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Green Growth and Hydro Power in Himachal Pradesh

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Table of Contents

List of Tables

1. Introduction

Hydropower is the second most important source of energy and accounts for 16.9% of the total installed capacity of 237742.94 MW as on 28th Feb, 2015 (CEA, 2014). India accounted for 4.4% of the global installed capacity and ranked 6th in the list of global nations for hydropower capacity and generation with a net installed capacity to the tune of 43.7 GW (REN 21, 2014). The importance of hydropower has gained wide popularity with the focus of moving away from fossil fuel generation dependence. Hydropower is considered a cleaner and greener source for generation of electricity compared to other energy sources. The significance of hydropower generation is described briefly below.

Hydropower is unique as it is a clean source of energy, renewable and green as compared to fossil fuel generation power plants. It does not cause air pollution nor does it burn any fuel with near zero emissions. Hydropower is relatively cleaner as compared to other sources of energy and the emission rate per unit of electricity generated from hydropower excluding tropical reservoirs is way below than emission rates for fossil fuel technologies (Steinhurst, Knight, & Schultz, 2012). In comparison to other renewables on a life cycle basis, GHG emissions release from hydropower is lesser relative to that of electricity generation from biomass and solar. The emissions are almost equivalent to those from wind, nuclear and geothermal power plants. Since hydropower generation does not require burning or combustion of any fuels, the cost of operation are not susceptible to market price fluctuations.

Unlike other sources of energy, hydropower generation provides an abundance of unique benefits which can be those emanating from the generation of electricity itself or from side benefits associated with hydropower reservoirs. Such benefits can include a secure water supply, irrigation and flood control including increased navigation and increased recreational opportunities. There can be scope for development of fisheries and cottage and small scale industries. Multipurpose hydropower projects also help in subsidizing other major features of the project such as those indicated above. In spite of recent debates sparking greenhouse gas emissions from reservoir based hydropower projects, hydropower generation is still a relatively cleaner source of energy in comparison to fossil based generation

2. Hydropower in Himachal Pradesh

2.1 Hydropower development

Hydropower exploitation in Himachal Pradesh began even before it was a full-fledged state with the commissioning of a 0.45 MW HEP by the Raja of Chamba in 1908. There were couple of other small projects that were executed like the 110 MW Shanan HEP in mandi district and the 60 MW HEPs each of Bassi and Giri (Department of Environment, Science and Technology, Government of Himachal Pradesh, 2005). In the late 50's and early 60's, the ersthwhile Punjab government started the construction of Shansha and Billing HEPs in Lahaul and Spiti.

2.2 Hydropower Potential

Himachal Pradesh has a generation potential of 23 GW as per preliminary hydrological, topographical and geological investigations and out of which only 8432.47 MW has been exploited by various agencies across the state which also include 477.50 MW by HPSEBL[1]. Five major snow fed rivers emanating from the Western Himalayas flow within Himachal Pradesh include Ravi, Chenab, Satluj, Beas and Yamuna. These snow-fed rivers and their tributaries carry abundant discharge all the year round which can be exploited for power generation. The basin wise capacities have been indicated in the table 1 below:

Table 1 The basin wise capacities of Himachal Pradesh

Name of Projects	Capacity (MW)
Yamuna	794
Satluj	10,226
Beas	5,721
Ravi	2,912
Chenab	3,037
Self-Identified / New Identified	310
Total	**23,000**

Source: (Economics and Statistics Department, Government of Himachal Pradesh, 2014)

Out of the total identified hydropower potential for the state, 3783 MW has been allotted to the state agents namely, HPSEBL/ HPPCL[2] while 9089 MW has been allocated to Central actors and Joint venture route while the remaining has been assigned to the private sector for development and construction as indicated in the table 2 below.

[1] Himachal Pradesh State Electricity Board Limited
[2] Himachal Pradesh Power Corporation Limited

Table 2 Total identified hydropower potential in Himachal Pradesh (in MW)

Sr. No.	Particulars	State Sector HPSEBL/ HPPCL (MW)	Central/Joint Sector/HP Share (MW)	Private Sector		Total (MW)
				Above 5MW	Upto 5 MW (through HIMURJA)	
1.	Projects Commissioned	478	5,903	1,829	222	8,432
2.	Under Execution/ Construction	966	2,532	765	179	4,442
3.	Under Implementation/ Obtaining Clearance	1,285	66	866	365	2,582
4.	Under Investigation	1,034	588	3,340	510	5,472
5.	Under Litigation/ dispute	--	--	1,007	--	1007
6.	Abandoned schemes in view of environmental & social concerns	20	--	735	--	755
7.	To be allotted	--	--	310	--	310
	TOTAL	**3,783**	**9,089**	**8,852**	**1,276**	**23,000**

Source: (Economics and Statistics Department, Government of Himachal Pradesh, 2014)

3. Policy interventions

The HP state government formulated the Hydro Power Policy in 2006 to accelerate the growth of the sector with a more inclusive growth and strengthen local participation in project execution, operation and maintenance. In line with the National Hydropower policy 2008, the state government have introduced a provision where hydropower developers shall provide an additional free power post the commissioning of the HEPs at the rate of 1% of the generated energy from all hydel power projects which would be earmarked for Local Area Development Fund (LADF). The fund would be available in the form of free power as an annuity over the entire project life and contribute towards upliftment of the local population in the project affected areas. Prior to the commissioning of the project, the developer will make a provision of 1.5% of final cost of the project towards LADF for projects more than 5MW capacity and a minimum of 1% in case of projects with capacity up to 5MW. The policy states reservation for employment for bonafide Himachalis with respect to unskilled/ skilled and other no-executive staff according to the requirements of the project operation. The state government has also stipulated a 15% minimum release for discharge of in the case of Run-of-the river (ROR) projects. The state government has also initiated cumulative impact assessment for the Satluj basin in a phased manner for all the river basins in the state to evaluate the aggregate environmental impact of hydropower projects planned on various rivers and its tributaries.

On the recommendations of the Committee of Himachal Pradesh Electricity Regulatory Commission (HPERC), amendments were made to the HP Hydro Power Policy 2006 to accelerate the growth of hydropower development in the state through simplification of No-objection certificates (NOC) procedures and simplification of statutory and non-statutory clearances. The new amendments provide regulatory support by rationalizing wheeling tariff to provide a level playing field to all hydropower generators across the state. In order to ease liquidity, the commission will determine two separate sets of levelised tariff i.e.one for first 5 to 10 years which may be higher and the second for the remaining period. The consent to operate for small hydro generation can be given once for the entire life of the project with facilities of concessional fees for projects up to 2MW.

4. Interventions for Green Growth

The major advantage in hydro power is the lack of emissions to the atmosphere during its fuel cycle as compared to other fossil fuels. But there are other negative externalities emanating from hydro projects which are related to the social, environmental, economic and cultural aspects of the local communities where the projects are located. Hydro power projects cause serious impact on the aquatic and riparian eco-systems through modifications and habitat destruction. They alter the bio-physical quality of ecosystems resulting in the loss of biodiversity, and other ecological functions, impacting the livelihood of people dependent on the ecosystems. (Rajashekariah, Kaushal, & Bhowmik, 2012). However, governments – both the state as well as the centre - in India have been cognizant of these problems and initiated several initiatives to limit the impact of these negative externalities which could be classified as good practices or 'green' initiatives. The following section explores some such initiatives undertaken by hydro project developers as well as the state governments.

4.1 Clean Development Mechanism

The Clean Development Mechanism (CDM) was developed as part of the Kyoto protocol and aimed as a means of allowing countries not part of the Annex I to achieve sustainable development and contribute to the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCC) (Slariya, 2012). This was a means to abate the monetary costs of curbing emissions. This mechanism enables Annex I countries to substitute their own emissions by purchasing carbon credits from climate protection projects in Non-Annex I countries.

Developers of hydropower projects must show that their projects will only be realised through the additional income generated from the sale of carbon credits. In keeping with this goal a number of hydroelectric projects in India aim to seek carbon credit under this mechanism as carbon-offsetting projects. There are 57 projects in Himachal Pradesh that have applied for CDM status as on June 29, 2011 (Yumnan, 2013). For example, the 192 MW Allain Duhangan project in the district of Kullu is expected to generate almost 500,000 certified emission reductions (CER) per annum (approximately revenue of $7 mn) which will be sold to the Italian Carbon Fund. Similarly the 1000 MW Karcham Wangtoo dam on the Sutlej river in the Kinnaur district will generate 3.5 mn carbon credits (approximate revenue of up to $ 50 mn) which will be sold to various buyers in Annex I countries (Erlewein & Nusser, 2011).

Table 3 Projects applied for CDM in Himachal Pradesh

Project	Capacity (MW)
Karcham Wangtoo	1000
Rampur	412
Allain Duhangan	192
Sawra Kuddu	111
Sorang	100
Malana II	100
Budhil	70
Chanju	36
Kut	24
Patkari	16
Neogal	15

Source: (Erlewein & Nusser, 2011)

4.2 Compensatory Afforestation Fund Management and Planning Authority

As per the provisions of the Forests (Conservation) Act, 1980, the hydro developer has to strictly comply with the statutory regulations of the act. Hydropower developers have to bear the cost of raising the compensatory afforestation (CA) including payment of the Net Present Value (NPV) of the forests land being diverted for non-forest purpose under the relevant Forests (Conservation) Act, 1980 and Environmental Protection Act, 1986 which are to be deposited with the Compensatory Afforestation Fund Management and Planning Authority (CAMPA). CAMPA works as the National Advisory Council under the chairmanship of the Union Minister of Environment & Forests for monitoring, technical assistance and evaluation of compensatory afforestation activities. The primary purpose of compensatory afforestation is to make up for the diversion of forest land proposed to be utilized for construction of the proposed hydroelectric projects. CA will also help in maintaining and improving the ecological and environmental balance and promote afforestation and prevent soil erosion. Moreover, if forest land has been used then, compensatory plantation has to be established on a degraded forest land which must be twice the size of the forest land used for the construction of the project. Compensatory afforestation also includes activities such as soil conservation, fencing, protection, monitoring and evaluation along with maintenance for a 5-year period along with protection of surrounding forests. For the year 2012-13, Himachal Pradesh had an approved Annual Plan of Operation (APO) of Rs. 62.16 crores against which it received Rs. 52.40 crores against which an annual expenditure Rs. 47. 23 crores was reported. For the year 2013-14, the Adhoc CAMPA had agreed to release Rs. 53.50 crores (HP State CAMPA, 2013).

Table 4 Sector-wise break-up of Approved APO for 2012-13 for Himachal Pradesh

Sector	Approved APO (Rs. Cr)	Funds Received from Adhoc CAMPA (Rs. Cr)	Expenditure (Rs. Cr)
NPV	19.00	52.40	11.26
CA	6.70		6.10
CAT Plan	26.70		21.35
RIM Plantation	5.02		3.07
WL Schemes	4.24		2.98
S&WC Schemes	0.32		0.26
Reclamation Plans	0.18		0.00
Total	**62.16**	**52.40**	**45.02**

Source: (HP State CAMPA, 2013)

4.3 Catchment Area Treatment & Sedimentation Removal

Hydro power projects cause large-scale changes in the catchment area altering the ecosystem. Thus Environment Impact Assessment (EIA) report along with a set of plans which form the Environment Management Plan (EMP) includes the catchment area treatment plan in addition to other components such as biodiversity conservation plan, fisheries management plan, R&R plan, economic rehabilitation plan among others. The stated objective of the Catchment Area Treatment (CAT) plan is to reduce the inflow of silt into the reservoir, conserve soil and minimise run-off. For example, the Ganga-Brahmaputra river system carries a billion tonnes of sediment annually, which is 8% of the total sediment load reaching the global oceans and the highest sediment load of any river system in the world. Moreover, studies have shown that the siltation rates in 21 Indian river valley projects were 182% higher than originally estimated (Thadani, 2006).

Reservoirs are subjected to sedimentation which embodies the sequential process of erosion, entrainment, transportation, deposition and compaction of sediment. (Government of Uttarakhand, n.a.). The deposition of sediment not only reduces the capacity and the lifespan of a reservoir but also impacts water availability. It is generally believed that sediment coarser than 0.20 mm in size is harmful for turbine blades and will thus have to be eliminated from power channels (Raju & Kothyari, 2004). The annual loss of storage in reservoirs due to sedimentation is about 1% corresponding to about 50km worldwide (Boroujeni, n.a.). Moreover, erosion of the sediment on the banks of streambeds and banks causes braiding of the river.

Various measures are put in place to manage sedimentation. Chief among them is watershed rehabilitation, sediment flushing, sediment routing and sediment removal and disposal. Watershed rehabilitation which essentially looks at soil conservation strategies including structural measures such as terraced farmlands, flood interceptions and diversion works, bank protection works, gully head protection, silt trapping dams; vegetative measures such as afforestation, rotation cropping, no-tillage farming among others. Sediment flushing essentially involves opening up the dam’s bottom outlets and allowing the accumulated sediment to be re-suspended and flushed out (Pande, 2015). However, apart from consuming lot of water, flushing is ideally not recommended due to its environmental impacts on fish gill clogging, changes in riverine habitats, clogging of agriculture fields, and reduced dissolved oxygen, among others. Sediment routing can be done in two ways. One is channelling sediment-heavy flows into a tunnel to avoid serious damage to the reservoirs and then using diversion methods (warping) to fill low lands and improve the quality of salinized land (Boroujeni, n.a.).

Typically, CAT plan accounts for 60% or more of the total EMP budget and 0.5-2.55% of the total project cost. CAT plans are project-specific and use different approaches to curb soil erosion and implement eco-restoration plans. Developers also use the Silt Yield Index (SYI) developed by the All India Soil and Land Use Survey (AISLUS) as part of the plan, since it provides a comparative erodibility criteria of the catchment but not the absolute silt yield. Once the CAT plan has been approved by the Impact Assessment Department of the MOEFCC, funds are released by the Adhoc authority to the state CAMPA depending on the APO provided by the Forest Division of that particular state. Table 5 and Table 6 is an example of the break-up of the cost – both biological as well as engineering - required for CAT for the Vishnu Pipalkoti Hydroelectric project.

Table 5 Cost estimate for CAT- Biological Measures (Vishnu Pipalkoti HEP)

Item	Rate (Rs.)	Target	
		Physical	Financial (Rs. Mn)
Plantation (800ha.)	25000/ha.	364ha.	9.10
Pasture Development	10000/ha.	280ha.	2.80
Social Forestry	25000/ha.	60ha.	1.50
Fuel wood and fodder	10000/ha	60ha.	0.60
Nursery Development	200000/no.	5	1.00
Maintenance of Nursery	100000/no.	5	0.50
Barbed wire fencing	100000/km	5 km.	0.50
Watch and ward for 3 years for 10 persons	5000/man/month	360 man month	1.80
		Total	**17.80**

Table 6 Cost estimate for CAT - Engineering Measures (Vishnu Pipalkoti HEP)

Item	Rate (Rs.)	Unit	Quantity		Target
				Physical	Financial (Rs. Mn)
Step Drain	2500 RMT	25 RMT	20	500 RMT	1.25
Check Dams	20000	-	20	20	4.00
Contour Bunding	25000/ha.	Ha.	15	15	0.38
				Total	5.63
Total Cost (Biological + Engineering measures)					**23.43**

A typical CAT plan will include compensatory afforestation for the loss of forest land to cover denuded slopes, biodiversity and wildlife conservation, managing environmental damage during construction, maintaining the quality of water, sustaining and enhancing the potential for fisheries and developing tourism as a means of providing alternate livelihood. A report by R. Thadani (2006) has found discrepancies in the manner CAT plans are implemented. For example, he states that a number of CAT plans are not based on ground reality, focus excessively on engineering solutions, do not implement biological solutions adequately, do not consider the impact on local communities and have weak monitoring mechanisms. Some of these points stand corrected while some others were corroborated when the authors of this paper went on a few field visits to Himachal Pradesh. For example, at the Kashang Hydroelectric project, regular public hearings with the Sub-divisional magistrate had been held such that the villagers were aware of the CAT Plan, but stated that their suggestions had not been incorporated in the plan. Moreover, since the project is still in the construction stage, muck continued to be deposited alongside the road or by the bank of the river. But other recent reports (Rajashekariah, Kaushal, & Bhowmik, 2012) suggest that a few hydroelectric developers are providing a number of benefits to the local community including subsidised electricity (Baira Sual HEP) and employment generation (Allain Duhangan HEP), planting 4.58 million saplings on a 2000 ha. in lieu of 982.5 ha of forest land lost for project construction as well as a fish farm, (Chemera HEP), among others.

4.3.1 Muck Management Plan

Constructing different components of the hydropower projects includes both surface as well as underground excavation and tunnelling leading to huge quantities of overburden and rock i.e. muck. Muck disposal has to be planned scientifically to designated areas so that it doesn’t interfere with either the environment or the ecology, nor does it impair the river flow regime or the quality of the water. The designated sites must be planned keeping in mind the nearness of the generating component and interference with either surface river flows or impact on ground water aquifers. A lot of hydro developers utilize a portion of this muck during construction activities itself. In fact state hydro policies including Himachal Pradesh (Hydro Power policy, 2006) have stipulated that the muck generated from the construction of a hydro power plant shall be used by the company for project activities and the remaining material can be used by other development departments like the state PWD.

4.3.2 Fisheries Management

Large scale construction of hydropower dams in India has impacted marine life, in particular movement by riverine fishes. Indian rivers hold close to 700 fish species and the highest fish endemism in Asia. The physical impact of dams like hydrological modification, loss of connectivity, drying up of downstream rivers, submergence, blocking migration paths, reduced nutrients, concentrated pollutants, changes in salinity etc have impacted fishing livelihood, and the diversity of fish species to a great extent (Dandekar & Thakkar, 2015).

EIA reports though do speak about fishery management by construction of fish ladders wherever possible to enable migration of fishes promote reservoir fisheries, but in practice it is rarely implemented. There are some examples of a fish farm at Chemera, the Pong reservoir which is the only reservoir to provide for Masheer angling, a trout farm at Parabati II but such examples are few and far between and more initiative needs to be taken on this front.

4.3.3 Environmental flow requirement

Of all the environmental changes wrought by dam construction and operation, the alteration of natural water flow regimes has had the most pervasive and damaging effects on river ecosystems and species (Richter & Thomas, 2007). When large dams block the flow of a river, they also trap sediments and nutrients vital for fertilizing downstream plains. They alter the natural flow regimes which drive the ecological processes in downstream areas. Quite literally they disrupt the connections between the upstream and the downstream, between a river and its floodplain (Vagholikar, 2011). In order to meet the requirement of downstream life forms and amenities like drinking water, fisheries and riparian right obligations etc, a minimum flow requirement is guaranteed. The Himachal Hydropower policy of 2006 also states that in case of RoR schemes, a minimum flow of 15% water immediately downstream has to be maintained including guaranteed provisions of water requirement during the lean season. For example, the Karcham Wangtoo project has built into its design, provisions for ensuring the mandatory 15% flows; provisions also exists for accessing real-time flows data through the project website (Rajashekariah, Kaushal, & Bhowmik, 2012). But Himachal Pradesh is only state to introduce general terms for minimum environmental flows.

5. Ways forward

Timeline	Issue	Recommendation
Short term (2020)	Misuse/ diversion of funds under LADF	Fund management under the *gram panchayat* along with regular auditing conducted by an independent body 9stat eor central)
	Ratio of non-forest land demarcated for CA lesser than deemed by law	Monitoring authority for compliance and stricter laws for non-compliance
	Non-recovery/ under assessment of NPV and CA funds	Centralised database of well-investigated projects with the amount of NPV and CA to be deposited by the user agency as mentioned in the EIA Stricter penal provision Creating a portal for states to file information on fund utilization NPV and CA funds to be distributed as per geography, topography and location
	Skewed EIA reports which under-estimate ecological and social risks	Catalogue greenfield and brownfield land banks along with the accompanied flora and fauna specimens to use as a reference for project-based EIA reports
	Violation of principles of social justice	Advocating and overseeing benefit-sharing contracts between project developers and PAFs
Medium term (2030)	Ratio of non-forest land demarcated for CA lesser than deemed by law	Monitoring authority for compliance and stricter laws for non-compliance
	Skewed EIA reports which under-estimate ecological and social risks	Catalogue greenfield and brownfield land banks along with the accompanied flora and fauna specimens to use as a reference for project-based EIA reports
	More efficient use of land and water resources in the face of competing demands which may also involve trade-offs.	Pre-emptive measures including creation of a river basin-based authority for dams management within the basin Integrated approach towards benefit-sharing of resources instead of reimbursement on project-specific basis Integrated approach includes fostering local industries like tourism (around the dam area) and fisheries Building multi-purpose dams to enhance irrigation facility in the country
Long term (2050)	Decommissioning of dams	Delay the decommissioning of dams via retrofitting the infrastructure as also, alternative designs to increase the shelf life Also look to create policy and institutional mechanisms to reduce the divergence between the designed and the actual dam life

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A unique developing country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. TERI has grown to establish a presence in not only different corners and regions of India, but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia, and the Gulf.

TERI possesses rich and varied experience in the electricity/energy sector in India and abroad, and has been providing assistance on a range of activities to public, private, and international clients. It offers invaluable expertise in the fields of power, coal and hydrocarbons and has extensive experience on regulatory and tariff issues, policy and institutional issues. TERI has been at the forefront in providing expertise and professional services to national and international clients. TERI has been closely working with utilities, regulatory commissions, government, bilateral and multilateral organizations (The World Bank, ADB, JBIC, DFID, and USAID, among many others) in the past. This has been possible since TERI has multidisciplinary expertise comprising of economist, technical, social, environmental, and management.

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