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Offsetting Greenhouse Gas Emissions in the Himalaya? Clean Development Dams in Himachal Pradesh, India

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The carbon-offsetting scheme Clean Development Mechanism (CDM) has evolved into one of the most important instruments for the funding of renewable energy projects in mountain regions in developing and newly industrializing countries. The CDM allows industrialized states to compensate for greenhouse gas emissions by investing in climate change mitigation activities abroad. These offsetting projects are intended to avoid emissions while simultaneously contributing to sustainable development at the local level. The most common project type under the CDM is hydropower, with the majority of projects being located in the mountain areas of China and India. However, doubts about the scrutinizing methods of the CDM as well as the often controversial impacts of dam building on mountain environments and communities raise questions about the ability of these "clean development" dams to serve as a sustainable means of mitigating climate change. The objective of the present article is to assess the effectiveness of large CDM hydropower projects in the Indian state of Himachal Pradesh. Analysis of planning documents and expert interviews revealed that "clean development" dams in the Himachal Himalaya fall short of achieving the goals of the CDM. Most projects are not in a position to compensate for emissions because they would have been built even without CDM support. Furthermore, it is arguable whether CDM dams contribute to sustainable mountain development, because the consequences of their construction are the same as for many other ordinary large dams, that is, environmental damage and conflicts that arise from the reallocation of land and water resources. Our results suggest that the promotion of large hydropower projects through the CDM in its current form is a highly ambivalent strategy. Shortcomings in the regulatory framework of the CDM may be undermining the environmental and social integrity of the CDM at both the global and local levels.

Keywords: *Hydropower; renewable energy; climate change mitigation; carbon offsetting; sustainability; Clean Development Mechanism (CDM); Himachal Pradesh; India.*

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Introduction

Discussions about mountains and climate change are characterized by a clear focus on the impacts of global warming on high altitude environments and on the respective adaptation strategies of mountain dwellers. Mountains are considered to be "among the regions most affected by climate change" (Kohler et al 2010: 53) and are described as "laboratories" in which the effects of changing thermohygric conditions can be witnessed more clearly than in less climate-sensitive regions (Carey 2007). However, mountains also are playing an increasingly important role in the realm of climate-change mitigation. The need to reduce greenhouse gas (GHG) emissions and the growing energy demands of newly industrialized and developing countries are leading to increased interest in the potential of mountain areas to generate renewable energy. On the one hand, this trend can be seen in the development of small-hydropower, biomass, and wind power projects that feed into decentralized electricity grids for local consumption. On the other hand, it is also leading to a renaissance of large-scale hydropower dams that supply surrounding lowlands with low-carbon energy. After decades of decline, there has been a rise in recent years in the construction of new dams, and "climate change is now a greater driver of hydropower expansion" (Moore et al 2010: 9).

This trend is most evident in the promotion of hydropower dams as carbon-offsetting projects. The Kyoto Protocol's Clean Development Mechanism (CDM) recognizes hydropower as a means of sustainable climate change mitigation and supports dam building in the global south through the allotment of tradable carbon credits. The majority of "clean development" dams are being built in the Himalayan regions of China and India, where great relief energy and high runoff rates provide ideal conditions for dam building, and energy demand in adjacent agglomerations is soaring. At the same time, the

CDM in general and "clean development" dams in particular are being subjected to severe criticism. Whereas some scholars and environmental activists question the concept of carbon offsetting in principle (Lohmann 2006; Böhm and Dabhi 2009; Gilbertson and Reyes 2009), reformist critics maintain that current directives for the accreditation and monitoring of CDM projects cannot ensure that CDM projects actually contribute to emission avoidance and sustainable development (Schneider 2007; Streck and Lin 2008; Paulsson 2009). Furthermore, it is argued that the often adverse impacts of dam building, in terms of environmental damage, and conflicts over the reallocation of land and water resources disqualify dams for support as a means to foster sustainable development (McCully 2001; Haya 2007). However, in contrast to the steadily rising number of CDM hydropower projects, there is still little on-the-ground research that can inform this discussion with empirical evidence (Mate and Yasmin 2009; Finley-Brook and Thomas 2010; Fletcher 2010). Against this background, the objective of the present article is to empirically assess the effectiveness of large "clean development" dams in the Indian state of Himachal Pradesh with respect to the dams' contribution to the CDM goals of climate protection and sustainable development.

Carbon offsetting in the Himalaya

Offsetting GHG emissions abroad has become a constituent component of market-oriented climate governance. Given that the monetary costs of emission abatement differ greatly, the outsourcing of climate protection activities to low-cost countries could significantly reduce the expenses of avoiding GHG emissions (Bumpus and Liverman 2008; Streck 2004). As part of the Kyoto Protocol's "cap and trade" approach to climate change mitigation, the CDM aims to make use of this comparative cost advantage. It enables industrialized signatory states (Annex I countries) to substitute their own emission reduction efforts by purchasing carbon credits, so-called certified emissions reductions (CER), from climate protection projects in newly industrializing and developing countries (Non-Annex I countries), thereby facilitating the achievement of the Protocol's aim to reduce GHG emissions in industrialized countries by 5.2% below the 1990 baseline by 2012. Of central importance for the climate effectiveness of the CDM is the notion of additionality. Given that offsetting projects are supposed to make up for emissions that occur elsewhere, they must be realized *additionally* to business-as-usual activities that would have taken place anyway. Developers of prospective CDM projects therefore have to affirm that their projects can only be realized through additional income gained from the sale of carbon credits. Furthermore, the CDM aims to support sustainable development in the countries that host CDM projects. Article 12 of the Kyoto Protocol stipulates that "the purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development … and to assist Parties included in Annex I in achieving compliance with their … reduction commitments" (UNFCCC 1998: 11).

In addition to climate-change mitigation activities in the realm of industrial gas reduction and energy efficiency, the CDM supports mainly hydropower and wind and biomass energy projects and is thus supposed to function as a catalyst for the dissemination of renewable energy technologies in the developing world (Haites et al 2006). With a share of 26%, hydropower is by far the most common technology used under the CDM. Currently, there are more than 770 large (≥15 Megawatts [MW]) and 900 small hydropower projects registered or applying for the CDM, which will earn several billion US dollars by selling their carbon credits mainly to European companies and states (UNEP Risø Centre 2011). An analysis of the spatial distribution of large CDM hydropower projects reveals that almost 60% are located in the Hindu Kush–Himalayan region and adjacent mountain areas (see Table 1). In Chinese mountain areas alone, 436 large "clean development" dams with a total capacity of more than 25,500 MW are being developed. Some of the biggest CDM dams are under construction in the Indian Himalaya, where 28 large-scale projects are expected to add around 5200 MW to the already installed capacity.

Within India, most CDM dams can be found in the northwestern state of Himachal Pradesh. Encompassing the upper reaches of the Sutlej, Beas, Chenab, and Ravi rivers, the total hydropower potential of Himachal Pradesh is estimated at more than 23,000 MW, of which 6460 MW has been tapped so far (GoHP 2009: 68). After decades of comparatively modest hydropower expansion, state authorities plan to more than double the installed capacity by 2017 "to develop Himachal Pradesh as the 'Hydro-Power State' of the country" (GoHP 2010: 56). Because of the lucrative "export" of peak demand electricity to urban and industrial centers in the Gangetic plains, hydropower is playing an increasingly important role in the state's economy, and the CDM is considered to be facilitating the accelerated expansion of hydroelectric projects (GoHP 2009; Him Dhara 2011). With the majority of proposed dams being allotted to nonstate developers, private corporations are expected to play a key role in the construction and operation of new projects. The importance of the private sector is further reflected in the ownership of CDM projects. Corporations are particularly active in applying under the CDM, and they account for 9 of the 11 large "clean development" dams in Himachal Pradesh (see Table 2). Most medium-scale CDM dams are to be found on tributaries of the Beas and Sutlej rivers, whereas the 2 largest projects, Karcham Wangtoo and

TABLE 1 Large CDM hydropower projects (≥15 MW) in the Hindu Kush-Himalayan (HKH) region and adjacent mountain areas.[a)]

Country	No. projects	Capacity (MW)
Afghanistan	**0**	**0**
Bhutan	**2**	**1314**
China[b)]	**436**	**25,574**
Gansu	60	3116
Guizhou	25	1128
Hunan	46	2260
Qinghai	10	392
Shaanxi	11	955
Sichuan	141	9479
Xinjiang	19	1898
Yunnan	124	6346
India[b)]	**28**	**5178**
Himachal Pradesh	11	2076
Jammu and Kashmir	2	89
Meghalaya	1	84
Sikkim	6	2111
Uttarakhand	8	818
Myanmar[b)]	**1**	**240**
Kachin	1	240
Nepal	**1**	**15**
Pakistan[b)]	**2**	**99**
Khyber Pakhtunkhwa	1	15
Azad Kashmir	1	84
Total HKH region	**470**	**32,420**
HKH share of total value	**58.60%**	**60.60%**

[a)]Delineation of HKH region according to ICIMOD 2011.
[b)]Only HKH region.
Source: CDM pipeline 1 April 2011 (UNEP Risø Centre 2011).

Rampur, harness the hydraulic energy of the Sutlej River directly (Figure 1).

Methodology

To assess the effectiveness of large "clean development" dams in Himachal Pradesh in offsetting GHG emissions, a 2-stage approach was applied. Initially, the additionality of all 11 projects was examined by analyzing the projects' chronological development based on data provided in CDM application documents, the so-called Project Design Documents (PDD). Given that the whole concept of neutralizing emissions is based on the premise that offsetting projects cannot be realized without support from the carbon market, one would assume that the construction of additional CDM projects should only commence after projects have been approved by the CDM Executive Board (Haya 2007). Thus, analyzing a project's timeline can allow for an initial appraisal of its potential to compensate for GHG emissions. In a second step, the information obtained through the document analysis was validated through expert interviews with the developers of 2 projects.

The first case study, Allain Duhangan, is a 192 MW project in the district of Kullu (see Figure 2). Built by a

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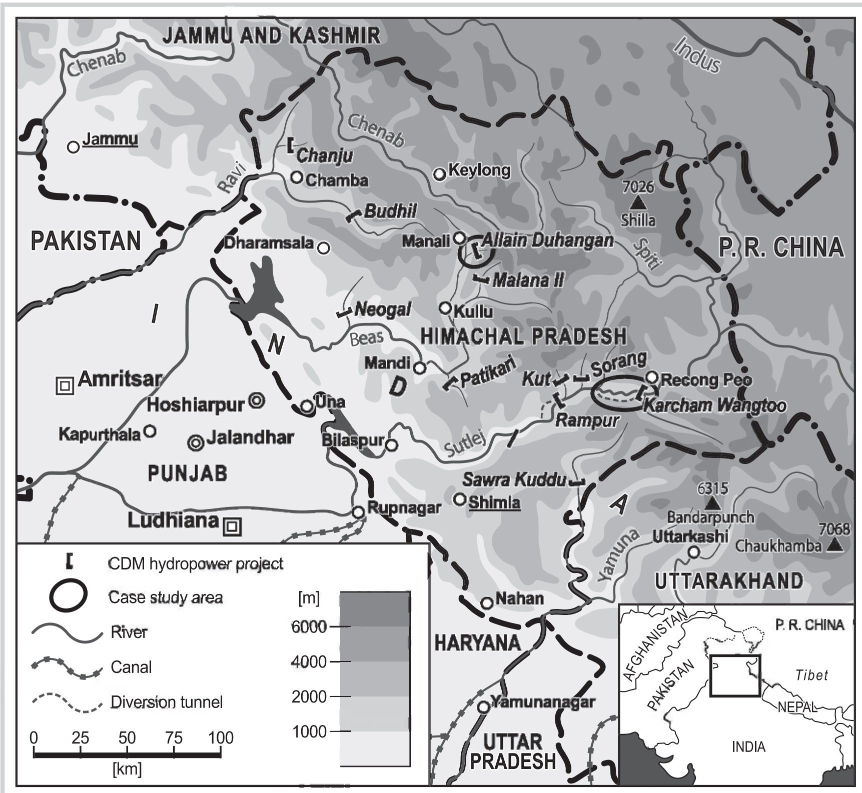
FIGURE 1 Distribution of large CDM hydropower projects (≥15 MW) in Himachal Pradesh. (Draft: A. Erlewein; cartography: N. Harm)



consortium of Indian and Norwegian energy companies and financed by loans from the World Bank's International Finance Corporation the project is expected to generate almost 500,000 CERs per annum (current trading value of approximately US$ 7 million) which it plans to sell to the Italian Carbon Fund (UNFCCC 2007). The other project studied was the 1000 MW Karcham Wangtoo Dam on the Sutlej River in Kinnaur District (Figure 3). Being among the largest "clean development" dams in the CDM pipeline, this project, developed by the Indian Jaypee concern, is expected to create revenues of up to US$ 50 million annually from the sale of its 3.5 million carbon credits to various buyers in Annex I countries (UNFCCC 2008).

The assessment of the second CDM goal, sustainable development, was limited to the 2 case studies. Apart from the directive that the avoidance of GHG emissions was not sufficient to meet the objective of sustainable development, neither the CDM regulations nor the respective Indian authority provided any substantial criteria for the assessment of this goal (Sutter 2003; Benecke 2009). In the absence of such specifications, a selection of the "strategic priorities" of the World Commission on Dams (WCD) was used as a basic framework to evaluate the environmental and socioeconomic impacts at the local level (WCD 2000). The respective data were obtained through expert interviews, supplemented by information provided in environmental impact assessments (ERM 2003; NEERI 2004) and PDDs (UNFCCC 2007; UNFCCC 2008). Altogether, 35 semistructured expert interviews were conducted with project-affected individuals from different social backgrounds (in terms of gender, caste, and profession), local and state-level authorities (mayors, members of "Gram Panchayat" village councils, sub-district magistrate, Pollution Control Board, Designated National Authority of the Indian Ministry of Environment and Forests), local and national nongovernmental organizations (NGO) (Dhumiya Ganga Sangharsh Samiti, Him Lok Jagriti Manch, South Asian Network on Dams Rivers and People) and project developers (Allain Duhangan Hydro Power Limited, Jaypee Karcham Hydro Corporation Limited, Himachal Pradesh Power Corporation Limited).

The effectiveness of large clean development dams in Himachal Pradesh

The chronological development of large CDM dams in Himachal Pradesh is presented in Table 2. By April 2011, only 4 projects were approved and registered by the CDM, whereas the remaining dams were still at validation. At the same time, however, all projects were already at an advanced stage of development, with some even

TABLE 2 Timelines of large CDM hydropower projects (≥15 MW) in Himachal Pradesh.

Project	Capacity (MW)	Ownership	PDD submission	CDM status	Start of construction	Project status
Karcham Wangtoo	1000	Private	30 Sep 08	At validation	Nov 05 (PDD: 3)	Completed (Mar 11)[a)]
Rampur	412	Private	03 Dec 08	At validation	? 07 (PDD: 2)	Under construction
Allain Duhangan	192	Private	04 Feb 06	Registered (17 May 07)	Jan 05[b)]	Completed (Jun 10)[c]
Sawra Kuddu	111	State	19 Nov 08	At validation	Jun 07 (PDD: 17)	Under construction
Sorang	100	Private	09 Jan 08	Registered (21 Oct 10)	Sep 07 (PDD: 15)	Under construction
Malana II	100	Private	28 Dec 07	At validation	Oct 06 (PDD: 36)	Under construction
Budhil	70	Private	25 Aug 06	Registered (07 May 09)	Apr 06 (PDD: 17)	Under construction
Chanju	36	Private	15 Aug 08	At validation	Mar 09 (PDD: 24)	Under construction
Kut	24	Private	14 Mar 09	At validation	Dec 08 (PDD: 23)	Under construction
Patikari	16	Private	15 Jun 06	Registered (16 Apr 07)	Jan 05 (PDD: 16)	Completed (Feb 08)[d)]
Neogal	15	Private	02 Feb 10	At validation	May 08 (PDD: 29)	Under construction

[a)]http://www.jppowerventures.com/karcham-projects.htm (13 April 2011).
[b)]http://www.snpower.com/images/India_ALLAIN_DUHANGAN_factsheet%5B1%5D_tcm82-11984.pdf (10 February 2011).
[c)]http://www.snpower.com/projects-and-plants/plants-in-operation/allain-duhangan/ (10 February 2011).
[d)]http://www.asiangenco.com/patikari-power.html (13 April 2011).
Data sources: PDDs of individual projects as available on UNFCCC website (www.unfccc.int) on 28 January 2011; CDM pipeline 1 April 2011 (UNEP Risø Centre 2011); websites of project developers, see links cited above.

completed. Project timelines show that the construction of all dams had begun without CDM registration. In fact, all projects except Chanju were already under construction when the CDM application process started with the submission of the PDD. The Karcham Wangtoo project even became operational while its CDM approval was still pending. The chronological development of all surveyed dams is thus contrary to what was expected. Developers did not wait for the decision of CDM authorities but started construction without knowing whether or not their projects would be approved by the CDM. This *modus operandi* involves considerable financial risks for developers and gives rise to concerns regarding the projects' additionality (Haya 2007). Conversely, it is stated in the PDDs of Allain Duhangan and Karcham Wangtoo that, although the projects were already under construction, the CDM had been taken into account when assessing their financial viability (UNFCCC 2007; UNFCCC 2008). Leading project officials, however, denied the CDM's relevance for the dams' realization. A manager of the Allain Duhangan project stated in an expert interview that "The project would have gone ahead regardless … the CDM is just another incentive." By referring to the fact that the CDM only became operational in 2004, whereas hydropower plants usually have a planning lead of several years, if not decades, he added: "The CDM is a very new thing…. Back in the 1990s it was not yet in place, so it was not considered in the decision-making process." In the case of Karcham Wangtoo, the implementation agreement between the project developer and the government of Himachal Pradesh was already signed in 1999 (Jaypee 2011). Although technoeconomic clearance was only given in 2003 (Jaypee 2011), it was acknowledged during an expert interview that the main lender was willing to finance the project even without taking into consideration additional revenues from the selling of carbon credits. Representatives of the Allain Duhangan and Karcham Wangtoo projects thus confirmed that both dams would have been built even without support through the CDM.

FIGURE 2 Allain Duhangan intermediate reservoir under construction. (Photo by A. Erlewein, 13 June 2009)

The socioeconomic and ecological implications of these large-scale projects are far reaching and cannot be presented in full detail within the limited scope of this article. Our focus, therefore, is on the most relevant findings from expert interviews with local stakeholders to approach the projects' contribution to sustainable development based on a selection of the "strategic priorities" of the WCD (see Table 3).

An integral part of the first WCD priority, "gaining public acceptance," is the "open and meaningful participation [of project-affected communities] at all stages of planning and implementation, leading to negotiated outcomes" (WCD 2000: 261). Although stakeholder consultations took place repeatedly at both project locations, the majority of interviewees expressed their dissatisfaction with prevailing practices. There was a widespread feeling that consultations merely served to inform villagers about decisions already made and did not provide a forum for meaningful participation. However, given the variations in payments for land acquisition, there seemed to be considerable leeway when it came to negotiating compensation packages. Interestingly, no one in the project-affected villages, not even members of "Gram Panchayat" village councils or local NGO leaders, was aware that these dams were planned as CDM projects and that there would have been a possibility to submit comments to the CDM Executive Board. Information about the CDM was completely absent at the project level.

Overall public acceptance of the projects differed greatly between and among the affected communities. In essence, the villagers interviewed comprised 3 different interest groups:

- Those who conditionally accepted a project based on existing compensation schemes, employment guarantees, environmental management plans etc;
- Those who would have accepted the project based on additional or enhanced conditions; and
- Those who completely rejected the project.

Members of the last group form the core of local resistance movements that have protested for years against the projects, including demonstrations, occupation of construction sites, and filing lawsuits. In the case of Karcham Wangtoo, it was mainly the members of the indigenous Kinnaura communities who opposed the project on the basis of environmental concerns and violations of Indian tribal law. According to

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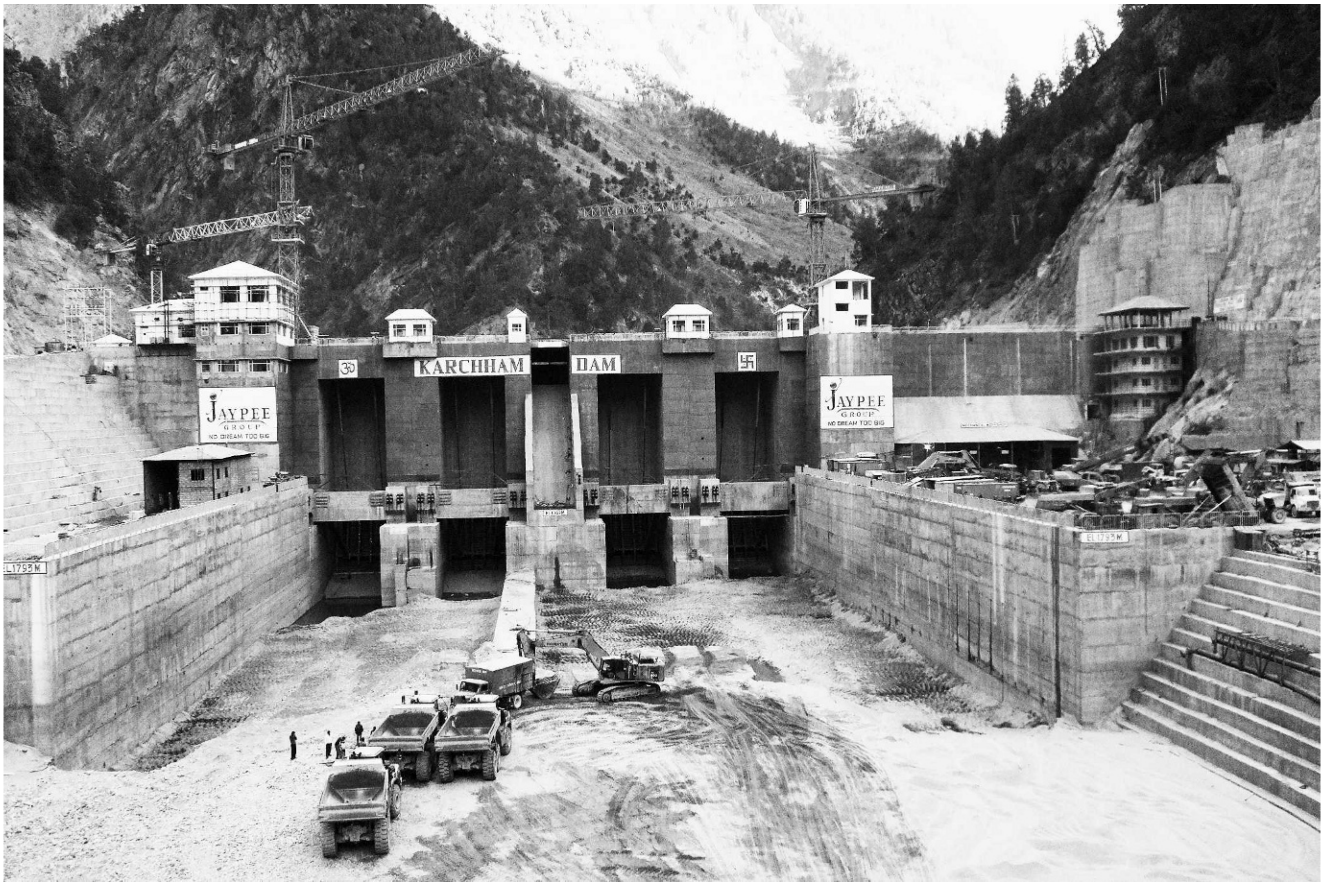
FIGURE 3 Karcham dam, located at the confluence of the rivers Sutlej and Baspa, under construction. (Photo by A. Erlewein, 10 November 2010)



representatives of indigenous groups, the developers of Karcham Wangtoo did not obtain the obligatory nonobjection certificate for land acquisition in tribal areas, thus clearly conflicting with the WCD provision of "free, prior and informed consent" (WCD 2000: 215) for dam building in indigenous areas.

The most severe environmental impact of the projects (WCD priority 4a: "sustaining rivers") is the lengthy disruption of river flow and thus the loss of longitudinal connectivity. Both projects divert rivers into long head race tunnels (Allain Duhangan: 6 and 7 km; Karcham Wangtoo: 17 km), which run parallel to the original watercourses. Whereas, this technique allows for relatively low dam heights (Allain Duhangan: 2 dams of 15 m; Karcham Wangtoo: 98 m), small inundation areas, and thus very limited displacement compared with most projects with similar generation capacities; it dries up long stretches of the river bed with largely unstudied effects on river ecology, biodiversity, and microclimate (SANDRP 2003; High Court of Himachal Pradesh 2010; Him Dhara 2011). The requirement for a minimum flow of 15% is supposed to mitigate these effects. However, it is unclear on which highly variable seasonal runoff data this value should be based, and experience with existing hydropower projects on the Sutlej shows that this regulation is only partially implemented and might not be able to maintain ecological functions (Hydro Tasmania 2007).

The disposal of vast amounts of excavation material that results from tunnel construction is a major problem up- and downstream of Karcham Wangtoo dam. Given the project's location in the deeply incised valley of the upper Sutlej, there is almost no plain area where this material could be piled up solidly. As a result, debris is dumped next to or sometimes illegally directly into the river, where it leads to highly elevated sediment loads that not only cause deterioration of water quality but also cause problems for other hydropower dams downstream (see Figure 4). Another major environmental impact at both project sites is deforestation. Both project developers were found to have felled significantly more trees than permitted, thereby increasing the risk of accelerated soil erosion and landslides as well as affecting the livelihoods of herders who used these forests for grazing their animals.

Other socioeconomic effects (WCD priority 4b: "sustaining livelihoods") resulted directly from the diversion of rivers. According to interview statements by affected farmers, the rerouting of the Duhangan stream

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TABLE 3 Major local impacts of the Allain Duhangan and Karcham Wangtoo hydropower projects after a selection of the strategic priorities of the WCD.

WCD strategic priority	Allain Duhangan (AD) and Karcham Wangtoo (KW)
"Gaining Public Acceptance" (WCD priority 1)	• Repeated stakeholder consultations but meaningful participation restricted to compensation negotiations • Project documentation publicly available • Local resistance movements against projects • Lawsuits filed against project developers • KW: Noncompliant with regulations regarding the participation of indigenous communities
"Sustaining Rivers" (WCD priority 4a)	• Loss of longitudinal connectivity and partial drying-up of river beds due to river diversions into head race tunnels → Adverse effects on river ecology, biodiversity, and microclimate. Mitigation measure: 15% minimum flow • Changes in sediment load, water temperature and oxygen content, due to creation of small reservoirs • Dumping of debris in flood zones affecting water quality • Dust and water contamination during construction
"Sustaining Livelihoods" (WCD priority 4b)	• Few displacements • Deforestation accelerating soil erosion and affecting grazing grounds (compensatory afforestation measures) • Employment generation • Investment in local infrastructure (roads, schools, health facilities) • AD: River diversion conflicts with water demand for downstream irrigation schemes • KW: Drying up of natural springs affects local water supply
"Recognizing Entitlements and Sharing Benefits" (WCD priority 5)	• Recognition of land tenures • Financial compensations for land acquisitions and expropriations • Obligatory contribution to local development fund (1.5% of the total project cost) • Progressive tax on CDM revenues
"Ensuring Compliance" (WCD priority 6)	• Compliant with agreed compensation schemes and infrastructure investments • Deficits regarding environmental regulations. For example, illegal deforestation (AD and KW) and debris dumping (KW)

Data sources: Expert interviews with project-affected individuals, local- and state-level authorities, NGOs, and project developers. Supplemented by information provided in: ERM 2003; SANDRP 2003; NEERI 2004; UNFCCC 2007; UNFCCC 2008; Choudhury 2010.

conflicts directly with water demand for irrigation schemes in the downstream village of Jagatsukh. Around Karcham Wangtoo, more than 100 natural springs that used to sustain the local water supply have dried up since the beginning of construction work. Whereas peasants and environmental NGOs argued that this was a direct consequence of extensive blasting activities to construct tunnels, project developers attributed this phenomenon to natural causes.

However, both projects gave a boost to local economic and infrastructure development. Although largely limited to the construction period, both projects created extensive employment opportunities, which are otherwise scarce in remote mountain districts. In fact, the number of employees (approximately 1500 at Allain Duhangan and 6000 at Karcham Wangtoo) exceeded the locally available workforce by far (UNFCCC 2007; UNFCCC 2008). The majority of construction workers were migrant laborers, mainly from other northern Indian states and Nepal. Furthermore, project developers invested massively in infrastructure development, primarily in the construction of roads and bridges but also in the funding of health and educational facilities.

WCD priority 5, "recognizing entitlements and sharing benefits," mainly concerns the issue of displacement and rehabilitation. Given the comparatively small size of both reservoirs, only a few families had to be displaced completely. According to the Environmental Impact Assessment (EIA), the construction of Karcham Wangtoo required the complete displacement of 6 families and the acquisition of land from 77 persons (NEERI 2004: 6/31). Most interviewees, however, estimated the actual numbers to be significantly higher. In the case of Allain Duhangan, no complete displacement has taken place. Based on data from the responsible subdistrict office, private land was acquired from 304 families, which is more than twice the number of 140 families that was projected by the EIA (ERM 2003: 3). However, at both locations, interviewees reported that land tenure was fully recognized. By contrast with the WCD guidelines, which recommend compensation "in the form of

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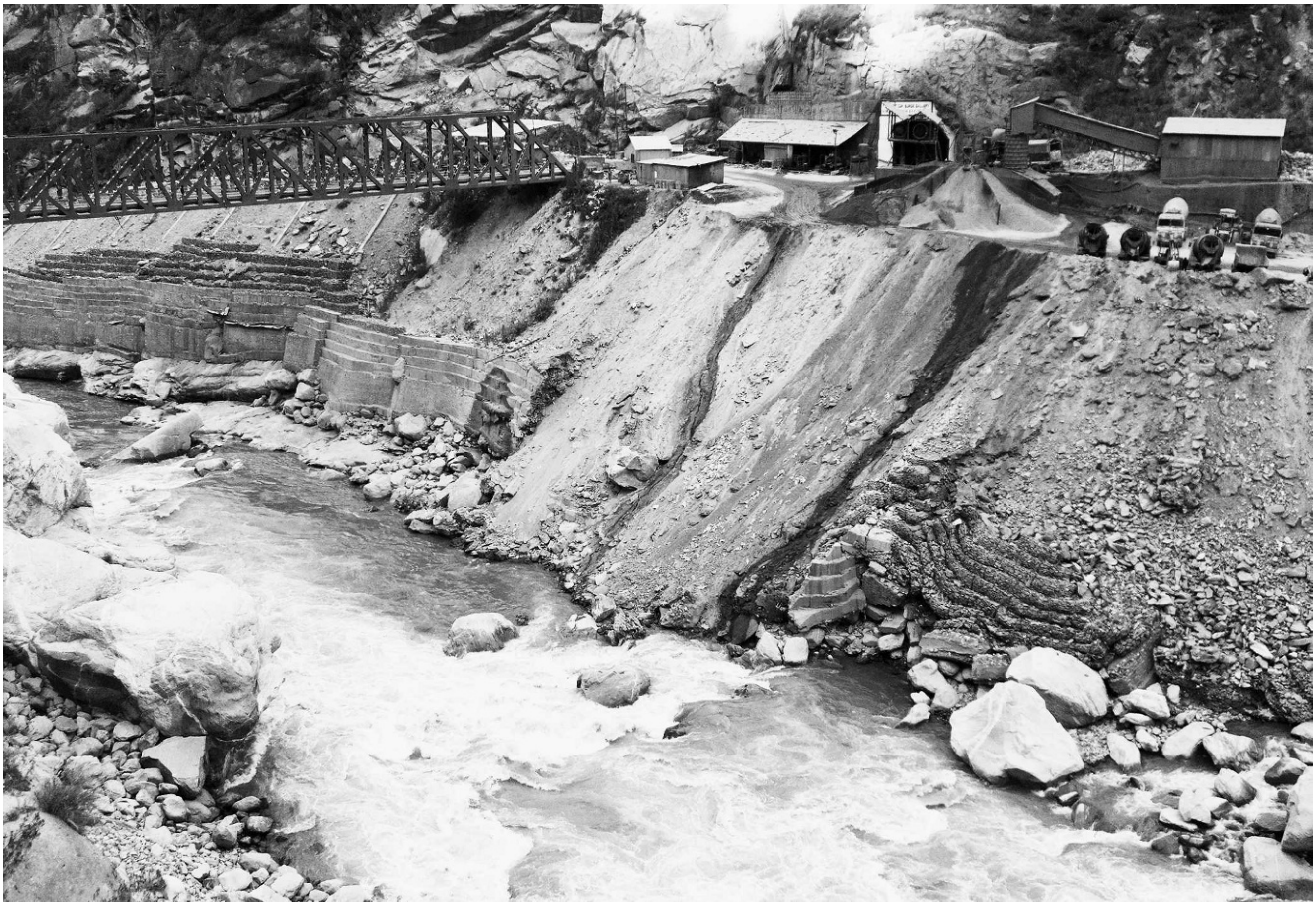
FIGURE 4 Instable debris dumping site close to Karcham dam. Protection walls have been washed away at many dumping sites, causing debris to slide down into the river. (Photo by A. Erlewein, 10 November 2010)



land-for-land options" (WCD 2000: 241), only financial reparation was offered because of the lack of arable land. Although local people appreciated that compensation rates were usually above market standards, some expressed concerns about their long-term economic wellbeing. Several villagers would have preferred to obtain alternative farm or grazing land, which would provide them with modest but consistent livelihoods.

To what extent project developers live up to their social and environmental responsibilities in the long run remains to be seen (WCD priority 6: "ensuring compliance"). Experience so far suggests that project developers do not hesitate to provide ample financial resources for compensation schemes and infrastructure development but are reluctant to comply with environmental regulations, particularly with regard to deforestation, debris dumping, and the protection of traditional water supply systems.

Discussion

Our results suggest that the Allain Duhangan and Karcham Wangtoo hydropower projects fall short of achieving the goals of the CDM. It has become clear that both projects would have been built even without the CDM and, therefore, are not in a position to lead to emission reductions that are "additional to any that would occur in the absence of the certified project activity" (UNFCCC 1998: 12). This finding is in line with other studies that reveal significant shortcomings regarding the additionality of "clean development" dams and other CDM project types (Haya 2007; Michaelowa and Purohit 2007; Paulsson 2009). Schneider (2007: 9) estimates that "additionality is unlikely or questionable for roughly 40% of the registered projects" and with regard to the Indian carbon market Benecke (2009: 363) notes that "CERs constitute an icing on the cake … as most of the CDM project activities would go ahead anyway."

The fact that the vague assessment of additionality continues to be a fundamental deficiency of the CDM is mainly based on 2 critical shortcomings. Although the regulations governing the accreditation of CDM projects are continually being revised, the validation of additionality still relies largely on information provided by project developers, thus leaving considerable scope for manipulation (Böhm and Dabhi 2009; Gilbertson and

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Reyes 2009). Second, the outsourcing of project validation to certification companies, so-called designated operational entities (DOE), has proven to be problematic. Given that DOEs are commissioned directly by project developers, there arises a conflict of interest, which has led to biased validation reports in the past (Haya 2007).

In view of the fact that the CDM is a compensation mechanism, flaws in additionality undermine the basic idea on which the CDM was founded. Without reducing any emissions whatsoever, nonadditional projects generate carbon credits that enable their buyers to maintain or even increase GHG emissions. In this sense, nonadditional projects are not only ineffective but counterproductive in terms of mitigating global warming, which gives rise to questions regarding equity and justice in climate change mitigation (for a detailed discussion see Erlewein 2012).

In the absence of any official criteria, it remains unclear to what extent Allain Duhangan and Karcham Wangtoo can be said to contribute to the second CDM goal of sustainable development. However, the above assessment of local impacts has shown that both dams are controversial large-scale projects that are opposed by substantial parts of the affected communities. Their ecological and socioeconomic consequences appear to be very similar to those of most non-CDM hydropower projects in the region, making it difficult to see what qualifies them as being particularly conducive to sustainable development (IRN 2008; Hydro Tasmania 2007; High Court of Himachal Pradesh 2010; Him Dhara 2011). This corresponds with other studies regarding the development contribution of the CDM. The local impacts of many CDM projects have been found to hardly differ at all from comparable project activities undertaken without CDM support (Sutter 2003; Olsen 2007; Sirohi 2007). These findings might be explained by a combination of policy- and technology-specific aspects that constrain the capacity of "clean development" dams in realizing CDM objectives (Erlewein 2012).

In light of CDM regulations, one-sided calculation of carbon credits constitutes a major limitation. The number of CERs that a project receives is based exclusively on the amount of emissions avoided without taking into account to what extent the project lives up to the objective of sustainability. Consequently, there are no financial incentives or disincentives that could lead project developers to design and operate their projects in a way that fosters sustainable development (Sutter 2003; Olsen 2007), which can even result in a trade-off between the goals of climate protection and contribution to development (Sutter and Parreño 2007). On the one hand, the CDM as a market mechanism is supposed to identify the most economic options for GHG reduction. On the other hand, realization of the objective of sustainability usually requires additional investment, thus rendering sustainable projects more expensive. This may result in a situation in which the contribution of a project to sustainability turns out to be a competitive disadvantage that undermines the objective of sustainable development.

Concerning technology-specific aspects, mixed experience with the impacts of large dams on mountain development raises questions about the appropriateness of hydropower projects for advancing CDM goals (McCully 2001; Kreutzmann 2004; Baghel and Nüsser 2010). Large dams are among the most controversial development interventions in mountain areas, and results of many studies have shown that their costs and benefits tend to be distributed unevenly, often at the expense of locally affected communities (WCD 2000; Nüsser 2003; Finley-Brook and Thomas 2010). Even though some adverse impacts of large dams might be considered as inevitable so to meet the energy needs of a rapidly developing country like India, there seems to be little reason for promoting them on the basis of their contribution to local sustainable development, as the CDM does.

With regard to dams in tropical climates, it also is questionable whether hydropower can avoid emissions in the first place. Results of studies have found some dam reservoirs in such regions to emit enormous quantities of methane, a particularly potent GHG (Giles 2006). However, this phenomenon is unlikely to be of major importance for dams in mountain areas like Himachal Pradesh, owing to low water temperatures and usually low organic material content (Soumis et al 2005).

Conclusions

Our analysis of large "clean development" dams in Himachal Pradesh has shown that the promotion of hydropower through the carbon offsetting scheme CDM is a highly ambivalent strategy. Evidence suggests that current regulations fail to ensure that "clean development" dams live up to the CDM goals of climate change mitigation and local sustainable development. In fact, large hydropower dams may even lead to outcomes that clearly conflict with these aims, thus undermining the environmental and social integrity of the CDM at both local and the global levels.

The CDM concept of supporting the development of climate-friendly technologies that would otherwise be unviable appears to be inappropriate vis-à-vis the dynamics of hydropower development in Himachal Pradesh. Driven by the continuously rising demand for power in northern India's urban and industrial growth centers, the expansion of hydropower in Himachal Pradesh as well as in other Indian mountain states is taking place at an unprecedented pace. In addition to their prominent function as "water towers," the Indian Himalaya may well be described as "power towers," which supply surrounding lowlands with hydroelectric energy. In such a context, the additional subsidization of large-scale hydropower projects through carbon credits appears to be redundant.

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This might also hold true for other countries in the Hindu Kush–Himalayan region and mountain areas across the developing world where hydropower expansion continues to be a priority on the political agenda, with or without support from the CDM: "Steady growth in the supply of hydropower is … projected to occur even in the absence of greenhouse gas (GHG) mitigation policies" (IPCC 2011: 5). This raises questions about the eligibility of large dams under the CDM in general and calls for a profound reform of the directives governing the accreditation and implementation of CDM hydropower projects. In particular, this concerns the formulation of clear sustainability guidelines for "clean development" dams as well as efforts to increase the trustworthiness of validation reports, for example, by avoiding the contracting of validators (DOEs) directly by project developers. As long as there are no effective means of preventing nonadditional and potentially counterproductive dams from entering the CDM, carbon investments should be directed away from large hydropower projects toward less established and often more sustainable technologies, such as solar, biomass, and wind power projects.

Apart from its problematic promotion as carbon-offsetting projects, hydropower can contribute to the avoidance of GHG emissions and is expected to play an important role in the transition to renewable energy systems: "Hydropower continues to be the most important and economic source of commercial renewable energy worldwide, and its popularity is increasing" (UNESCO 2009: 118). However, the reframing of large dams as a means of combating global warming exerts additional pressure on mountain environments. Conflicts about the appropriate use of mountain water resources are likely to be increasingly characterized by trade-offs between local environmental protection and global climate change mitigation.

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