbines as well.

Hydro power dams are not the only threat to fisheries in India — pollution, encroachment, irrigation diversions, etc also pose serious threats.

The Report of the Working Group on Fisheries and Aquaculture of the 12th Five Year plan acknowledges: "Water abstraction for irrigation and power generation is perhaps the biggest reason (for problems of inland fisheries), causing reduced or no flow in the main channel to support fisheries and other riverine fauna and flora[37]."

In many countries, fish-ladders are used to let migratory fish (especially salmon type fish that need to go upstream to procreate and spawn) bypass dams by letting them jump up a stair-like structure, with each 'step' designed low to enable fish to pass upwards.

The fish-ladder concept is far from universally accepted even in Europe and North America with critics stating that the ladders often aren't designed well enough to be effective. Besides, tropical rivers and fish have their own issues depending on species and the hydrology of the river.[38]

India has a few fish-ladders, one being in the lower Ganga barrage, but its efficacy is so far unclear, especially since the designs are based on fish-ladders in temperate zones with a different fish-fauna.[39] Although officials of the Karnataka Renewable Energy Development Limited (KREDL) say that all the SHP projects have fish-ladders, none of the projects examined by a CSE researcher had fish-ladders or any other bypass possibilities for fish.[40] Engineers on site questioned either did not know what a fish-ladder or fish-way was or claimed that there were "very few" fish in the river.[41]

It is essential to have documented knowledge of the abundance of fish in the rivers to implement a fish-ladder. Also, the migratory pattern and abilities of the fish would first have to be known, before a dam and diversion are built. At present, there is little knowledge of these things. Of course, for any fish-ladder/fish-way to work, there also needs to be environmental flow in the river between the dam and the tail-race.

SHP in Karnataka

SHP in Karnataka is governed by the policy on renewable energy released in 2009 (applicable for the period 2009-2014). The policy includes the following key aspects with regard to SHP project development:

- It is targeted to have 600 MW of SHP projects during the policy period.
- The responsibility of identifying potential sites for SHP development lies with KREDL on Public Private Partnership (PPP) / Build Operate Own Transfer (BOOT) mode.
- Mini hydro projects in the Western Ghats will be restricted to a maximum of 5 MW (preferably ROR projects).
- A single window clearance mechanism is available for facilitating expeditious commissioning of the targeted hydro projects.
- KREDL will identify the pico hydel projects (less than 10 kW) in a fast track mode. The central financial assistance of 90 per cent of the project cost, provided by MNRE, will be passed on to the eligible beneficiaries speedily.

The power generated through SHP projects in Karnataka accounted for roughly 4.4 per cent of the total energy generation in the year 2011-12. This is considering the total energy generation of 53,595 million units (MU)[42] with SHP contributing around 2,365 MU[43].

Case study

Kempehole and Nethravati rivers

Kempehole river is a major tributary of the Nethravati, a west-flowing river in the Shiradi Ghats in the southern part of the Karnataka section of the Western Ghats. The two rivers run through thick evergreen forests (where elephants, leopards, lion-tailed macaques and many other species roam), plantations and farmlands.

Since 2002, multiple SHP projects have been constructed on the Kempehole and other tributaries of the Nethravati: over 44 projects are currently under development on them.[44] These projects are, in some cases, being implemented back-to-back with one project starting just where the last one left off.

In the case of Paschim Hydro Energy project (9 MW), the tail-race flows directly into the reservoir of the International Power Corporation Limited's (IPCL) Kempehole project (18 MW). A second tributary joining Kempehole, not more than 1.5 km downstream of the IPCL project, also has a project being developed on it, the Nagarjuna Hydro Energy Project (15 MW).

Since each project's capacity is below the 25 MW limit for which an EIA is not needed, there has been no study of their effects on the forest areas around them. While all projects are classified as ROR, they have weirs with heights ranging from 5-20 m; this is, in effect, the same height as a dam. The weirs have created reservoirs that have used up forest land. The 18-MW IPCL project has a dam of at least 21 m in height which makes it at least 9 m taller than the 97-MW Tashiding Hydro Electric Project in Sikkim.

The IPCL dam and diversion leave about 1 km of the river bed almost dry, and the Nagarjuna project does the same to 1.7 km of river bed. The Paschim Hydro project leaves dry a distance of about 1-2 km.[45]

Individually, the impact of all the projects may not be very big, but the collective impact of leaving at least 3.7 km of river bed dry in a very small area is bound to affect the wildlife and ecosystem of the area. During monsoons, these dry stretches may still have water if the flow is larger than what the SHP station can handle, but this is still uncertain.

As for ecological flow, CSE researchers found that the project managers and forest officials were unclear about the details, even though at the IPCL project, the managers stated that from time to time they were told by the forest department to let out a small amount of water for maintaining the river's flow. However, this was an informal agreement with no documented standard limits, said the IPCL managers.[46]

While engineers at the IPCL project state that there is "no wildlife" within 10 km range of the site, the workers at Nagarjuna project, which is less than four km away by road, state that they see elephants on a weekly basis. A visit to the Maruti Gen Hydro project being constructed upstream reveals

The weir of the 18-MW International Power Corporation Ltd SHP project on Kempehole river is approximately 21 metre in height. This is higher than many 100+ MW projects in the country

SITE VISIT: MARUTHI GEN

Going to visit the Maruthi Gen project means driving in a few kilometres from the Bengaluru-Mangalore highway into some of the densest possible Western Ghat forests. Inside, after crossing a rapidly (even in the dry period) flowing stream, one comes upon a worker's camp in a clearing. Bengaluru-based conservationist Sanjay Gubbi states: "The location of the project would impress anyone interested in forest and wildlife conservation. Multi-layered forests, lofty trees, epiphytes, climbers, gushing streams; a perfect rainforest habitat. The landscape is home to tigers, elephants, hornbills, the Travancore flying squirrel, the Nilgiri marten and many other wildlife species."

The tunnel exit for the project is about 1.5 km up from the camp on a steep trek of a mud-road cut into the hill. Periodically, one comes across fresh elephant dung and marks in the hillside showing elephants have climbed the side of the road, albeit with some difficulty; it can be seen from their toe-prints that they have slipped repeatedly on the vertically cut muddy side wall.

At the mouth of the tunnel, trees have been cleared. Rubble from the blasting, that was reported to have scared away much of the local wildlife, is strewn down the hillside, squashing everything in its way. In fact, according to the Karnataka Forest Department, the company dumped the rubble wherever it was convenient, and not at the allocated dumping sites. The tunnel entrance has made a 10-20 m high vertical cut in the hillside. Inside the half-finished tunnel, the ground goes soft and in the mud one could see fresh leopard paw-prints.

The project was, in fact, going to have a total capacity of 37.9 MW. It was split into two projects to avoid conducting an EIA and undergoing the more rigorous forest clearance procedure. The total forest clearance needed was for 8.38 hectare (ha), which would have required a clearance from the MoEF with scrutiny by the State Advisory Group. However, after splitting the project, the forest diversion needed for it was 4.18 ha and 4.20 ha respectively; in such cases, the decision lies with the state government, with only a final clearance required by the MoEF's regional office.

The fact that both projects are one made the forest department file a 'First Incident Report'. The project has now been stopped because of a High Court stay on projects in the forests of the Western Ghats.

fresh elephant dung as well as leopard tracks. Locals as well as academics report an increase in human-elephant conflicts in the area.[47] This has been attributed, in part, to the small hydro plant as well as to the linear projects located in the forest, such as power lines and roads. Some of the roads in the area used by the SHP projects are already existing coupe roads (roads used for logging mature trees). These roads were developed by the forest department; they are made up of gravel and mud. The traffic on them has increased due to the projects, scaring away the wildlife.

It must be mentioned here that the extent of the impacts of the SHP plants on the forest remains unclear, since the forest area is also experiencing encroachment by farmers and from other projects.[48]

State action

The Karnataka state government has now banned SHP projects in the forest areas in the Western Ghats; the same order, incidentally, also bans wind power from these forests.[49] The Karnataka High Court has also halted SHP projects in the Western Ghats due to an ongoing Public Interest Litigation (PIL). Unusually so, activists as well as developers seem unaware of the state government's ban, though they know about the High Court's temporary stay order.[50]

The damage has already been done; the plants, tunnels and dams which are already constructed will remain, and the river beds will remain dry for long stretches. A hydro power dam once built can be functional for up to 60 years; even after this period, dams can be refurbished and refitted to last indefinitely. There does not seem to be any movement towards taking down the plants and rehabilitating the forests.

Although SHP projects in the forests surrounding Kempehole have been suspended because of the order, another project on the same river remains under development. This is the Gundia Hydel Project, with a capacity of 200 MW and an inundation area much larger than any of the SHP projects (400 ha of forest area).[51] The project is awaiting environmental clearance. The Gundia project is expected to change the ecological flow of the rivers and may make the SHP projects on Kempehole and other tributaries of Nethravati redundant. Complicating the situation further is a huge project to use garland canals and tunnels in the hills to divert part of the Nethravati flow eastwards for drinking and irrigation purposes.[52] This would affect both the Gundia and the SHP projects.

Of course, SHP plants do generate power and Karnataka is a power-starved state. The 9-MW Paschim Hydro Energy project produced 25,307 MWh in 2012, with a 32 per cent capacity utilization factor. The 18-MW IPCL Kempehole project produced 46,119 MWh or 29 per cent of its total capacity. The state's per capita consumption of electricity is estimated to be 873 KWh per annum.[53] A rough calculation reveals that these two projects produce enough power for 80,000 people in the state.[54]

SHP in Uttarakhand

Uttarakhand has an estimated SHP potential of 1,700 MW. The installed SHP projects are worth 170 MW, which is around 5 per cent of the nation's total installed capacity of 3,496 MW. The projects under construction are approximately 14 per cent of the 1,250 MW being built nationally.[55]

The government of Uttarakhand, through its 2008 renewable energy policy, aims at harnessing 600 MW of hydro power potential through SHP by 2020.[56] The state wants to harness this potential through private/public/community participation. For this, the Uttarakhand policy provides the following incentives to private developers:

- Single window clearances in a time-bound manner.
- The electricity produced shall be purchased by the Uttarakhand Power Corporation Limited (UPCL), which will have the first right to purchase. The state government will provide a guarantee for the payments to be made by UPCL for such purchases.
- Evacuating infrastructure shall be provided by the UPCL or the Power Transmission Corporation of Uttarakhand Limited (PTCUL) to the developer project site.
- SHP projects are exempted from paying any royalty for the first 15 years beyond which there is an applicability of 18 per cent royalty towards usage of water resources.

The high potential supplemented by favourable policy instruments and high rate of returns (see Annexure 1) has resulted in the growth of SHP in Uttarakhand. However, the state's policy fails to mention anything about EIA requirements or regulations; also, there is no rehabilitation and resettlement (R&R) policy for plants with a capacity up to 100 MW.

Case study

CAG report: SHP impacts in Uttarakhand

One of very few large-scale studies on the impact of hydro power in India that also looks specifically at the impacts of SHP was carried out by the Comptroller and Auditor General of India (CAG) in 2008-09. The report, titled *Performance Audit of Hydropower Development through Private Sector Participation, Uttarakhand*[57], studied five operational plants, six that were under progress and three in their initial stages of development. Of the five projects which were operational, four were SHP plants (see *Table 10:* Power plants audited by CAG).

CAG identified three major issues pertaining to SHP development in Uttarakhand:

- Non-maintenance/applicability of downstream flow and consequent ecological impacts
- Muck generation and its use and disposal plans
- Non-adherence to plantation and/or afforestation plans by roughly 38 per cent of the projects and the resulting damage to local ecology

Inadequate downstream flow

Almost all the SHP projects in Uttarakhand are ROR type, implying that there is no reservoir creation. Instead, the water is diverted for a certain distance using diversion weirs through tunnels or open channels.

This diversion is necessary for creating a head. The head is dependent on the geographical location of the power plant. Hence the distance between the diversion weirs to the powerhouse varies depending on the geographical location. The longer the distance, the greater is the extent to which the natural river course is diverted and hence, the more significant the impact on the riverine ecosystem.

To reduce this impact, ecologists and biologists across the world suggest leaving a certain quantity of the natural flow in the original course of the river. However, quantification becomes difficult in the absence of an acceptable definition of ecological needs. While domestic and agricultural requirements can be easily quantified, it is difficult to decide what comprises legitimate ecological needs.[58]

The water quality is also impacted by improper muck disposal — rubble and muck is released in huge quantities based on the tunnelling length and the construction of other infrastructure such as roads. The assorted waste going into the river channel contributes to the turbidity of the water and leads to deterioration in water quality.

The impacts on human environment include reduced or intermittent supply of drinking and irrigation water. Further, for the projects which have pondage, sediment from the upper

TABLE 10 Power plants audited by CAG

Name of project	Capacity (MW)	District	River/tributary	Developer	Date of commissioning
Rajwakti	4.4	Chamoli	Nandakini	Himurja	April 2002
Debal	5	Chamoli	Kailganga	Chamoli Hydro Power Pvt Ltd, Hyderabad	2007
Hanuman Ganga	4.95	Uttarkashi	Hanuman Ganga Nallah	APH Regency Power Group	April 2005
Loharket	4.8	Bageshwar	Sarju, tributary of Kailganga	Parvatiya Power Ltd, under Sarda Energy and Minerals	February 2008

Source: *Performance Audit of Hydropower Development through Private Sector Participation, Uttarakhand for the year 2008-09*, Comptroller and Auditor General of India.

The Kaliganga: The natural course of the river will dry up once Kaliganga II project is commissioned, as the flow will be diverted to feed the SHP

reaches of the Himalaya gets trapped in the silt, thus depriving it of critical sediment in the alluvial planes.

In its audit report, CAG noted: "The physical verification (during May 2009 to July 2009) at the project sites of all the four operational projects, falling in the audit sample, showed that river beds downstream had almost completely dried up and the water flow was down to a trickle and extremely inadequate for the sustenance of ecology and nearby groundwater aquifers."[59]

Based on ground interaction with villagers, CAG made the following observations on the four projects:

- *Debal hydro power:* Villagers informed the CAG about the depletion in natural water resources used for both irrigation and drinking, after the establishment and operation of the project. The depletion was evident in 4 km of the river stretch from where the water has been diverted through the tunnel. The inhabitants of Kail village reported that they and their livestock were vulnerable to attacks by wild animals from the neighbouring forest. This was a result of the drying up of the river stretch which used to act as a boundary between the village and the forest.
- *Rajwakti hydro project:* The lift irrigation system built for the purpose of providing water for irrigation was defunct due to the diversion of the river. There were around 60 affected resident families in the villages of Tefina and Gwalla.
- *Loharkhet and Hanuman Ganga:* Due to the trench type diversion weir, during the lean season, the downstream flow ceases completely.

In order to ascertain the impacts of curtailing downstream flow, the CAG calculated that the average diversion of ROR projects was 4.16 km for both small and large projects (*see Table 11:* Comparison of diversion reaches for small and large hydro power plants).

Muck disposal

The MoEF clearance condition states that muck generated from excavation in the course of construction activity must be disposed of in a planned manner so that it takes less space, is not hazardous to the environment and does not contaminate

TABLE 11 Comparison of diversion reaches for small and large hydro power plants

Name of the project	Capacity (MW)	Diversion reach* (in km)
Small hydro power		
Rajwakti	4.4	2.56
Debal	5	3.79
Hanuman Ganga	4.95	1.86
Loharket	4.8	2.67
Bhyunder Ganga	24.3	4.42
Birahi Ganga-II	24	3.29
Bhilangana-III	24	4.77
Large hydro power		
Srinagar	330	4.72
Alaknanda	300	5.8

Note: * The diversion reach has been calculated by summing up the lengths of intake, desiliting tank, penstock and tail-race. This gives a conservative estimation of the diversion length; the actual diversion can be even larger due to topography.

Source: *Performance Audit of Hydropower Development through Private Sector Participation, Uttarakhand for the year 2008-09*, Comptroller and Auditor General of India

any land or water source[60]. With specific reference to hilly regions, muck disposal should be carried out in such a way that usable terraces can be developed with suitable retaining walls. The terrace in due course of time shall be covered with fertile soil and suitable plants.

However, proper muck disposal is not being done by most developers. In fact, it seems to be an accepted practice that the muck will get eroded with rainwater during the monsoon season.

The CAG report has identified the following issues that result from improper muck disposal:

- Increase in turbidity of river water
- Shrinkage of the river catchment area
- Impact on aquatic biota

It found the following non-compliance on muck disposal:

- *Debal project:* According to MoEF regulations, the muck disposal site should have been developed by making terraces, covering them with fertile soil and doing suitable plantation. This has not been implemented even though the project has been operational since 2007.
- *Rajwakti project:* The muck generated during the construction of the project must have been dumped in the Nandakini river as there is no muck disposal site which the project proponent could show to CAG auditors.
- *Agunda Thati project:* This project lacked a proper muck disposal process. This is evident from the fact that there was no protection wall constructed for protecting the power channel, which could have stopped the muck from being disposed off in the Balganga river.

These cases clearly reflect the need for proper planning, implementation and management of muck disposal. This is very essential to protect the locations from soil erosion, encourage afforestation, and to ensure proper utilisation of muck during the construction of roads, check dams and slope maintenance. There needs to be a monitoring mechanism penalising the project proponents for not adhering to the laid out regulatory framework.

Impact on terrestrial ecosystem

One of the relative advantages that ROR small hydro power projects have over large hydro (with storage) or large ROR with small pondage, is that they do not involve submergence of huge areas. This in turn avoids a large number of issues such as changes in landscape, rehabilitation and resettlement of project affected people, soil erosion, groundwater recharge, water quality, sediment transportation resulting from submergence of vast tracts of land and massive deforestation activities.

However, deforestation still takes place due to the construction of project facilities like power houses, head-race, tail-race, transmission lines and access roads to the project site. The significant concerns due to deforestation observed by the CAG audit included increased soil erosion, disruption of local flora and fauna and disturbance of hill slopes.

CAG auditors also noticed that out of the four SHP projects, two, Loharket and Debal, reported zero achievement with regard to afforestation while Rajwakti reported 50 per cent achievement; Hanuman Ganga was the only project adhering to the afforestation requirement. However, the survival ratio was not made available to the CAG auditor by the forest officials.

Case study

The IMG report

The MoEF has constituted a inter-ministerial group (IMG) to look into the issues related to hydro power plants and ecological flows on the Ganga. In its report titled *Report of the Inter-Ministerial Group on issues relating to River Ganga*, dated April 2013, the IMG has taken note of the fact that hydro power development exerts an impact on environment, ecology (both terrestrial and aquatic), and economic and social life. Presently, 70 hydro power projects with a capacity of 9,580.3 MW have been proposed on the Bhagirathi and Alaknanda basins — the two main tributaries of the Ganga in Uttarakhand. These include 17 operational projects with a capacity of 2,295.2 MW, 26 projects with a capacity of 3,261.3 MW which are under construction and 27 projects under development (including projects under scientifc investigation or at the project feasibility report stage) having a capacity of 4,023.8 MW.[61]

Environmental flow regulation

The IMG looked at the issue of hydro power and ecological flow (e-flow) and concluded that the e-flow regime must be based on two key parameters:

- An important component of the e-flow regime has to be the mimicking of the river flow to keep it very close to the natural flow. The requirements must reflect, in addition to ecological and environmental needs of the river, the requirements of the community for societal, cultural and religious purposes and the energy needs. This consideration is important especially during the winter season when the availability of water gets reduced sharply.
- There is a need to have an e-flow policy regime which is effectively implementable by different hydro projects. An essential ingredient of such a policy is simplified e-flow norms with minimum variations during the year.

Based on the above two criteria, the IMG recommended e-flows (for the hydro power projects on

A power house along with the sub-station of a SHP plant on the river Mandakini

MAP 1 Hydro power projects in the Alaknanda and Bhagirathi river basins

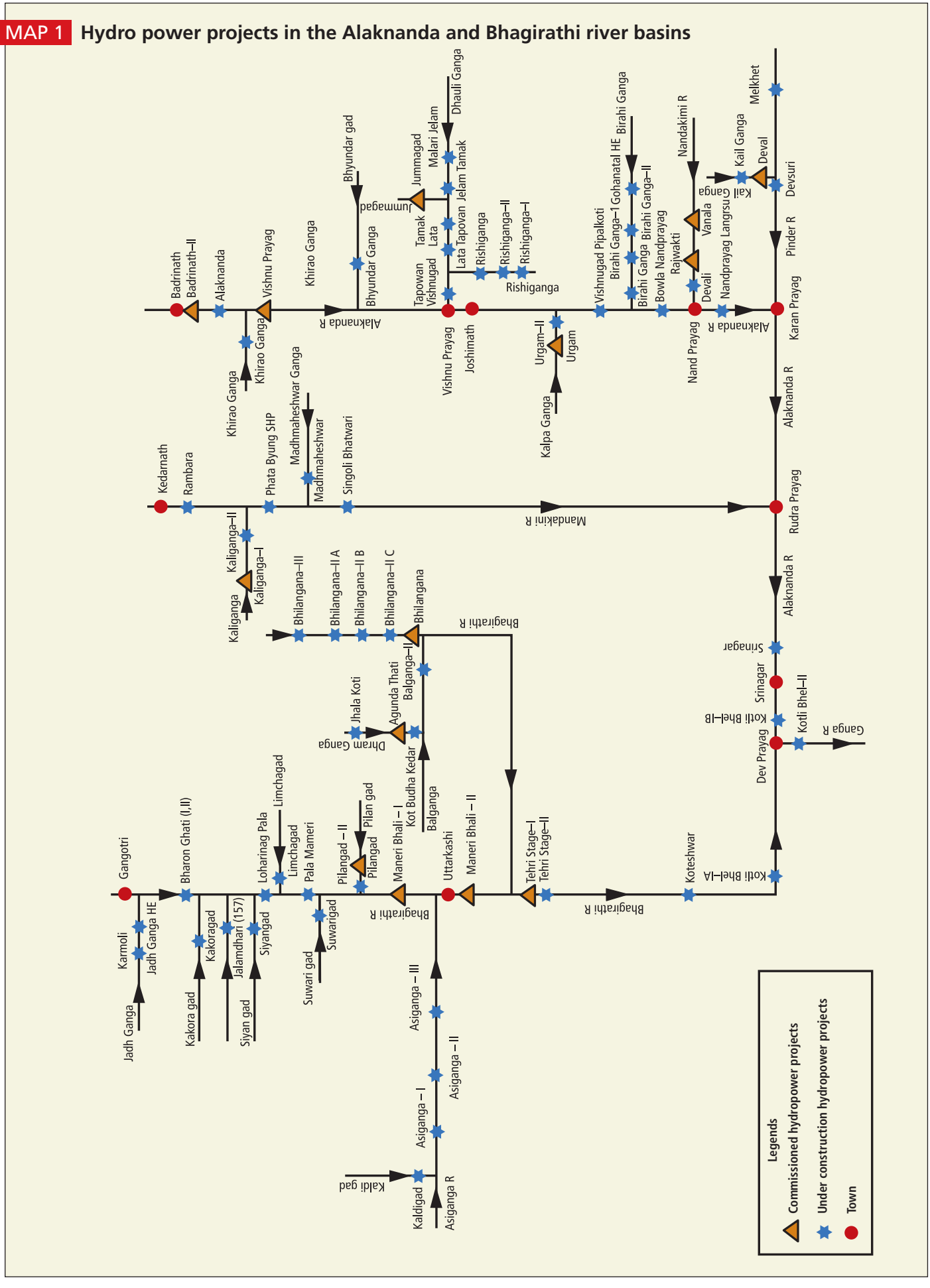


TABLE 12 E-flows recommended by IMG in the Alaknanda and Bhagirathi river basins

Time Period	E-flow recommended by IMG		
May-September (high flow season)	25%		
April, October and November (average flow season)	25%		
December-March (lean flow season)	50%	40%	30%
	For those hydro power projects where the average monthly river inflow during lean season (Dec-March) is less than 10% of the average monthly river inflow of the high flow season (May-Sept)	For those hydro power projects where the average monthly river inflow during lean season (Dec-March) is between 10-15% of the average monthly river inflow of the high flow season (May-Sept)	Otherwise

Source: *Report of the Inter-Ministerial Group on issues relating to River Ganga*, IMG, April 2013

TABLE 13 Impact of different e-flows on tariff and power, based on CEA observations

River basin	Power loss (%)	Increase in levelised tariff (%)
Alaknanda	11-23	13-30
Bhagirathi	8-20	10-23

Source: *Report of the Inter-Ministerial Group on issues relating to River Ganga*, IMG, April 2013

Alaknanda and Bhagirathi) between 25-50 per cent based on the season and the flow regime in the rivers (*see Table 12: E-flow recommended by IMG in Alaknanda and Bhagirathi river basins).*

The corresponding loss in power generation on the hydro projects on both the river basins ranged from 8-23 per cent, and the tariff increased from 10 to 30 per cent (*see Table 13:* Impact of different e-flows on tariff and power, based on CEA observations).

The IMG members, however, have not agreed unanimously on the Group's recommendations. Sunita Narain, one of the members, has instead proposed a 30 per cent ecological flow for May to October and a 50 per cent flow for November to April. She has submitted an analysis showing that it is economically viable to run hydro power plants with the recommended ecological flows (*see Annexure 2*).

Case study

SHP site visits: Uttarakhand

In Uttarakhand, CSE researchers made site visits to two SHP projects: the 4-MW Kaliganga-I commissioned in 2012 and the 6-MW Kaliganga-II under construction. Since the project is funded by the Asian Development Bank, EIAs had been executed and environment management plans (EMP) developed.

The EMPs outline the work to be done by the Uttarakhand Jal Vidyut Nigam Limited (UJVNL), the project developer: "UJVNL will ensure that the following activities will be undertaken after construction namely, stream restoration and stream bank stabilisation; restoration of gravel mining and dredging areas in the impacted sites; protection of riparian vegetation; monitoring of water quality; use of eco-friendly techniques for any road development and maintenance; and establishment of strong working partnerships among civil engineers, environmental biologists and the public."[62]

It adds: "The design will include mitigation measures for weirs and maintenance of flow level to address any de-watering effect downstream during dry season."

During the visit to these power plants, it was observed that no stream restoration work had been undertaken by the UJVNL, no proper muck disposal plan had been made and the muck was being disposed off at the exit of the adit tunnels. Since the weir is of trench type, there is no provision for environmental flow water to be released as the weir is along the entire stretch of the riparian river stream.

Official policy needs to define project-affected villages. The CSE team noticed that the project developer interpreted 'project-affected villages' as only those whose lands had been acquired for various project activities. The electricity generated is not provided to the project-affected villages, nor to villages in close proximity to the project. These villages had electricity for only six-seven hours a day; 5 per cent of the electricity generated by these projects would be enough to fulfil the needs of these villages for the entire day (considering power requirement of 500 kW for six villages around the project).

Regulations

EIA and EC

Understanding the consequences of development and forecasting its impact on environment and people is referred to as Environmental Impact Assessment (EIA). The objective of EIA is to foresee and address potential environmental problems/concerns at early stages of project planning and design.

According to the EIA notification 2006, a hydro power plant below 25 MW capacity does not need an EIA. So, all SHP projects in India are being constructed without an EIA. This has led to a situation where some projects are falsifying information to get international funding for clean energy (see Box: *It's easy to lie when you have no EIA requirement*). Most serious is the way large hydro power projects are being split into two to avoid EIA regulations (see Box: *Two projects on paper, one on the ground - how to avoid EIA in Karnataka).*

TWO PROJECTS ON PAPER, ONE ON THE GROUND – HOW TO AVOID EIA IN KARNATAKA

The minimum limit for having to do an EIA is 25 MW. If the forest diversion is less than 5 ha, then it can be cleared at the state level. If the project is declared as SHP, it gets a higher tariff than a large hydro project (Rs 3.40/kWh as compared to Rs 2.30/kWh). Most importantly, private players are restricted from developing large hydro power projects in Karnataka. All these factors have made it lucrative to split up projects with a capacity above 25 MW. In at least three cases, companies have tried to pass off one project as two.

TABLE A Projects evading the EIA requirements

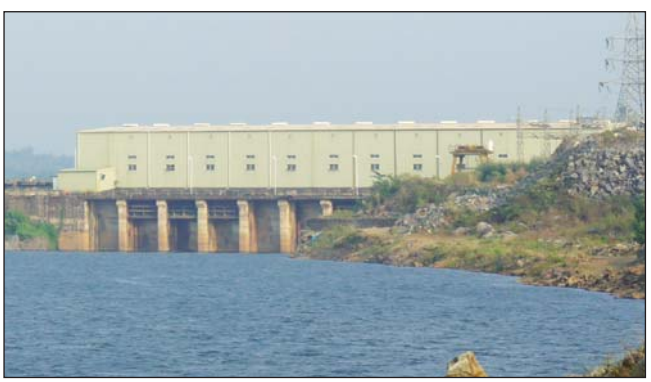
Project	Area	Stated capacity/ actual capacity in MW	Issue	Status
Pioneer Genco: Ranganathaswamy/ Shivasamudram	Cauvery basin, Shivasamudram village, Chamrajnagar district	24.75/49.5	Pioneer built a dam and diversion big enough for a 50-MW project but set up a 24.75-MW capacity turbine house. It then bought the rights to a smaller 4-MW project downstream; this was then moved upstream and increased in capacity. The company is now planning on using the same dam and penstock as the original project (which must therefore have been oversized for the original capacity).[1,2]	First plant finished, second plant in process with State Board for Wildlife (as the project is less than 10 km from a wildlife sanctuary). Proponent contends it is two projects. State Forest Department objects, stating it needs an EIA as it is one project.
Maruthi Gen: Yedakumari/ Hongadalla	Yedakumari village, Sakleshpur taluk, Hassan district	18.9/37.9 (possibly 48 MW)[3]	Maruthi Gen received approval to set up two projects in the same area but it began building a joint dam and tunnel for both projects with plans to only have separate turbine sheds. Digging/blasting of tunnel has been partly completed and labour camp and roads have been built.[4,5]	The project is now stalled because of high court orders to stop all projects in Western Ghats forests. Project proponent is arguing to continue because of sunk investments.
Greenko: AMR Perla/Rithwik Shamburi	Nethravati river, Bantwal, Dakshin Kannada district	24.75/49.5	Separate dam on paper, but on the ground it is just one dam over the whole Nethravati river which has dried up on one side (approx 2 km) of the river as the dam has been built just before a river island[6,7]	Commissioned and operating.[8]

Source: Analysis done by CSE

One project on paper becomes two on the ground: a pictorial representation

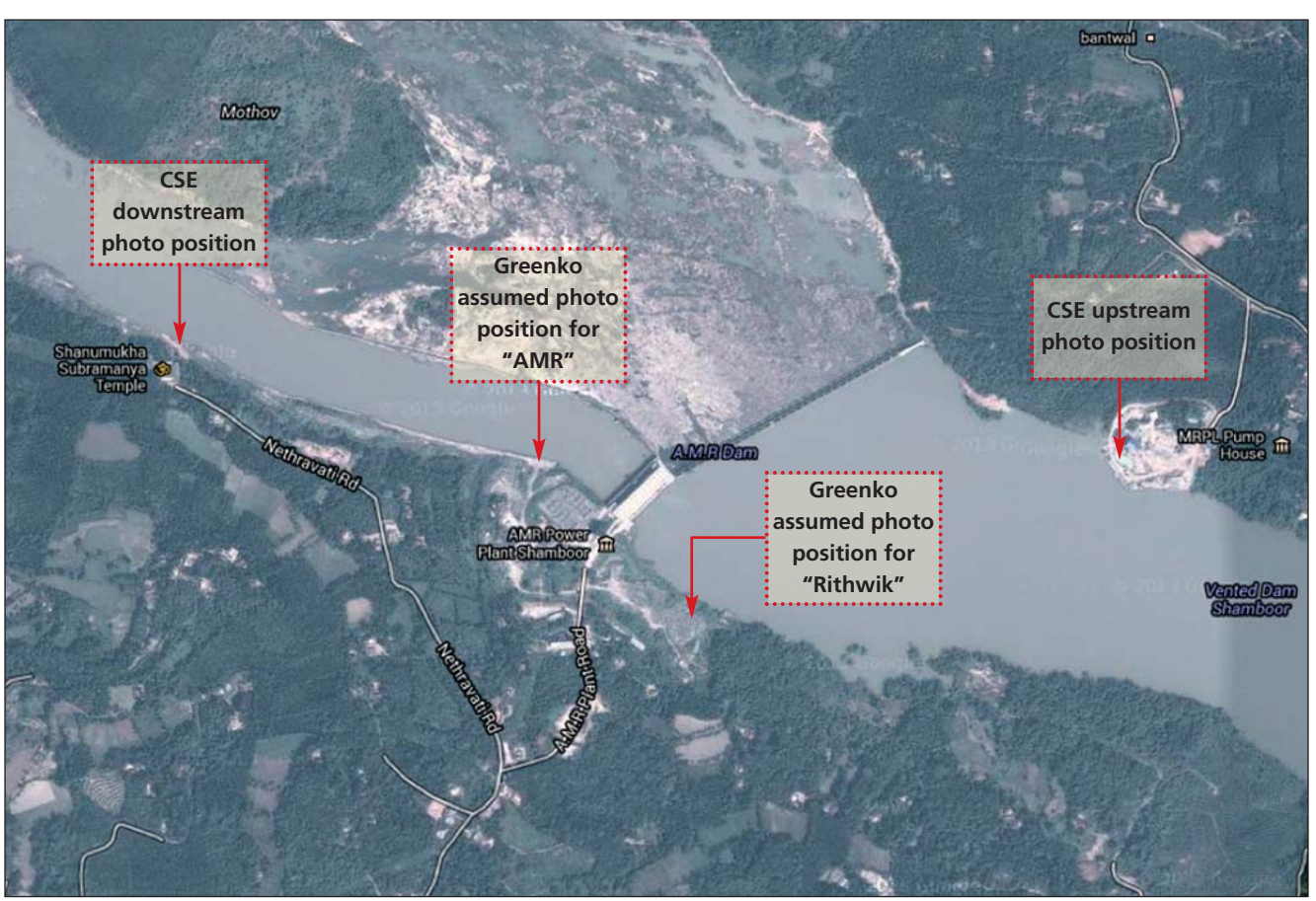
AMR
24.75-MW hydro power project located on the banks of Nethravati river in Karnataka

Rithwik
24.75-MW hydro power project located at Shamburi village, Bantwal taluk of Dakshina Kannada, Karnataka



Photograph taken by CSE researcher from downstream of the project

Photograph taken by CSE researcher from upstream of the project



Pictures on the top are from the Greenko Group website identifying two separate projects of 24.75 MW each. Pictures taken by the CSE researcher show that the photos passed off as two separate projects are actually of the same building, one taken from downstream and one from upstream. Time of day, season and photo-position may be different (for instance, the CSE upstream photo was taken from other side of the river), but the building layouts (number of windows, outside structures etc) are identical

IT'S EASY TO LIE WHEN YOU HAVE NO EIA REQUIREMENT

The International Power Corporation Limited (IPCL) SHP project in the Western Ghats lies in one of the most pristine forest areas in India. However, since its capacity is below 25 MW, an EIA is not mandatory. The project has applied for and is receiving funds under Clean Development Mechanism (CDM); IPCL says the project is a step forward for climate change mitigation.

The CDM funding comes with a requirement to prove the environmental sustainability of the project. The EIA submitted for the purpose of CDM funding shows multiple issues have been concealed and there has also been some falsification. If an EIA had been mandated by the MoEF, the project could have had its clearances cancelled. Since only a CDM clearance is required, work on the project continues.

TABLE A Comparison of environment impact relative to what is stated in CDM documents

CDM document statement	The ground reality
"Preliminary designs were made and land likely to be submerged and used for power channel was identified. This land came in the category of marginal land with gravelly and lithic type of soils."	The IPCL CDM document gives the height between the river bed (319 metres above sea level) and full weir level (340 metres above sea level) as 21 meters. The weirs of these heights create inundation and submergence and the area inundated is actually forest land. It now appears that forest clearance may not have been given for this area.
"Transmission lines were laid avoiding reserved forest areas. This route is devoid of vegetation and didn't involve cutting of trees and any disturbance to any wildlife. The study of the transmission line system indicates that the route length is on exposed rock and little soil cover."	It would be humanly impossible to avoid forest area in this location as the project is surrounded by forests. In fact, the power line goes through a thick forest area for at least 10 km. It is now clear that trees must have been felled if not lopped or otherwise
"Within the radius of 25 km from the project, there are no ecologically sensitive areas. Hence the implementation of project in no way affected the wildlife. Birds, plants and animals common to cultivated and populated areas are found in the area. No rare or endangered species have been reported".	Pushpagiri Wildlife Sanctuary is 15 km away and in the area near to the project, there have been repeated sightings of elephants and other endangered species.

Source: Analysis done by CSE

Forest clearance

Process

The forest clearance, given by the MoEF through the State Forest Department, is provided subject to conditions of compensatory afforestation to be undertaken by the project proponent. The afforestation required is ascertained based on the quantity of forest area being converted or the capacity of the SHP project. Table 14 details the existing standards in this regard.

However, compliance with these guidelines by project developers is a point of concern (see CAG audit findings). Ecologists say that when a full grown tree is cut, the trees being planted to take its place will take their own time for mitigating the impacts.

How much clearance and how fast

An analysis of forest clearance data for 138 SHP projects done by CSE reveals that on an average, 1 MW of project capacity requires about 1 ha of forest area clearance. According to the MoEF, the total approved forest area diverted for 757 MW of SHP projects in the country is around 604 ha (see Table 15: *Approved forest clearances for SHP*).

- The median number of hectares per MW is 0.67. For large scale hydro projects, the median is 0.47 ha.

TABLE 14 Compensatory afforestation

Range of area diverted/ capacity of power plant	Compensation to be done by developer
<1 hectare	Tree plantation equivalent to 10 times the number of trees cut.
>1 hectare	Compensatory afforestation equivalent to twice the area diverted
>10 MW	Catchment area treatment plan

Source: Based on discussions with Forest Department officials, Uttarakhand

TABLE 15 Approved forest clearances for SHP

	Hectare/MW
Highest	16.67
Median	0.67
Average	0.98
Lowest	0.06

Source: Analysis done by CSE

The forest area diverted in not only beacuse of SHP plant construction, but also due to linear intrusion like transmission lines and access roads

- For SHP projects, the median time until first stage forest clearance approval was 6.4 months from the time of submission of application to final approval. Principal approval took on a median about two months. The fact is that 1 ha/MW does not appear to be too large a number. But the impact cannot be judged solely on the basis of the area of the forest. The number of trees, type of forests, the impact of linear intrusions from roads and power lines, and the fact that clearing forests on a riverbank separates the river ecosystem from the forest ecosystem (both of which rely on each other) should also be taken into consideration.

Clearances given by SPCBs

All pollution control boards follow the guidelines stipulated in the Air and Water Acts. The PCB at the state level provides Consent to Establish and Consent to Operate certificates (often called 'No Objection Certificates'). Without these consents, a project is not allowed to operate. The parameters on which a PCB provides approval are air, water and hazardous waste disposal. The time period for this process is within 120 days of the receipt of application. Different SPCBs handle SHP differently, with some handling it only under the Water Act, Air Act, Hazardous Waste Rules or Noise Pollution Rules, or under a combination of all of them. However, since the Water Act mainly covers pollution in water and not its diversion, withdrawal or damming, the usage of the Act for hydro power, which is deemed non-polluting in the operational stage, is limited.

Most of the SPCBs use a colour-coded system of 'red', 'orange' and 'green' based on the potential environmental impacts of different types of projects. This is done to determine how often a project should be scrutinised and how detailed that scrutiny should be. At least some states assess SHP as 'green' which means it is the least scrutinised and only needs a renewal of the Consent to Operate every five years. In Uttarakhand, the SPCB has placed SHP in the 'red' category, which means the scrutiny is more in-depth and Consent to Establish needs to be renewed every two or three years.

An analysis done by the Alternate Hydro Energy Centre (AHEC) of IIT Roorkee on the *effort* and *time* required for obtaining clearances in SHP projects, reveals that forest, land acquisition and techno-economic clearances take most of the time and effort. On the other hand, pollution clearance takes relatively less time but equal efforts.[63]

Clearing SHP in Karnataka

A plethora of agencies is involved in giving clearances for SHP in Karnataka. The KREDL is the nodal agency in the state, facilitates the process for setting up SHP plants. It is, however, far from being a single-window clearance agency.[64] Some of the major approvals needed to set up a SHP plant in the state are forest clearance, approval from the Irrigation Department, land approval from the Revenue Department, Consent to Establish and Operate from the Karnataka State Pollution Control Board (KSPCB), approval from the Fisheries Department, approval from the Department of Factories and Boilers and approval from the Karnataka Power Transmission Corporation Limited (KPTCL).

- ***Fisheries Department*** **:** In terms of hydro power with dams as well as those leaving rivers dry, the Department takes a compensation fee depending on the size of the dam area or the river area affected. This compensation is then used to seed reservoirs with economically important fish such as mahaseer. It is important to note that the Fisheries Department cares about fisheries and fisherfolk, and not the

TABLE 16 Renewable energy and the State Pollution Control Boards

	Wind	Small hydro	Solar PV	Solar thermal	Biomass
Is Consent to Establish/Consent to Operate needed?					
Haryana	No	Yes	No	No	Yes
Rajasthan	Yes	Yes	Yes	Yes	Yes
Sikkim	Nil projects	Yes	No	Nil projects	Yes
Uttarakhand	No	Yes	No	No	Yes
If yes, under which Acts? (Air Act (A), Water Act (W), Hazardous Waste Rules (H), Noise Pollution Rules (N)					
Haryana	–	A,W,N	–	–	A,W,N
Rajasthan	A,W	A,W	A,W	A,W	A,W
Sikkim	–	W	–	–	A
Uttarakhand	–	A,W,H	–	–	A,W,H
Category of project (Red - most concern, Orange - medium concern, Green - least concern)					
Haryana	Green	Green	Green	Green	Red
Rajasthan	Green	Green	Green	Green	Red
Sikkim	Categorization of industries is under process				
Uttarakhand	–	Red	–	–	Red
Whether water cess is collected					
Haryana	If using water	Yes	Yes	Yes	Yes
Rajasthan	Yes in all processes using more than 10 kiloliter per day				
Sikkim	The matter is under consideration and awaiting government approval				
Uttarakhand	–	No	–	–	Yes

Source: Based on e-mail survey sent to State Pollution Control Boards in March 2013. Uttarakhand noted that it had no applications for solar PV, solar thermal or wind power projects so far.

fish. There seems to be little concern about the loss of fish species that are of no economic value.[65]

- ***Irrigation Department:*** The Karnataka Neeravari Nigam Ltd under the Water Resource Department clears any diversion of rivers and heights of weirs. According to KREDL, it also decides the minimum flow for hydro projects. There is, however, little involvement as long as projects do not interfere with irrigation projects. Projects in the Western Ghats forests are of little concern to the department as it does not irrigate any crop land there. There has been no attempt to decide about the minimum environmental flow, contrary to the information provided by KREDL.[66]

- ***The Karnataka Department of Ecology and Environment (DEE)*:** DEE enforces a number of acts and rules at the state level, including the Environmental Protection Act, the Biological Diversity Act, Air Act, Water Act and the EIA notification. The department houses the State Environmental Impact Assessment Authority (SEIAA). In this way, it seems to overlap with the KSPCB. In fact, environmental clearance from the SEIAA is not given until the Consent for Establishment is given by the KSPCB. As per the state government's regulations, SHP plants in the state need to be considered and approved by the SEIAA (along with 'red' category projects with investments of above Rs 10 crore).[67] What exactly is being considered when an environmental clearance is given is unclear. A review of three projects by CSE, for which clearances were obtained from the SEIAA, shows that the terms of clearances were the same. All three clearance letters state:

"The subject was discussed in the State Environmental Clearance Committee (SEIAA). Various documents produced by the industry such as Project report, Consent for establishment, on-site emergency plan, Environmental Management Plan, and other connected documents were verified in detail. After discussion, the committee decided to renew/issue the Environmental Clearance issued to the project."[68]

A number of project-specific as well as general conditions are included in the Environmental Clearance (EC). From the conditions, it is clear that SHP plants in Karnataka are supposed to have an EMP (*see Table 17:* Conditions put during EC in Karnataka). But the conditions given do not include any measures related to environmental flow, heights of weirs or implementation of fish-ladders.

TABLE 17 Conditions put during EC in Karnataka

General conditions	Project-specific conditions
DEE reserves the right to withdraw the EC with any change in government policy	Strictly follow the Consent for Establishment and Consent for Operation conditions issued by KSPCB
DEE and the Regional Office of KSPCB will monitor implementation of stipulated conditions. Environmental Management Plan and additional information to be submitted to Regional Office	Dispose solid waste in a scientific manner without causing underground and surface water pollution
If project is altered a fresh reference shall be submitted to DEE to assess and incorporate additional environmental protection measures	Adopt rainwater harvesting in industry within six months and submit compliance report
EC letter advertised in newspapers of vernacular language and posted in the tehsildar's office	Earmark 33 per cent of the project land for green belt
Enforcement of Water Act, Air Act, Environmental Protection Act, Hazardous Wastes Rules etc.	Scientifically dispose wastes generated in the project such as waste gear/lubricating oil, batteries etc.
DEE reserves the right to revoke EC if conditions stipulated are not implemented to satisfaction	Provide sanitary facilities in sufficient number for employees of project
Fugitive dust emissions should be controlled by water spraying on haul roads, loading and unloading and transfer points.	Undertake river bank/canal bank afforestation programme
Measures should be implemented to keep noise levels below 85 dBA in the work environment	Comply with all environmental protection measures incorporated in the EMP
Personnel working in dusty areas should be provided with protective respiratory devices	The proponent shall earmark at least 2 per cent of the project cost towards corporate social responsibility and execute the same (2 per cent for 1.5-MW project, 5 per cent for 24.75-MW project)
Concealing, or submitting false data may result in withdrawal of clearance and attract action under the Environmental Protection Act.	The proponent shall construct ladies' toilets and overhead tanks in government schools and distribute books and stationery to poor students towards social commitment plan and submit a report to DEE

Source: Analysis done by CSE, 2013

According to the DEE, cumulative impact assessments could either be done by asking the project proponent to include assessments against other projects coming up in the same area or by constituting a group in the department to look at the overall impacts. Cumulative impact assessments by a group constituted by the department looking at whole river catchment areas have been undertaken previously, but no documentation from these studies were available.

For ROR SHP projects, the DEE looks specifically at the size of embankment, storage area, area of inundation, impact of roads, amount of forest land used and whether the project makes the river drier.[69]

- ***Karnataka State Pollution Control Board (KSPCB):*** The KSPCB works with the DEE with Consent for Establishment given first by the KSPCB, followed by the EC given by DEE and a Consent to Operate given again by the KSPCB. SHP plants are "non-significant" for the KSPCB, as it mainly enforces the Water and Air Acts and SHP has no significant sources of pollution. The KSPCB makes it mandatory to use debris from excavation in road construction. Inspections are made before giving consent.[70]

- ***Karnataka Forest Department:*** It gives clearance and inspects any project in the state requesting forest clearance. Proposals are given by the developer through Form A Part-1 as per Rule 6 of the Forest Conservation Rules, 2003.[71] This proposal needs to justify the project's use of forests and give information on the type of forest, wildlife, biodiversity and displacement of people (including tribals). The local forest officer inspects and gives opinions on the project. Form A Part-2 provides the location and density of the forest, enumeration of trees, vulnerability of forest area to erosion, flora and fauna of the area and any specific recommendations. According to the Forest Department, every SHP project proposal is scrutinized as site-specific to see if it could be placed upstream or downstream to avoid forest use. Power evacuation and road needs are also scrutinized.[72]

Over time, there seems to have been a change in the way SHP plants in Karnataka (and especially in the Western Ghats) are viewed. One project has spawned many more in the same area and fragmented forests have led to human-wildlife conflicts. "A patch of a project appears small, but fragments a lot more than its hectarage:"[73] this is the reason given for the government of Karnataka order that prohibits SHP in Western Ghats forests.[74] The department also believes that SHP impacts micro flora and fauna, which are areas that have not received much attention before. Projects within 10 km from wildlife

TABLE 18 Clearances required for SHP in Uttarakhand

Name of clearance	Department/government agency
Environmental clearance	All SHP projects less than 25 MW do not need any environment clearance as per the MoEF's 2006 notification
Pollution clearance	State/Central government only for those states where specific notifications are enforced
Forest clearance	MoEF through state forest departments
Water availability	State nodal department/Central Water Commission for inter-state projects
Rehabilitation and resettlement of people	State government as per REPR policy, 2007
Land availability	State government/private sector
Archeological clearance	Archeological Department
Mining for construction material	Mining Department

Source: Based on information received from officials at Alternate Hydro Energy Centre (AHEC), IIT Roorkee

sanctuaries or national parks are forwarded for assessment by the State Board for Wildlife (which is a part of the state forest department) before being sent on to the National Board for Wildlife.

All in all, SHP in Karnataka gets assessed for its environmental impacts by multiple agencies, but the issue of dry river beds and minimum environmental flow seems to have fallen between the cracks.

Clearing SHP in Uttarakhand

In Uttarakhand, there are two nodal agencies for developing SHP projects — the Uttarakhand Renewable energy Development Authority (UREDA) is responsible for micro hydel projects up to capacities of 100 kW, while the Uttarakhand Jal Vidyut Nigam Limited (UJVNL) is the nodal agency for projects above 100 kW.[75] The projects are allotted through competitive bidding, which has the upfront premium paid to the nodal agency per MW as the discerning factor. Although the policy mentions providing single-window clearances, it is not so in practice.

The project developer in Uttarakhand, as in Karnataka, has to apply for a number of approvals before setting up an SHP project (*see Table 18:* Clearances required for SHP in Uttarakhand). Under the existing policy regulations, a SHP developer needs Consent to Establish and Consent to Operate from the Uttarakhand Environment Protection and Pollution Control Board (UEPPCB). The board issues the Consent to Operate valid for three years after inspection of the site.

CAG audit findings have revealed that almost 75 per cent of the projects are operating without the consent of the UEPPCB.[76] The absence of applicability of EIA for SHP along with the SPCB's laxity in fulfiling its responsibilities (such as monitoring submission of monthly reports, muck disposal and ensuring minimum downstream flow) has led to a precarious condition for the environment. The CAG audit also points out that no penal action has been taken against project developers who are ignoring environment stipulations, nor have there been any regular inspections carried out by the board personnel (except visits obligated for issuing Consent to Operate).

Global best practices

While most countries set a limit for what is a "small" hydro power project, not all use that limit to decide when an EIA is needed (see *Table 19:* Maximum limit of small hydro). While some nations may relax EIA requirements or take decisions on a case-by-case basis, complete removal of the EIA process is uncommon among industrialised countries. Generally, the best practice is to not treat SHP projects any differently from large hydro projects. If the project is reservoir-based, it has exactly the same impacts as a large project. The area affected has more to do with the geography, hydrology and topography of the location of the plant and less to do with the capacity of the turbine.

If the project is a ROR project, the issue of diversion of water and dry river beds may arise. A small but winding river can be left dry for kilometres by a 7-MW project, while a larger straighter river could mean a much shorter dry section for a 100 MW project.

India

In India, projects above 25 MW need environmental clearance as per the 2006 EIA notification. This could mean that a 24.75-MW ROR project needs no clearance, while a 26-MW ROR project does. Even if the projects are technically identical they are worlds apart in the eyes of the law. The Terms of Reference (ToR) states what needs to be included and abided by in an EIA. A hydro power ToR specifies minimum flow and requires studies on (among other things) impacts on both terrestrial and aquatic flora and fauna, impacts on local population, R&R requirements of inhabitants in proposed inundation area, identification of risk areas for slope erosion, inundation area, noise levels during construction and possibility of a fish pass (fish-ladder).

Barrage of the 9.3-MW Mohmadpur canal-based SHP on Upper Ganga canal in Uttarakhand

TABLE 19 Maximum limit of small hydro

Country/organisation	Limit (in MW)
UK	5
United Nations Industrial Development Organization (UNIDO)	10
Sweden	15
Colombia	20
Australia	20
India	25
China	25
The Philippines	50
New Zealand	50

Source: T Abbasi and S A Abbasi, 'Small hydro and the environmental implications of its extensive utilization', *Renewable and Sustainable Energy Reviews 15*, 2011

The ToR puts a norm of a minimum 15 per cent of the lean flow level as environmental flow to be released by the projects in the case of high flow rivers; but it "may have to be" closer to the full lean season flow for "low flowing stream", though what exactly constitutes a low-flowing stream is not defined (see *Table 20:* Environmental clearance conditions for large hydro projects).

Noise levels are meant to comply with the Noise Pollution (Regulation and Control) Rules, 2000**.** The ToR does mandate that the cumulative impacts of diversions on multiple streams of a river are shown: *"The details of other streams (with their discharges) joining the affected reaches downstream to the various diversion structures be tabulated and to be shown in a map."*[77]

The ToR and the environmental clearances given also require a plan for handling muck from construction and sanitation at the site, and give precise numbers for afforestation, creation of slope erosion protection and pasture land.

South Africa

As opposed to the EIA requirement in India which is based on the type of project and its generation capacity, South Africa assesses multiple parametres such as the area of the project (any generation facility using a combined area over 1 ha), height and size of the dam (set at 5 m in height or covering an area of 10 ha or more), and the capacity of the project (20 MW or more).

A basic assessment needs to be done for projects not fulfilling these criteria. These projects should be within the flood

TABLE 20 Environmental clearance for large hydro projects

Project	State	Capacity in MW	Environmental flow requirement	Fish-way/fish-ladder required
Nyamjangchhu HEP	Arunachal Pradesh	780	3.5 cumecs or 20% of the average of four leanest months whichever is higher; average release during the monsoon months shall be at least 30% of the total monsoon discharge unobstructed.	Yes
Khuitam HEP	Arunachal Pradesh	66	20% of the 10 daily average discharge over four consecutive leanest months in the 90% dependable year which works out to 3.55 cumec.	Yes
Bajoli Holi HEP	Himachal Pradesh	180	20% of the average of four leanest months.	No (but compensatory fish seeding)
Shangtong-Karcham ROR HEP	Himachal Pradesh	420	20% of the average of four leanest months or as per a future study by a reputable institute, whichever is higher.	No (but compensatory fish seeding)
Integrated Kashang ROR HEP	Himachal Pradesh	243	15% of the average flow of four consecutive leanest months or as per future study, whichever is higher.	No (but compensatory fish seeding)
Ratle HEP	Jammu & Kashmir	850	33.43 cumecs during the lean season from November-February (about 27% of lean season) at the downstream to be strictly adhered to through a continuously running 30-MW turbine. Monsoon flow shall be at least 30% of the monsoon discharge.	No
Tashiding ROR HEP	Sikkim	97	2 cumec water to be released during lean season. No clarity on what percentage of flow this is.	Unknown

Source: Based on Environmental Clearances given in MoEF database (all projects given Environmental Clearance since 2009), http://environmentclearance.nic.in/

line of a river, or within 32 m of the bank of a river where the flood line is unknown, or when dredging of soil of more than 5 cubic m from a river is happening. These requirements mean all MW-size SHP projects, including ROR projects, would at least need a basic assessment and most would need a full EIA.

These rules emanate from the South African National Environmental Management Act (1998),[78] which provides regulatory power to demand impact assessments from projects before authorisation to proceed is given. Among other things, the Act also demands that the assessments take into account cumulative impacts. The lists of projects needing EIA have been put forth in GNR 387 of 2006[79] (*see Table 21:* Activities related to hydro power requiring some kind of environmental assessment in South Africa).

South Africa's National Water Act (1998) also identifies water uses which require licensing, and covers diversion of a water course and impeding the flow in a water course (including through the use of a dam or weir). In comparison, the Indian Water Act (1974)[80] says weirs and dams are not an offence against the Act.[81]

TABLE 21 Activities related to hydro power requiring some kind of environmental assessment in South Africa

Environmental assessment required	Activities
Requires EIA if:	The construction of facilities or infrastructure, including associated structures or infrastructure, for the generation of electricity where the elements of the facility cover a combined area in excess of 1 ha
	The construction of a dam where the highest part of the dam wall, as measured from the outside toe of the wall to the highest part of the wall, is 5 m or higher or where the high-water mark of the dam covers an area of 10 ha or more
Requires basic assessment if:	The construction of facilities or infrastructure, including associated structures or infrastructure, for any purpose in the one-in-10 year flood line of a river or stream or within 32 m from the bank of a river or stream where the flood line is unknown, excluding purposes associated with existing residential use, but including dams
	The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5 cubic m from a river, tidal lagoon, tidal river, lake, in-stream dam, floodplain or wetland

CASE STUDY

THE BOSTON MINI-HYDRO PROJECT ON THE AS RIVER[1]

The As river, flowing through Free State, South Africa has multiple hydro projects on it. The Boston Mini-Hydro project is a 4.1 MW ROR project of 800 m length, with a 10 m high weir. The project proponent has conducted a full EIA assessing the project's impacts both during construction and operation phases on terrestrial and aquatic ecology, flora and fauna, sewage accumulation, sedimentation, disturbance to nearby population during construction, impact on eco-tourism, noise and visual impacts, erosion and contamination of topsoil, job opportunities, carbon avoidance, etc.

Cumulative impacts have been taken into consideration at each step putting the project in relation with the already established upstream projects. For the Boston Mini-Hydro project, the EIA describes each impact in relation to the existence of other dams upstream and downstream. In the case of the As river on which the dams are located, the EIA makes it clear that the river has changed dramatically in the last two decades with increased flow and multiple hydro dam projects. However, the cumulative impact section of the EIA broadly uses the argument that since dams have already destroyed much of the natural environment, one "extra" dam will not make much difference. This might be a questionable logic.

A positive aspect of the EIA is the use of photographs to illustrate possible impacts on the environment and to give a better understanding of the geology and ecology of the area. Photographs of nearby hydro power stations are used to show what the finished project may look like. Compare this with an EIA for a 70-MW project in India, which only features a single photograph on its front page.[2]

TABLE A Major impacts and mitigation measures in Boston Mini-Hydro project

Impact category	Status before project	Description of impact	Mitigation measure
Aquatic fauna	EIA states that few migratory species are present because of already existing dams and waterfalls. It gives a full list of potential fish in river with one endangered species possibly present.	Risk of negative impact and hampering of migration to fish due to erosion, "pulsating" flow and "Lack of capacity/commitment to manage operations in terms of environmental flow". Further fish can be attracted (and taken off course) by outflow.	Establish monitoring program together with aquatic ecologist; Prevent vegetation clearing where not necessary; slow and direct outflow; "Implement a fish-ways monitoring programme prior to construction to obtain a baseline and during the operational phase to monitor the potential impact of the development on the functionality of the fish-ways"
Erosion	At the site the banks of the As River are vertical with almost no marginal vegetation cover. Gradual bank erosion still occurs in places.	Risk of erosion of banks, slopes and run-off of topsoil into river during construction	Where work is to be done topsoil shall be stripped and stockpiled, vegetated (to bind the soil) and when construction is completed topsoil shall be returned to disturbed areas for re-vegetation
Loss of biodiversity (flora and fauna)	Grass covered slopes with some bushes, no rare and endangered fauna. Some mammals such as otter, mongoose, antbear.	The project will mean removal of some grasses and bushes. Noise and visual changes can disturb animals.	Species, especially grasses, trees and shrubs occurring naturally in the region must be used to rehabilitate disturbed areas; No fires allowed; No killing of animals allowed; no pets or livestock allowed on site; daily check of trenches for trapped animals.
Impact on eco-tourism	The area is a hot-spot for rafting and canoeing both as adventure tourism and as sport.	Will make rafting and canoeing on a stretch of 800 m impossible and break the flow. Job creation in tourism may be affected negatively and thereby create economically negative impact.	No mitigation given only states "Entire As River is not lost for sporting and leisure activities. Project will only impact on approximately 800 m of the river."

Recommendations

As with other developmental projects, as long as no EIA requirement exists, there is no way of knowing what impacts a project may have.

1. SHP plants above 1 MW in size should be included under EIA notification 2006 as Category B projects, changing the text under 1(c) River Valley Projects to: "(i) < 50 MW ≥ 1 MW hydroelectric power generation". Based on screening, the need for an EIA should be decided. Further, it should be added that projects to be based in an already existing irrigation canal would be exempted from EIA requirement.
2. Before taking up further hydro power development, a carrying capacity study over a river basin should be executed for all rivers. The distance between projects and the overall percentage of river length affected must be decided on the basis of the carrying capacity study.
3. As part of the environmental clearance for any project, a part of the stream should remain undammed and provide a natural or artificial water course designed for the local environment to allow passage of fish and macro-invertebrates. A minimum environmental flow rule should be set in place for all SHPs. CSE recommends that 50 per cent of the flow in lean season and 30 per cent of the flow in monsoon should be set aside as ecological flow. This parameter should be publicly monitored.
4. Forest diversion should take into consideration the land concreted due to coup roads, linear intrusion etc. Forest Clearance should be given based on the combined impact of SHP and linear intrusion. Also, there should be stricter monitoring of the afforestation rules.
5. Clearance given by the Fisheries Department should not include the clause of introduction of invasive species into the river ecology.
6. There should be clear rules and a plan prepared for muck disposal by the developers along with better monitoring and enforcement of the said plans by the State Pollution Control Board.
7. An assessment of the infrastructure being constructed for SHP projects has to be done. There have been cases where bigger infrastructure has been created in order to increase the power production capacity in future.
8. Benefits from the projects must be shared with the local communities. For instance, the first right to power should be with them. Profits generated should be shared with the local population for development. Project-affected villages have to be clearly defined so that it can be evaluated who will receive the benefits from SHP.

Annexure 1

Economics of SHP in Uttarakhand

The SHP policy of the Union ministry of new and renewable energy and the Uttarakhand government is explicit in incentivising private developers for setting up small hydro power plants. What is implicit is that only financially strong investors-developers are actually able to set up these plants.

A financial institution (FI) approves debt funding to borrowers only after an evaluation of the latter's capability to repay the principal along with the interest amount. On similar lines, an investor only funds (primarily equity) a SHP project if there is a high probability of getting the desired returns on the investment made.

There is hardly any data on the returns on investments made by SHP projects. To get some idea about the level of returns made by SHP projects, CSE analysed and quantified the returns for two commissoned SHP projects in Uttarakhand.

Various financial techniques can be used within the ambit of project finance to analyse returns on investments. One of the more widely acceptable ones is 'Equity Internal Rate of Return (Equity IRR)', defined as "the discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project"[1]. Another technique in use is Debt Service Coverage Ratio (DSCR), which is "the amount of cash flow available to meet annual interest and principal payments on debt, including sinking fund payments"[2]. CSE researchers evaluated Equity IRR.

CERC tariff regulation for SHP

Based on the Central Electricity Regulatory Commission (CERC) guidelines on tariff determination, the State Electricity Regulatory Commission (SERC) determines tariffs for SHP depending upon the location of the project (whether it is situated in a hilly region or in the plains). The tariff is determined based on parameters for which benchmarks are set for a particular time frame termed as the control period. The SERC revises these guidelines from time to time based on the fall or rise in benchmark figures for the various parameters.

In Uttarakhand, the UERC or Uttarakhand Electricity Regulatory Commission is responsible for consolidating the laws relating to generation, transmission, distribution and trading of electricity within the state. The UERC (Tariff and Other Terms for Supply of Electricity from Non-conventional and Renewable Energy Sources) Regulations, 2013 has specified benchmarks for SHP projects (see Tables 1 and 2):

1. *Interest on loan capital:* 13.25 per cent valid till control period of 31.03.2013 with 10 year loan repayment period.
2. *Interest on working capital:* 12.75 per cent valid till control period of 31.03.2013.
   (Interest on loan and working capital, for analysis, was taken from Regulation of 2010 as there are no specific values mentioned in Regulation, 2013).
3. Normative operation and maintenance (O&M) expenses allowed for the year of commissioning shall be escalated at the rate of 5.72 per cent per annum.
4. For generic tariff the depreciation rate for the first 12 years of the tariff period shall be 5.83 per cent per annum and

TABLE 1 UERC regulations pertaining to SHP in Uttarakhand

Year	Interest on loan capital	Interest on working capital	O&M escalation	Depreciation	Return on investment
06.07.2010 valid up to 31.03.2013	13.25	12.75	5.72%	7% for first 10 years and then spread over remaining 25 years	Pre-tax 19%
30.04.2008 valid up to 31.03.2012	11.25	12.25	4-5%	–	14%

Source: Renewable Energy Tariff Regulation available on UERC website

TABLE 2 Benchmark parameters considered for SHP by UERC

Project size	Capital cost (Rs lakh/MW)	O&M expenses for year of commissioning (Rs lakh/MW)	Capacity utilization factor (%)	Auxiliary consumption (%)
Up to 5 MW	700	21	45%	1%
5-10 MW	685	20		
10-15 MW	670	18		
15-20 MW	650	17		
20-25 MW	630	15		

Source: Renewable Energy Tariff Regulation available on UERC website

TABLE 3 Gross and net tariff applicable from 01.04.2013 for SHP plants in Uttarakhand

Particulars	Up to 5 MW	>5-15 MW	>15-25 MW
Gross Tariff	4.22	4.02	3.74
Less: AD	0.30	0.30	0.30
Net Tariff	3.92	3.72	3.44

Source: UERC regulation, April 2013

TABLE 5 Actual generation and plant load factor for power plants

Project	Jan-11 to Dec-11 (MU)	PLF (%)	Jan-12 to Dec-12 (MU)	PLF (%)
Vanala	44.17	33.61	39.05	29.71
Bhilangana	67.29	34.1	77.93	39.53

Source: Accessed through Right to Information (RTI) Act

TABLE 4 Power plant details on tariff applicable and actual capital cost incurred

Project	Capacity (MW)	Levelised tariff (Rs/unit)	Capital cost (Rs lakh)	Capital cost/MW (Rs lakh)	Commissioned date
Vanala	15	3.50 (entire life)	7665.5[3]	511	06-12-2009
Bhilangana	22.5	3.30 (entire life)	16114	716	27-08-2009

Source: Accessed through Right to Information (RTI) Act

the remaining depreciation shall be spread over the remaining useful life of the project from 13th year onwards.

5. *Return on investment:* (a) Pre-tax 20 per cent per annum for the first 10 years; (b) Pre-tax 24 per cent per annum 11th year onwards.

Based on the above parameters and considering accelerated depreciation benefits, the UERC has arrived at gross and net tariff (see Table 3). The tariff is applicable to project getting commissioned on or after 01.04.2013.

In case of government-owned projects, default tariff as per UERC guidelines are applicable. Private developers have the option to opt for getting the project specific, and higher, tariff determined in case the capital cost has surpassed the benchmark level. Hence, it is a win-win for developers.

Analysis and results

CSE analysed the Vanala (15 MW) and Bhilangana (22.5 MW) SHP plants in Uttarakhand. The plants were assessed for their financial viabililty based on actual data for tariff, energy generation, capital cost incurred and date of commissioning, as per the information accessed through RTI act.[4]

The financial parameter analysed was Equity IRR, as UERC gives a benchmark for the same. Typically, an investor looks at this figure in order to make an investment decision.

The UERC benchmarks Equity IRR at 14 per cent as per the 2008 regulation which was applicable till March 31, 2012. But in August 2010 the benchmark was revised to 19 per cent pre-tax for first 10 years of operation and 24 per cent pre-tax from the 11th year onwards. Further, in April 2013 the benchmark was revised again to 20 per cent pre-tax for first 10 years and 24 per cent pre-tax from 11th year onwards. Since, the two plants analysed by CSE were commissioned in 2009, we have considered the benchmark Equity IRR as 14 per cent.

The information on tariff and capital cost used in the financial model is consolidated in Table 4. The generation details and the corresponding plant load factors are presented in Table 5.

The subsidy from MNRE has been considered as the sum of Rs 2.25 crore and Rs 37.5 lakh per MW of name plate capacity. What has not been factored in is the upfront premium amount which the project developer has to pay for getting the project, as this information is not available.

The Equity IRR of Bhilangana and Vanala, as estimated by CSE, was found to be more than the benchmark of UERC. It is important to note that there are two factors — on which the cash flow depends — impacting the economics to a great extend. First, the tariff which the project gets. Both these projects had assumed much lower tariff when they were being designed. According to the CDM project design document, both these projects had assumed Rs 2.35-2.50/unit as tariff.[5] They are presently getting a tariff of Rs 3.3-3.5/unit. So, their IRR has increased simply because of higher tariff. Second, the plant load factor (PLF) of both these projects in the last two years is lower than the designed PLF. If these plants would have achieved 45 per cent PLF then the Equity IRR would have risen sharply. Hence, the Equity IRR figures which CSE has arrived at are conservative figures and over the life of the project the return would be much higher than calculated (see Table 6).

The Equity IRR without capital subsidy amount is also higher than the benchmark IRR, therefore there is clearly a case that SHP is financially viable without capital subsidies (see Table 7).

TABLE 6 Comparison of Equity IRR with UERC benchmark when capital subsidy is included from MNRE

Equity IRR	Bhilangana	Vanala
Benchmark	14%	14%
Actual achieved	18.24%	23.56%

Source: Analysis done by CSE

TABLE 7 Comparison of Equity IRR with UERC benchmark when capital subsidy is excluded from MNRE

Equity IRR	Bhilangana	Vanala
Benchmark	14%	14%
Actual achieved (without subsidy)	15.00%	18.45%

Source: Analysis done by CSE

Annexure 2

Is 30-50 per cent ecological flow (e-flow) feasible?

Based on the data available to the inter-ministerial group (IMG) to look into the issues related to hydro power plants and ecological flows on the Ganga, CSE did an analysis to find out the impact of having an environmental flow regulation under various scenarios for hydro power projects located on the Alaknanda and Bhagirathi river basins. The impacts were studied on two parameters, namely increase in tariff and reduction in energy generation due to leaving certain percentage of flows during high flow and lean season. An important consideration was to have a minimum variation in ecological flows during the year to ensure its practical applicability on project sites.

Presently, all SHP projects are designed with no ecological flow regulation (unrestricted scenario). The entire river is diverted to produce electricity. The analysis done by CSE on SHP projects show that even when all water is diverted for power generation, most of the power (more than 70 per cent) is actually generated during the monsoon season (see Graph 1). With this as the background, CSE undertook an analysis to find out power reduction and tariff increase under different e-flow regimes. The analysis showed that a 30 per cent e-flow during high flow season and 50 per cent during lean flow season is feasible (see Table 1).

The analysis was performed on seven SHP projects whose tariff and design energy were provided. Their corresponding impact on increase in tariff and reduced energy generation was calculated to ascertain the impacts of obligating the ecological flows.

It is seen that considering the ecological flow of 30-50 per cent for each six-months period, the energy generation is reduced by 24 per cent and the corresponding impact on levelised tariff is 27 per cent (see Table 2: *Impact on energy generation and tariff due to 30-50% e-flow*).

TABLE 1 e-flow recommended by CSE

Season	Ecological flow (%)
May to October(High Flow)	30
November to April(Low Flow)	50

Source: Analysis performed by CSE

Power analysis

It has been observed that maximum energy (around 70 per cent of the annual energy) is generated only during the high flow season, from May to September. The average energy generated during lean season (six months) in only around 31 per cent of the total energy (*see Graph 2: Energy generation under unrestricted flow and 30-50% e-flow regime*). Thus, without e-flow the natural flow of the stream dries out completely for more than six months in a year during the lean season. Therefore, CSE proposes that leaving 50 per cent of the flow as ecological flow, during the lean season, will not impact energy generation as already the energy generated during this period is less, relative to the other six months period (see Graph 2: *Energy generation under unrestricted flow and 30-50% e-flow*).

Tariff analysis

The average tariff increased due to reduced energy generation is around 27 per cent (see Graph 3: *Current Tariff applicable and increase in tariff due to 30-50% e-flow*). In most of the projects this average tariff increase stands valid, with not much deviation. With projects like Asiganga-II already having a tariff of Rs 8.50/unit which is even higher than solar photovoltaic, an increase of 25 per cent in tariff to maintain the river ecology and the societal need is justified.

GRAPH 1 Percentage of energy generated during lean flow vs high flow season in unrestricted flow scenario

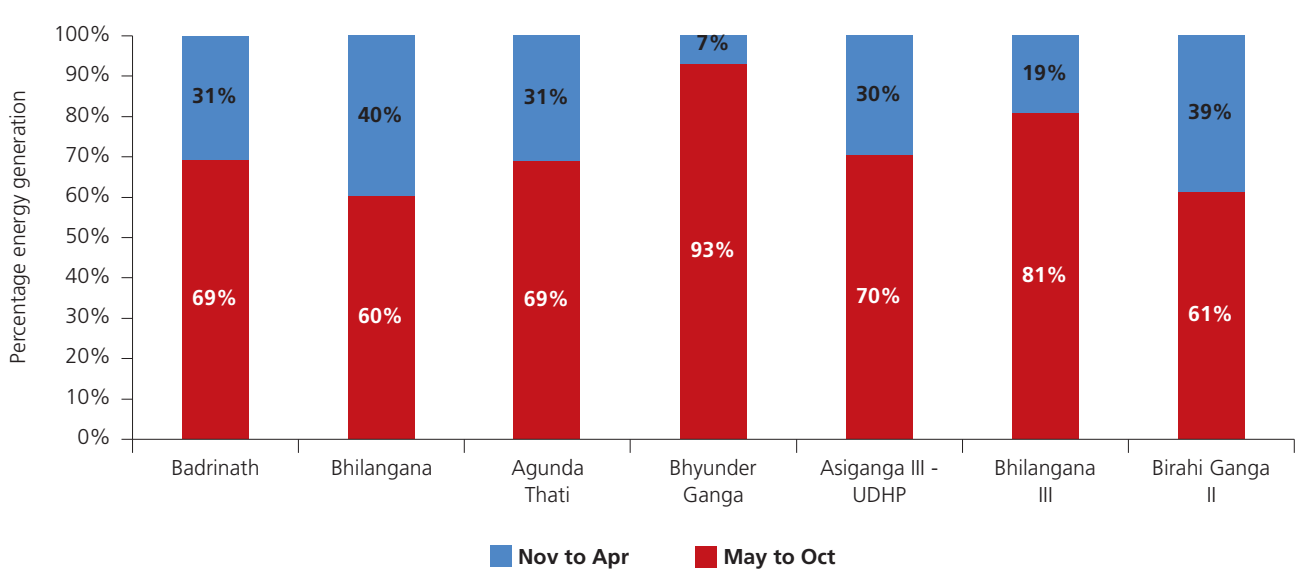
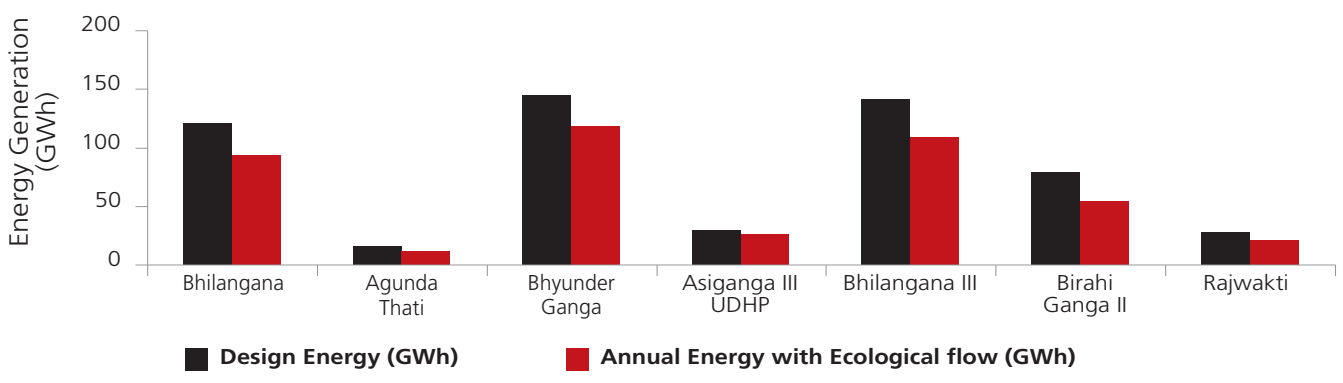


TABLE 2 Impact on energy generation and tariff due to 30-50% e-flow

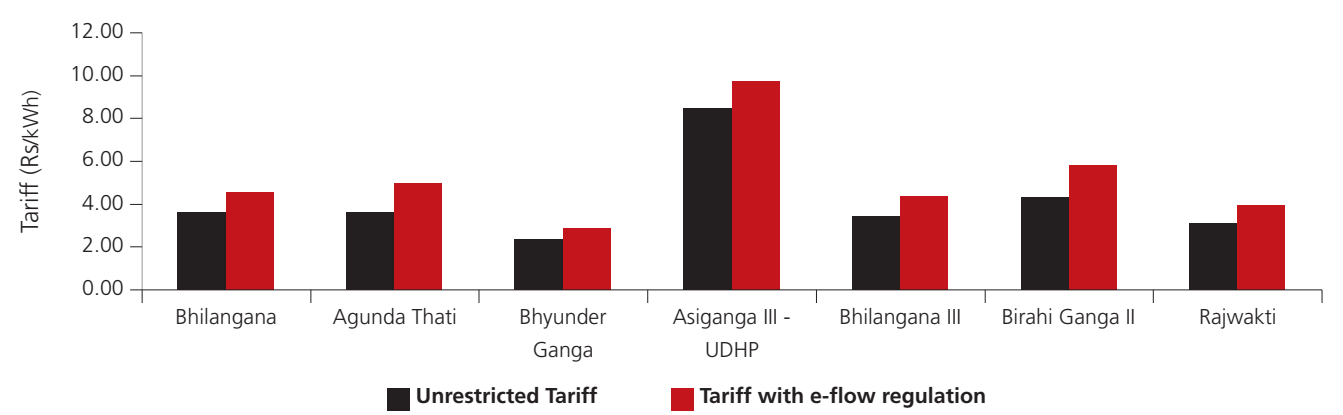
Name of project	IC (MW)	Design energy (GWh)	Annual energy after 30-50% EF (GWh)	% Decrease in energy after 30-50% EF	Tariff (Rs/kWh)				% increase in tariff after 30-50% EF
					Without EF		After 30-50% EF		
					I Yr	Levelised	I Yr	Levelised	
Bhilangana	22.5	121.11	93.31	23.0%	3.61	3.04	4.55	3.84	26.0%
AgundaThati	3	16.48	11.13	32.5%	3.62	3.04	4.96	4.17	37.0%
Bhyunder Ganga	24.3	144.68	118.24	18.3%	2.37	1.99	2.86	2.4	20.7%
Asiganga III - UDHP	9	29.74	25.94	12.8%	8.49	7.13	9.73	8.17	14.6%
Bhilangana III	24	141.32	108.95	22.9%	3.45	2.9	4.35	3.66	26.1%
Birahi Ganga II	24	78.97	54.71	30.7%	4.33	3.64	5.85	4.91	35.1%
Rajwakti	4.2	27.66	20.89	24.5%	3.08	2.58	3.94	3.3	27.9%
			Average	24%				Average	27%

Source: Analysis done by CSE

GRAPH 2 Energy generation under unrestricted flow and 30-50% e-flow



GRAPH 3 Current tariffs applicable and increase in tariff due to 30-50% e-flow



References

1. Varun *et al* 2012, 'Life cycle greenhouse gas emissions estimation for SHP schemes in India', *Elsevier*, Energy 44 (2012) 498-508
2. Anon, 'Sidrapong Hydel Power Station', Department of Power & Non-conventional Energy Sources, Government of West Bengal http://wbpower.nic.in/sidra.htm, as viewed on April 2, 2013
3. Anon, 'Achievements', Ministry of new and renewable energy, http://www.mnre.gov.in/ mission-and-vision-2/achievements/ website, as viewed on March 25, 2013
4. Anon, '(Draft) Twelfth Five Year Plan 2012-2017: Economic Sectors Volume 2', Planning Commission, p. 194, http://planning-commission.gov.in/plans/planrel/12thplan/pdf/vol_2.pdf, as viewed on April 10, 2013
5. MNRE further classifies plants up to 100 kW as 'micro-hydro' and plants between 100 kW and 2 MW as 'mini-hydro', http://www.mnre.gov.in/schemes/grid- connected/small-hydro/, as viewed on April 2, 2013
6. T Abbasi and S A Abbasi 2011, 'Small hydro and the environmental implications of its extensive utilization', *Renewable and Sustainable Energy Reviews* 15, 2011
7. Site visits by CSE researcher in Uttarakhand, January 2013
8. Analysis by CSE researcher on the line diagram of the Nagarjuna hydro project
9. Jed Brown *et al* 2013, 'Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from half-way technologies', *Conservation Letters,* January 16, 2013
10. Nachiket Kelkar, 'Thirsty Rivers, Bygone Fishes, Hungry Societies', South Asia Network Dams, Rivers and People, http://sandrp.in/rivers/Thirsty_Rivers_Bygone_Fishes_Hungry_Societies_Nachiket_Kelkar_Dec2012.pdf, as viewed on April 10, 2013
11. Dominique Egrea and Joseph C Milewski 2002, 'The diversity of hydropower projects', *Energy Policy* 30 (2002) 1225–1230
12. George Ledec and Juan David Quintero 2003, 'Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects', *Latin America and Caribbean Region Sustainable Development Working Paper 16,* World Bank, November
13. Robert Goodland, 1995, *How to distinguish better hydros from worse: the environmental sustainability challenge for the hydro industry*, The World Bank
14. Chris Lang 2001, 'Strangling the life-source of millions: China dams the Mekong', World Rainforest Movement, *WRM's Bulletin N° 46,* May
15. Edward Goldsmith and Nicholas Hildeyard, 'The effects of large-scale water projects on fisheries', as part of The Social and Environmental Effects of Large Dams: Volume 1, Overview., January 1984 http://www.edwardgoldsmith.org/1019/the-effects-of-large-scale-water-projects-on-fisheries/, as viewed on April 10, 2013
16. Anon 2011, *Assessment of cumulative impact of hydropower projects in Alaknanda and Bhagirathi basins up to Devprayag*, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, December.
17. Interview with Praveen Bhargav, Managing Trustee of Wildlife First and ex member of National Board for Wildlife, Bangalore, February 19, 2013
18. Planning and design of Asiganga-II and Asiganga-III small hydro power stations for tandem operation, http://2010.hidroenergia. eu/pdf/4B.06.pdf, as viewed on April 15, 2013
19. The usage of three lean months seem to be standard; it is however not mentioned in the hydro power policy of the state: (see clause xxxiv http://ireda.gov.in/writereaddata/compendium/HP/HPper cent20per cent20SHPupper cent20toper cent205per cent20MW-03.pdf)
20. Computed from 1994 data of Balloki and Sidhani headworks for three months of highest flow compared to three months of lowest flow, Waqar A Jehangir, Asad Sarwar Qureshi and Nazim Ali, 'Conjunctive Water Management in the Rechna Doab: An Overview of Resources and Issues', IWMI, 2002 http://www.iwmi. cgiar.org/Publications/Working_Papers/working/WOR48.pdf
21. R Kaur and T Kendall, 'Myth of power', *Down To Earth*, September 15, 2008, http://www.downtoearth.org.in/ node/4975
22. Anon, *Karnataka Renewable Energy Policy 2009-14*, KREDL
23. Shreekantha, 'Sahyadri e-news: Issue XVII', Energy & Wetlands Research Group, Centre for Ecological Sciences, IISc Bangalore, http://www.ces.iisc.ernet.in/biodiversity/sahyadri_enews/newsletter/issue17/main_index.htm, accessed on April 11, 2013
24. T P Nijish, 'Endangered fish found in Western Ghats', *The Times of India,* November 30, 2012, http://articles.timesofindia. indiatimes.com/2012-11-30/kozhikode/ 35483954_1_ralf-britz-aquarium-fish-puffer
25. Anon, 'Small Hydro', Karnataka Renewable Energy Development Ltd. http://www.kredltest.in/hydroreport.aspx, accessed on April 11, 2013
26. Anon, 'Dario urops: a new fish species from the Western Ghats', *Zoospooks*, June 14, 2013, http://ichthy. wordpress.com/2012/06/14/dario-urops-a-new-fish-species-from-the-western-ghats/
27. Latha Anantha and Parineeta Dandekar, '15 MW Barapole Small Hydel Project coming up in Western Ghats Biodiversity Hotspot, does not deserve CDM Credits', SANDRP, http://cdm.unfccc.int/ filestorage/q/z/JGLGXCFT76Q92TZCSLILZ7I9OTT816.pdf/Commentper cent20submittedper cent20byper cent20SANDRP.pdf?t= R218bWwzNWd0fDDizbFHRQoLaAXn—eo9zJM
28. Biju Govind, 'New freshwater fishes found in Western Ghats', *The Hindu*, October 30, 2010, http://www. hindu.com/2010/10/30/stories/2010103059770400.htm
29. Stanley Pinto, 'Expert pushes for more research in Western Ghats', *The Times of India*, March 30, 2012, http:/ /timesofindia.indiatimes.com/city/mangalore/Expert-pushes-for-more-research-in-Western-Ghats/articles how/19290357.cms
30. Interview with Professor Renee Borges at IISc Bangalore, Bangalore February 18, 2013
31. Pinaki Roy, 'Hilsa may go for good', *The Daily Star*, July 25, 2012, http://cmsdata.iucn.org/downloads/wedne_ sday_1.pdf
32. Sanjay Kumar, 'Himalayan dam-building threatens endemic species', *New Scientist*, December 21, 2012, http://www. newscientist.com/article/dn23033-himalayan-dambuilding-threatens-endemic-species.html
33. Parineeta Dandekar, Damaged Rivers, Collapsing Fisheries: Impacts of Dams on riverine fisheries in India', SANDRP, September 2012 http://sandrp.in/dams/Impacts_of_Dams_on_Riverine_Fisheries_in_India_ParineetaDandekar_Sept2012.pdf
34. K L Seghal, 'Coldwater fish and fisheries in the Indian Himalayas: rivers and streams', http://www.fao.org/ docrep/003/x2614e/x2614e04.htm, accessed on April 12, 2012
35. Gerd Marmulla ed, 'Dams, fish and fisheries: Opportunities, challenges and conflict resolution', http://www. friendsofmerrymeetingbay.org/cybrary/pages/20010000_UN_FAO_Dams,per cent20fishper cent20andper cent20 fisheries.pdf#page=6
36. *Ibid*
37. Annual 12th Five Year Plan, Working Group on Fisheries and Aquaculture
38. Tyson R Roberts, 'On the river of no returns: Thailand's Pak Mun dam and its fish ladder', NAT. HIST. BULL. SIAM SOC. 49: 189-230. 2001 http://www. thaiscience.info/journals/ Article/Onper cent20theper cent20riverper cent20ofper cent20noper cent20returnsper cent20thailandsper cent20pakper cent20 munper cent20damper cent20andper cent20itsper cent20fishper cent20ladder.pdf
39. Upali Ananda Amarasinghe, Tushaar Shah and R P S Malik, *Strategic Analyses of the National River Linking Project (NRLP) of India*, International Water Management Institute, 2009, Colombo, Sri Lanka
40. Interview with KREDL senior officer of hydro power at KREDL office in Bangalore, February 18, 2013
41. CSE field study, February 2012, visiting IPCL, Nagarjuna Hydro Energy Project, Paschim Hydro Energy project and Maruthi Gen Hydro project.
42. Anon, *KERC Thirteenth Annual Report 2011-12*
43. This is calculated considering 30 per cent CUF for 900 MW of SHP installed in Karnataka. This is a good approximation based on generation analysis for all the projects during 2011 and 2012.
44. Parineeta Dandekar, 'Impacts of Dams on Biodiversity: Need for Urgent Collaborative Action', SANDRP, December 2012, http://sandrp.in/rivers/Damned_Biodiversity_Presentation_Indian_Biodiversity_Congress_December2012.pdf
45. CSE field study, February 2012, visiting IPCL, Nagarjuna Hydro Energy Project, Paschim Hydro Energy project and Maruthi Gen Hydro project.

46. Discussion with forest officials of Sakleshpur taluk and with engineers of IPCL and Nagarjuna Hydro projects
47. Interview with Dr T V Ramachandra, IISc Bangalore, February 18, 2013
48. Anon, 'Mining, encroachment major threat to Western Ghats: IUCN', *Business Standard*, December 24, 2012, http://www. business-standard.com/article/pti-stories/mining-encroachment-major-threat-to-western-ghats-iucn-112122400454_1.html
49. Anon, 'Proceedings of the meeting with regard to implementation of works related to Mini Hydel Power Project & Wind Power Projects and Stone Quarrying activities in the Western Ghats under the chairmanship of Principal Secretary to Government, Forest Environment and Ecology Department on 23.06.2011 at 11.30 AM', Government of Karnataka
50. Abhinav Goyal, 'Kerala overlooks environmental aspects of proposed small hydropower plants', *Down To Earth*, March 29, 2013, http://www.downtoearth.org.in/content/kerala-overlooks-environmental-aspects-proposed-small-hydropower-plants
51. Interview and site visits to Gundia area with Kishor Kumar, president, Malenadu Janapara Horata Samiti, Sakleshpur taluk and Gundia, Hassan district, February 21-22, 2013
52. Interview with R Rudraiah, managing director, Karnataka Neeravari Nigam Limited, Bangalore, February 28, 2013
53. Anon, 'Per Capita Power Consumption', Press Information Bureau, May 18, 2012, http://pib.nic.in/newsite/erelease.aspx? relid=84206 (note that these figures are three years old)
54. 2011 census source: http://www.censusindia.gov.in/ 2011-prov-results/paper2/data_files/karnataka/3-figure-7.pdf
55. Analysis by CSE on the data available from MNRE
56. Anon, Policy for harnessing renewable energy sources in Uttarakhand with private sector/community participitation, 29.1.2008
57. Performance Audit of Hydropower Development Through Private Sector Participation, Uttarakhand for the year 2008-09, Comptroller and Auditor General of India, http://cag.gov.in/ html/cag_reports/uttranchal/rep_2009/pa_cont.htm
58. Report of Working Group to advise WQAA on the minimum flows in the rivers, Government of India, ministry of water resources, Central Water Commission, July 2007.
59. Performance Audit of Hydropower Development Through Private Sector Participation, Uttarakhand for the year 2008-09, Comptroller and Auditor General of India
60. *Ibid*
61. Anon, Report of the Inter-Ministerial Group on issues relating to River Ganga, April 2013
62. This is based on field visits to Kaliganga I and II power plants during the month of January 2013 and the EIA document
63. Personal communication with Dr Arun Kumar, AHEC, IIT Roorkee during January 2013
64. Interview with K Ramesh, senior officer, KREDL, Bangalore, January 18, 2013
65. Interview with Nagaraj, associate director, Fisheries Department, Bangalore, February 28, 2013
66. Interview with R Rudraiah, managing director, Neeravari Nigam Ltd
67. Anon, 'Government Order No. FEE 132 ECO 2011, Bangalore Dated 17.10.2012', Government of Karnataka
68. No. FEE 137 ECO 2011 Issue of Environmental Clearance to M/S Flax Hydro Energy (1.5 MW) - 03.11.2012/ No. FEE 121 ECO 2012 Issue of Environmental Clearance to M/s Rising Sun Power (2 MW) - 15.12.2012/ No. FEE 5 ECO 2011 Renewal of Environmental Clearance for Pioneer Power Corporation (24.75 MW) - 07.02.2011 All obtained from Department of Ecology and Environment, Government of Karnataka, Bangalore, February 2013
69. Interview with senior scientific officer, Department of Ecology and Environment, Bangalore, February 20, 2013
70. Interview with K M Lingaraju, senior officer, Karantaka State Pollution Control Board, Bangalore, February 19, 2013
71. http://moef.nic.in/divisions/forcon/forms.htm, accessed on April 15, 2013
72. Interview with Deputy Conservator of Forests, Karnataka Forest Department, Bangalore, February 19, 2013
73. *Ibid*
74. Anon, 'Proceedings of the meeting with regard to implementation of works related to Mini Hydel Power Project & Wind Power Projects and Stone Quarrying activities in the Western Ghats under the chairmanship of Principal Secretary to Government, Forest Environment and Ecology Department on 23.06.2011 at 11.30 AM', Government of Karnataka
75. Discussion with Executive Engineer, Uttarakhand Jal Vidyut Nigam limited (UJVNL), Dehradun, Uttarakhand
76. The CAG audit sample has seven SHP projects of the eight project considered. Performance Audit of Hydropower Development Through Private Sector Participation, Uttarakhand for the year 2008-09, Comptroller and Auditor General of India
77. Anon, 'Terms of Reference for the Preparation of Environmental Impact Assessment [EIA] Report and Environment Management Plan [EMP] On Hydro Electric Projects for Consideration by State Expert Appraisal Committee in Himachal Pradesh', MoEF
78. South African National Environmental Management Act (1998), Government of South Africa, http://www.info. gov.za/view/DownloadFileAction?id=70641
79. Anon, 'List of activities and competent authorities identified in terms of section 24 and 24(d) of NEMA 1998', Department of Environmental Affairs and Tourism, April 21, 2006, http://www.enviroleg.co.za/acts/Nationalper cent20Environmentalper cent20Management/REGS/ 387-06per cent20Listper cent20ofper cent20Activitiesper cent20andper cent20Competentper cent20Authorities.pdf
80. http://www.dwaf.gov.za/Documents/Legislature/ nw_act/NWA.pdf
81. http://www.moef.nic.in/legis/water/wat1c5.html

Box: **Two projects on paper, one on the ground: how to avoid EIA in Karnataka**

1. Interview with senior official, Karnataka Forest Department, Bangalore, February 28, 2013
2. Project Design Document for 24.75-MW Ranganathaswamy Mini Hydel Project, Karnataka, India
3. Anon, 'Small Hydro', Karnataka Renewable Energy Development Ltd, http://www.kredltest.in/hydroreport.aspx, accessed on April 11, 2013
4. Interview and site visits to Maruthi plant with Kishor Kumar, president Malenadu Janapara Horata Samiti and Forest Department officials, Sakleshpur taluk, Hassan district, February 21, 2013
5. Sanjay Gubbi, 'Gone Missing', December 21, 2011, http://sanjaygubbi.blogspot.in/2011_12_01_archive.html
6. Panduranga Hegde, G L Janardhana and Parineeta Dandekar, "Halt small hydel projects pending review, regulatory mechanism', ESC, SANDRP, SWGM, August 8, 2012
7. Site visit on February 23, 2013 (access to the plant was denied)
8. Anon, 'Small Hydro', Karnataka Renewable Energy Development Ltd, http://www.kredltest.in/hydroreport.aspx, accessed on April 11, 2013

Box: **The Boston Mini-Hydro project on the As river**

1. http://aurecon.webfoundryza.com/assets/files/Boston%20Hydro/ EIR_Draft_21092011%20Ver%200%202_No%20Images.pdf, accessed on April 29, 2013
2. Anon, 'Environmental impact assessment for Dhamwari Sunda HE Project', International Testing Centre, http://moef.nic.in/ divisions/iass/Ex-Sum_Dham.pdf

Annexure 1: **The economics of small hydro power in Uttarakhand**

1. Investopedia
2. Investopedia
3. Vanala small scale hydro power Validation report available at UNFCCC website, http://cdm.unfccc.int/Projects/DB/SGS-UKL1300101472.3/view, accessed on May 15, 2013
4. Information received through Right to information Act, 2005 from Uttarakhand Power Corporation Limted (UPCL) and Himurja, the project developer
5. Appendix 2-IRR Vanala 15 MW, available online https://cdm.unfccc.int/Projects/DB/SGS-UKL1300101472.3/view accessed on May 15, 2013; Bhilangana tariff figure assumed from UERC Regulation, 2006

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi – 110 062
Tel: 91-11-29955124, 29956110, 29956394 **Fax:** 91-11-29955879
Email: cse@cseindia.org Website: www.cseindia.org