The proposed Pancheshwar Dam, India/Nepal

A preliminary ecosystem services assessment of likely outcomes

www.ies-uk.org.uk

Citation:

Everard, Mark and Kataria, Gaurav. (2010). *The proposed Pancheshwar Dam, India/Nepal: a preliminary ecosystem services assessment of likely outcomes*. An IES research report.

Corresponding author: Dr Mark Everard, mark@pundamilia.co.uk

Executive summary

The Sangam, or meeting of rivers, at Pancheshwar in the Himalayas (Uttarakhand State, India), is the site of proposals to build the Pancheshwar Dam to control flow of the Kali River and its tributaries. The proposed Pancheshwar Dam would be the world's second-tallest, a rock-filled structure intended to harness hydroelectric power and water.

The Pancheshwar site and the substantial area affected, both upstream and down, is of significant ecological, cultural and spiritual, and well as tourism importance. Much of this would be lost were the dam to proceed. Large dams are also highly disruptive to river ecosystems for substantial distances downstream, and to the many people dependent upon them both directly and indirectly. Although there are various planned beneficial dam outcomes in terms of water and energy, it appears that these wider ramifications and their consequences for the many people potentially affected by them have not been included in planning. There is certainly a lack of engagement of local people, a paucity of published information, and consideration of environmental and social consequences have come only belatedly in the planning process, seemingly too late to influence scheme design and decisions with their associated sunk costs and for which no other options appear to have been contemplated or appraised.

On the basis of information from published sources, interviews on a site visit, and polling experts both from India and the international community, this study explores the likely marginal impacts of dam construction on the many beneficial ecosystem services provided by the river system. It was not possible to quantify or monetise these positive and negative impacts, owing largely to lack of any budget for the detailed investigations necessary to derive them. However, weighting 'likelihood of impact' on the basis of stated assumptions and evidence proved informative, and adequate to derive some firm conclusions. Marginal changes were assessed at two different scales: (1) local to the dam; and (2) wider catchment impacts. This highlighted potential impacts on a wide range of beneficiaries of ecosystems services, many of whom seem to have been omitted from consideration (as has so often been the case for major dam schemes around the world).

The findings from the ecosystem services analysis were structured against the seven 'strategic priorities' identified by the UN's World Commission on Dams (WCD), published to guide more sustainable and equitable water resource development. The Pancheshwar proposals and process, insofar as information is available, fail all seven WCD 'strategic priorities' and can therefore not be assumed to be sustainable, fair or economically sound.

We conclude that the negative environmental consequences of the proposed Pancheshwar Dam would be substantial and long-lasting, and would affect people and ecosystems over a wide geographical scale. They would threaten not only high-priority nature conservation areas and the general river ecosystem downstream, but also the livelihoods of many people, both local and across the catchment, by degrading the ecosystem services provided by the catchment ecosystem. There would also be destruction of sacred sites, traditions and lifestyles, particularly amongst rural communities which have been largely omitted from consideration but potentially also affecting the wellbeing of millions

of people overall. The impacts of earthquakes on dam integrity also seem to have been overlooked, despite the likely implications of the massive weight of the proposed reservoir on a highly active earthquake zone. When the quanta of substantial and overlooked costs is considered, as they seem not to have been to date in dam planning, it is highly probable that they will substantially outweigh planned benefits. It is not clear who will pick up these costs.

The net value of the proposed Pancheshwar Dam to Nepal, India and beyond is highly questionable; some potential positive outcomes appear to have been overstated whilst negative consequences have been substantially overlooked. Evidence of marginalisation of stakeholders in the decision-making process, 'lock in' to a single large-scale engineering solution and late development of EIAs and other studies based only on this option points to a 'top down' process advantageous to politically- and economically-powerful players. There is therefore a serious democratic failing in the process, with widespread potential impacts upon many people and the ecosystem services upon which they depend almost wholly overlooked.

Since only one 'big technology' solution is considered, and there is a lack of consideration of how people actually use water and energy and how else this might be more appropriately delivered without such major disruption to the catchment ecosystem, far-sighted decisions addressing all likely dam impacts are a remote possibility.

The evident failure to observe UN-backed 'strategic priorities' about dam design, the opaque decision-making process, evident favouring of already-advantaged stakeholders, failure to communicate and engage many sectors of society and a narrow focus on technology solutions exposes the Indian government, at both state and national levels, to charges or perceptions of being undemocratic and subject to nepotism, patronage and corruption. This has ramifications for the perception of India on the world stage in terms of overlooking the interests of the majority of its people, infringing their human rights and ability to participate in decisions affecting their futures, and ignoring international conventions and protocols. This may dent the confidence and fail criteria required by financial institutions including funding agencies, donors and banks, on the basis of inadequate risk assessment and additional ethical and environmental concerns.

In the light of searching questions about net public value likely to result from the Pancheshwar Dam development a currently proposed, it is recommended that the scheme is reassessed with a fresh appraisal of options on the basis of desired objectives which must this time include implications of development proposals for ecosystem services and their many beneficiaries at all scales. The WCD 'strategic priorities' provide an appropriate and internationally-accepted framework for this review, and it is also recommended that ecosystem services assessment is undertaken as a comprehensive and inclusive means to explore the wider environmental and societal consequences of all options to address the objectives. Transparency in the process, engagement of wide stakeholder communities, and clarity about how development proposals will contribute to public wellbeing are essential.

Acknowledgements

The authors of this report are grateful to many people whose views have shaped this ecosystem services assessment. These people have been named in Table 2.2: Sources of input to the Pancheshwar Dam evaluation.

Contents

List of tables

List of figures

1 The proposed Pancheshwar Dam

The proposed Pancheshwar Dam is to be located on the Kali River bordering northern India and Nepal. This section provides background information on the location and the scheme.

1.1 The Kali River and its major tributaries

The Kali River rises at an altitude of 3,600 metres in the Greater Himalaya range at Kalapaani, in the Pithoragarh district of Uttarakhand (formerly known as Uttaranchal) State, India. Uttarakhand borders Tibet (China) to the north and Nepal to the east. It also abuts the Indian states of Uttar Pradesh to the south and Himachal Pradesh to the north west, and has a narrow border with Haryana between the two to the west. The upper course of the Kali River forms India's continuous eastern boundary with Nepal.

The Kali River takes its name from the Hindu Goddess Kālī, associated with eternal energy, to whom a temple is located in Kalapaani near the Lipu-Lekh pass at the border between India and Tibet. The name 'Kali' is interchangeable with 'Mahakali' (meaning 'great Kali'). The river changes name a number of times throughout its course, generally below significant tributary rivers. The area around Pancheshwar is called 'Kali Kumaon' (Kali in the district of Kumaon). Below the confluence below the (Uttarakhand) town of Tambaur of the River Karnali, which drains from Nepal, it adopts the new name of River Sarayu. Once the Kali River descends from the Himalayan foothills and onto the Gangetic plain, including at the large barrage across the river at Banbassa near the town of Tanakpur, its name changes to the Sharda River. The Kali/Sharda River is a part of the Ganges river system, joining the main Ganges River further downstream below the city of Madhubani.

The centre of the Pancheshwar Dam proposal is the confluence immediately downstream of the village of Pancheshwar at the confluence of the Saryu and the Kali Rivers. The Saryu is a perennial, spring-fed river with clear water flowing in from higher in the Himalayas within the state of Uttarakhand, whilst the Kali flows strongly with water turbid with rock flour and is more intermittent being predominantly glacial- and snow-fed by melt water higher in the Himalayas to the north.

1.2 Characteristics and ecosystems of the Pancheshwar region

The Himalayan topography of Pancheshwar, as indeed much of Uttarkhand, is steep and dramatic, constituting tall and extensively forested mountains intersected by deep ravines including river gorges. The confluence is at an elevation of approximately 460 metres with surrounding mountains on the Indian and Nepalese banks rising to over 1,400 metres. Although mountain and

hill tops can be cool at night and during cooler seasons, valley bottoms tend to be much warmer due to the substantial difference in elevation. The region is generally arid for much of the year, with heavy rain or snowfall during the monsoon swelling rivers and recharging the groundwater, snow and glaciers which sustain river flows throughout the year. Rivers therefore vary significantly in pace, depth and discharge throughout the year, rivers often braiding through coarse cobble and gravel substrates as flows decline. The recirculation of moisture within the microclimate of steep valleys, evaporating from river surfaces and corridors and captured by forests and other complex vegetation on the steep valley sides, is likely to be significant for the water balance of catchment landscapes upon which food production and ecological character depend.

Sight or signs of leopard (*Panthera pardus*), jungle cat (*Felis chaus*), jackal (*Canis aureus indicus*), common langur (*Entellus Langu*), rhesus monkey (or rhesus macaque, *Macaca mulatta*) and small deer were observed during a site visit to the Sangam at Pancheshwar in April 2010. The river is also known to hold stocks of otters, which may include all of the three species of otter found in India: the Eurasian otter (*Lutra lutra*), the smooth-coated otter (*Lutra perspicillata*) and the small-clawed otter (*Amblonyx cinerous*). There appear to be no formal mammal checklists for the vicinity, but the habitat is currently in good condition and should hold a diversity of regionally-characteristic Himalayan species including ungulates such as bharal (Himalayan blue sheep, *Pseudois nayau*), Himalayan tahr (*Hemitragus jemlahicus*), serow (*Capricornis thar*), goral (*Naemorhedus gora*), several species of deer including Himalayan Musk Deer (*Moschus leucogaster*), bears including Himalayan black bear (*Ursus thibetanu*) and Himalayan brown bear (*Ursus arctos*), as well as diverse small mammals. In addition, there are local sightings of the increasingly scarce tiger (*Panthera tigri*) and the Sharda river downstream flows close to Dudwa National Park, thought to be one of the finest National Parks in northern India supporting rare wildlife including great Indian rhinoceros (*Rhinoceros unicornis*), tiger and leopard, hog deer (*Axis porcinus*) and swamp deer (*Cervus duvauceli*), Indian elephant (*Elephas maximus indicu*) and, perhaps the rarest of all, the hispid hare (or bristly rabbit, *Caprolagus hispidus*) which had been declared extinct but was rediscovered here in 1984.

In addition to this highly incomplete but representative list of mammals, the bird life of the wider region around Pancheshwar is exceedingly diverse with over 350 species. Kataria (unpublished) is developing a bird checklist for upper Kumaon District that includes such rarities as the critically-endangered white-rumped vulture (*Gyps bengalensis*) and red-headed vulture (*Sarcogyps calvus*) and the near-threatened satyr tragopan (*Tragopan satyra*), great hornbill (*Buceros bicornis*), lesser fish-eagle (*Ichthyophaga humilis*), cinereous vulture (*Aegypius monachus*), pallid harrier (*Circus macrourus*) and laggar falcon (*Falco jugger*).

Pancheshwar also holds stocks of fishes of conservation importance, particularly large broodstock and smaller year classes of the golden mahseer (*Tor putitora*) which are under extreme pressure across much of their range in the Ganges and Bhamaputra river basins due to overexploitation by destructive fishing methods including dynamiting, netting and poisoning, pollution in addition to water abstraction, and obstructions to spawning runs particularly

including dams. Other fishes observed or reported from the river include species of *Garra* (small fishes locally named as 'stone sheep' for their habit of grazing algae and detritus from submerged surfaces), eels (*Anguilla bengalensis*), freshwater garfish (*Xenentodon cancila*), ansala (the local name of a small cyprinid of uncertain taxonomy) as well as redfin mahseer (*Tor tor*) and copper mahseer (*Neolissochilus hexagonolepis* also known as chocolate mahseer but which are not 'true' mahseer of the genus *Tor*). Some of these fishes, particularly species of mahseer, are also threatended elsewhere across the major river systems of India by various factors significantly including obstructions to their spawning runs and life cycle by impoundments.

This list of mammals, birds and fish is, of course, very far from complete but does give an indication of the breadth of larger and more charismatic species inhabiting the area, indicative of the diversity likely to be encountered in all other locally-adapted plant, animal and microbial taxa.

It also highlights that the catchment downstream, including both river and riparian habitat and adjacent catchment including the important wildlife areas that it runs through or near, depend upon the flows of water, energy, sediment and living organisms in the river system. This includes many of the species highlighted above as well as various reptile species including the increasingly threatened gharial (*Gavialis gangetic*) for which the habitat is perfect; 260 gharial were released into the Sharda River under the Uttar Pradesh Crocodile project (Bustard, undated).

The Mahakali River also bounds part of the Western edge of the Shuklapantha Wildlife Reserve in Nepal, Nepal's oldest wildlife reserve gazetted in 1973 and subsequently scheduled as a UNESCO World Heritage Site in 1984. The Shuklapantha Wildlife Reserve supports the largest Nepalese population of Bengal florican (or Bengal bustard, *Houbaropsis bengalensis*) and swamp deer (or barasingha, *Rucervus duvaucelii*), which may conceivably be impacted by the dam along with the savannah floodplain upon which they depend.

1.3 Human activities in the Pancheshwar region

A diversity of human activities occurs in the Pancheshwar region and the wider area that would be inundated or otherwise profoundly influenced by the reservoir. Some towns occur in the region (notably Pithoragarh between the Eastern Ramganga and Kali Rivers as illustrated in Figure 1.1). However, there are many villages and also an extensive and widely-scattered population between them. There is no major industry in the immediate region of Pancheshwar.

Angling and wildlife tourism make a significant contribution to the economy. The confluence at Pancheshwar has been well known for its big mahseer since the colonial period, and is considered one of the few places left in the Himalayas where large golden mahseer up to as much as 50 pounds (22.7 kilogrammes) are still caught. Fish can be caught in the dependable flows of the spring-fed Saryu river all year round, but the best time for the biggest fish is immediately ahead of the spawning run on the onset of the monsoon in May-June, and then again following the run as the rivers drop back in pace and height around September.

There is a prominent army presence due to security concerns related to the Nepalese border, and this is important to the local economy. The army takes charge of road construction and maintenance in the border region through the BRO (or Border Roads Organisation).

Many communities live subsistence lifestyles, growing cereals (mainly wheat and oats but not rice as the altitude is too high and water resources too sparse) and grazing cattle on cascades of individually small terraces often cascading dramatically to cover hundreds of metres of steep slopes where soils and topography are suitable. This characteristic landscape may have been formed and worked in this way for millennia.

All Sangams, or river confluences, are of spiritual importance to Hindu people. The joining of the large and important Saryu and Kali rivers at Pancheshwar is particularly significant. Indeed, the name Pancheshwar is a compound of the Hindi words 'Panch' (five) and 'Shwar' (lord), representing the 'Lord of five rivers' as five major rivers join upstream of Pancheshwar. The Eastern Ramganga and Saryu River join at Rameshwar some twenty kilometres upstream of the junction with the Kali, which is joined upstream of Pancheshwar by the Gori Ganga and Dhauli Ganga rivers. Consequently, the Sangam at Pancheshwar plays frequent host to Kriya Karam (Hindu ceremonial cremations), which people come to perform from significant distances (tens to hundreds of kilometres).

1.4 The proposed Pancheshwar Dam

The proposed Pancheswar Dam would straddle the Kali River close to the village of Pancheshwar. The project is international as the river here forms a 230 kilometre (193 mile) boundary between India and Nepal. The Indo-Nepal Mahakali Treaty was signed between India and Nepal in February 1996, envisaging basin development under the aegis of a bi-national Mahakali Commission. The Commission was set three priorities:

(1) Management of the Sharda Canal, already in existence, which diverts water from the Kali River at the Tanakpur (Sharda) Barrage to the dry and over-abstracted basin of the Gomti (or Gumti or Gomati) River to the south in the Indian state of Uttar Pradesh;

(2) Management of the Tanakpur Barrage, commissioned in 1993 and already installed, which is part of a run-of-river hydroelectric power scheme located at Banbassa near the town of Tanakpur in the district of Champawat. It comprises a barrage across the Sharda River, which diverts river flows into a 6.2 kilometre (3.9 miles) long power channel with a generation capacity of 120 MW; and

(3) Development of the proposed Pancheshwar Multipurpose Project, the central structure of which is the proposed dam stemming the Kali River at Pancheshwar, also in the district of Champawat.

The Pancheshwar Dam is planned to be a huge 315 metre (1,033 feet) high rock fill dam, which would constitute the world's second-tallest dam after the Rogun Dam in Russia at 335 metres (1,099 feet). The project is the largest hydropower project in South Asia. The dam will submerge an area of 134

square kilometres (121 square miles) and (in 2007 prices) was projected to cost Rs 21,780 Crores (217,800 million Rupees, the equivalent of £3.2 billion or $US4.9 billion at April 2010 exchange rates).

This compares with the dam height of only 101 metres (331 feet) from river level of China's Three Gorges Dam, which houses the largest hydroelectric generation facility in the world which also comprises the world's largest electricity-generating plant of any kind, and has a dam width of 2,335 metres (7,661 feet) making it the world's largest.

The time-line of the proposed Pancheshwar Dam project to date is:

- 1962: Identification by India;
- 1971: Pre-feasibility study;
- 1984-1991: Engineering field investigations;
- 1991: Project definition;
- 1995: Detailed project report;
- 2002: Scoping of the Nepalese Environmental Impact Assessment (EIA);
- 2005-2008: EIA study in Nepal (involving 26 national experts on the physical, biological and social environment);
- 2009: Nepal and India due to discuss the EIA Report and detailed Project Report;
- 2010: Nepalese EIA due for release at a date unspecified at the time of writing;
- India and Nepal recently formed the Pancheshwar Development Authority with its headquarters in Nepal to complete the Detailed Project Report on the project; however
- Maoist successes in the Nepalese government are threatening to delay or derail the project.

The location of the proposed Pancheshwar Dam, related project and key locations in the wider region are illustrated in Figure 1.1.

Figure 1.1: Map of the Kali River and Pancheshwar region

'Re-regulation dams' are also being planned at Rupaligadh. The purpose of a re-regulating reservoir, usually built immediately downstream of hydropower facilities, is to mitigate some of the hydrologic impacts of hydropower generation re-regulating to 'undo' unnatural fluctuations caused by hydropower operations on a short-term (day-to-day or within-day) basis by releasing water in a pattern much closer to natural flows. However, whilst they may buffer short-term fluctuations in throughput of water, small re-regulating dams can't be expected to restore natural flow patterns on longer cycles (part of which the Pancheshwar Dam is anyhow designed to buffer), and will not address the issue of sediment starvation in out-flowing water which is likely to erode floodplain and river channel habitats and soil fertilisation for substantial distances downstream along the river system.

The general inaccessibility of project documentation and the late commissioning of an EIA and other studies on only one option (the large dam proposal) demonstrate that other means for delivering planned energy and water benefits

have not been considered to any serious extent. Indeed, it is evident that decisions have already been made about this major and disruptive 'big technology' approach without consulting many of the parties most seriously affected, and that all of the substantial investment in scheme design and (late) appraisal are 'locked in' to just one option which, if a foregone conclusion were political deadlocks to be resolved, would mean that any environmental and social concerns raised by such studies would not be material to the scheme progressing.

This then raises big democratic questions about whose futures are deemed to matter and whose are disregarded or implicitly considered unimportant in the planning process. This in turn provokes economic questions about the likely overall balance of benefits versus costs, beyond benefits assessed from energy and water management for a few more influential target beneficiaries, and their distribution across different sectors of society. It is therefore highly likely that ecosystem destruction and the loss of many associated ecosystem services supporting the livelihoods of very many people, both around the dam site and in the catchment downstream, will result in substantial costs which are neither considered up front nor planned for in terms of mitigation, compensation or the retrospective price of damage.

1.5 Documentation relating to the Pancheshwar Dam

Official documentation about the Pancheshwar Dam programme is difficult to track down. At the time of writing, India's Environmental Impact Assessment (EIA) for the Pancheshwar Dam has yet to be completed.

However, an EIA has been completed by Nepal though has to be published at the time of writing, and is under evaluation by the Nepalese government. It has, however, been summarised in various news publications. Extracts from one such online publication (República, 2010) are included in Table 1.1. This Nepalese EIA report was set to be released after three months, but has not been published at the time of writing.

Table 1.1: Extracts from the Nepalese Pancheshwar EIA reported in República (2010)

- The Nepalese EIA was commissioned by the Department of Electricity Development (DED).
- The proposed Pancheshwar High Dam will inundate a total of 5,738.5 hectares of land in Darchula and Baitadi districts in Nepal.
- A further 348.4 hectares, 3,511.3 hectares and 5,803.2 hectares will be inundated by the Rupaligadh re-regulatory dam, the Purnagiri re-regulatory dam and Purnagiri high-dam respectively. Altogether some 79 Village Development Committees (VDCs) will be directly affected.
- The ratio of land inundation between Nepal and India will be 33 percent and 67 percent respectively.
- Community forests lying higher than 700 metres above sea level will be

affected by planning for the project, with direct habitat loss to animals, birds and fishes.

- Some 21,621 people will be displaced by the Pancheshwar project. An additional 1,144 and 18,565 locals will be displaced by the re-regulatory dams at Rupaligadh and Purnagiri projects.
- An additional 32.69 hectares of fertile land will be wiped out by the construction of the Patan-Pancheshwar assess road.
- This will lead to a direct annual loss of Rs 460 million in agriculture production from the Pancheshwar and Rupaligadh re-regulatory dams and another Rs 560 million from the Pancheshwar and Purnagiri dams.
- Project-in-charge officer Dilli Bahadur Singh claimed that, “Although the negative side of the project cannot be sidelined, the project in itself is one of the most viable and cost-effective”. He was reported as adding that, “The rate of return is estimated at 25.4 percent, which means the country will reap returns within three to four years”, and that “The entire Pancheshwar site can be developed as a tourism destination”. He also said that thousands of people will find employment, a 300 km ring road will be built, a cable-car line can be erected, 9,000 hectares of forest area can be developed, and another 100-150 km south-north road will be built.
- The Nepalese DED EIA has proposed a Detailed Resettlement and Rehabilitation Plan and the production of another Detailed Environment Management Plan to recommend impact minimisation.

1.6 Other major dams in the region

The government of the state of Uttarakhand, established by partition of the once more extensive state of Uttar Pradesh in 2000, has invested significantly in economic development. This includes initiatives to capitalise on handloom and handicrafts, the burgeoning tourist trade, as well as tax incentives aimed at luring high-tech industry to the state. The city of Rudrapur, on the edge of the plains adjacent to the Himalayan foothills, is a burgeoning and sprawling industrial centre to which many businesses have been drawn by tax breaks.

Uttarakhand state is also promoting big dam projects, which have become increasingly controversial and criticised in India. Uttarakhand is the birthplace of the Chipko environmental movement, a socio-ecological movement instigated in the early 1970s practising Gandhian methods of non-violent resistance, as well as a range of other social and environmental movements.

The Kali (Sharda) River is already dammed. The Tanakpur Hydroelectric Project comprises a barrage across the river at Banbassa, near the town of Tanakpur, commissioned in April 1993 by the Uttarakhand Irrigation Department and with an intended hydroelectric generation capacity of 120MW.

The state’s big dam projects include the 261 metre (856 feet) high Tehri dam on the Bhagirathi-Bhilangana rivers, centred near the town of Tehri. The Bhagirathi River is a principal tributary of the sacred River Ganges. The Tehri

Dam was initially conceived in 1953. Dam filling started in 2005, with generation commencing in 2006. The Tehri Dam is not only the primary dam of the Tehri Dam Project but, at 261 metres (855 feet) high, is the fifth tallest dam in the world. The reservoir behind the Tehri Dam submerged an area of 51.7 square kilometres (20.0 square miles). The Tehri Dam is intended to generate 2,400 MW of hydroelectric power, enable new irrigation for an area of 270,000 hectares, and supply 270 million gallons of drinking water per day to a wide range including as far afield as Delhi. The planned benefits of the Tehri Dam are listed in Table 1.2. A smaller dam some 14 kilometres downstream of the Tehri Dam close to the town of Koteshwar, also constituting part of the Tehri Dam Project hydroelectric plan, is designed to produce 400 MW of electricity.

Table 1.2: Planned benefits from the Tehri Hydropower Complex

Statistics reproduced from the Ministry of Power, Government of India, Annual Report for 2005-2006 (http://www.powermin.nic.in/):

- An additional installed generating capacity in the northern region of 2,400 MW
- Annual energy availability (peaking) at 6,200 MU
- Additional irrigation of 2.70 Lac (270,000) hectares
- Stabilisation of existing irrigated area of 6.04 Lac. (604,000) hectares
- 300 cusecs (162 million gallons per day) of drinking water for Delhi, which will meet the requirements of about 40 Lac. (4,000,000) people
- 200 cusecs (108 million gallons per day) of drinking water for towns and villages in the adjacent Indian state of Uttar Pradesh, which will meet the requirement of 30 Lac. (3,000,000) people
- Integrated development of the Garhwal region of Uttarkhand state, to the west of Champawat, including construction of a new hill station town with provision of all civic facilities
- Improved communication, education, health, tourism, development of horticulture, fisheries, and afforestation of the region

Active protests by environmental organisations and local people have surrounded the Tehri Dam due to consequences for the environment and human rights (dam construction entailed the relocation of more than 100,000 people). At the time of writing, compensation has yet to reach the people to which it was promised. Furthermore, campaigners claim that not all displaced people were included in official figures or scheduled for compensation.

Furthermore, various published sources (the UN's World Commission on Dams 2000 report *Dams and Development* and also Patrick McCully's 2001 *Silenced Rivers*) highlight that financial compensation is far from adequate when people's livelihoods and traditions are disrupted, often putting them into sustained poverty and conflict with communities into or adjacent to which they are relocated. Furthermore, it is far from safe to assume that higher elevations above inundated areas will be as productive agriculturally or favourable for settlement as lower elevations close to former river channels, exacerbating livelihood stresses, land erosion and further unaccounted loss of habitat with its associated wildlife and beneficial ecosystem services.

These literature sources also emphasise the widespread problem of salinisation of irrigated land in hot climates, resulting from evaporation of water leaving behind a build-up of salts. The value and yield of soils with high contents of salts are significantly reduced, causing severe socio-economic and environmental problems in the long term and representing a serious problem worldwide which is estimated as costing the equivalent of US$11 billion per year (CISEAU, iptrid and FAO, 2005). Furthermore, where water tables are disrupted by irrigation or over-extraction, accumulations of problematic substances in groundwater can occur with serious health consequences such as health impacts arising from arsenic build-up in water widely reported from Bihar (for example Jai Bihar, 2010; Hindustan Times, 2010).

Further concerns relate to the geological stability of the Tehri dam as it is located a major geologic fault zone, the Central Himalayan Seismic Gap, which was the epicentre of a major earthquake in October 1991. The Central Seismic Gap is about 800 km (500 miles) long, lying at the interface of the tectonic plates of the Indian subcontinent and Eurasia. All major dams are considered to result in seismic disturbances due to the sheer physical weight of stored water (World Commission on Dams, 2000; Chen, 2009), but where this occurs in zones that are not only prone to earthquakes but where major and potentially catastrophic earthquakes are predicted then the vulnerability and risks of large dam projects is highly questionable.

On the Alakhnanda River, about 15 kilometres (9.3 miles) downstream of the holy ‘Badrinath' Shrine near the town of Joshimath, but upstream of where the river joins the Bhagirathi River for form the sacred Ganges, the Vishnu Prayag Hydro Project in the Chamoli District of Uttar Pradesh is also being planned for multiple benefits including substantial energy generation. However, there seems little consideration of the potential wider ramifications for the catchment ecosystem and the many people dependent upon it as a result of damming the river. For example, The Tribune (2008) reports that families in Chaanyeen village on the verge of displacement due to the forthcoming Vishnu Prayag Hydro Project have petitioned the chief minister of Uttarakhand demanding a rehabilitation and resettlement policy for the displaced and dispossessed, as the government had yet to initiate a resettlement and rehabilitation policy programme for families suffering from scheme-related subsidence in October 2007.

1.7 Planned benefits from the proposed Pancheshwar Dam

The purposes of the proposed Pancheshwar Dam project are electricity production, generation of water for irrigation and flood control. Installed turbines are intended to produce 6,480 MW of electricity, compared to the 2,400 MW peak production at Tehri. Uttarakhand was initially scheduled to benefit from 12% of free power as a royalty, this figure rising to 13% later in the planning stages.

Water for irrigation is intended to benefit farmers in Uttar Pradesh. Also, by storing water, it is intended that floods in Bihar and Uttar Pradesh will be

reduced. So important is the aspect of flood control that officials of Bihar and Uttar Pradesh were a part of the expert group created to advance negotiations in 2004.

The creation of the reservoir behind the proposed Pancheshwar Dam is also seen as a tourist attraction, reported both in the Indian press and by the Nepalese Project-in-charge officer. Of the 134 square kilometres of lake formed behind the Pancheshwar Dam, upstream on the Mahakali River as far as Baluwakot, 120 square kilometres are in the Indian state of Uttarakhand whereas a more modest 14 square kilometres are in Nepalese territory.

1.8 Controversy surrounding the Pancheshwar Dam

The Pancheshwar Multipurpose Project is a major cause of concern to many people on both sides of the national border, forming the topic of protests by environmentalists, local villagers and anti-dam activists in both India and Nepal. The Indo-Nepal Mahakali Treaty is widely seen in Nepal as prejudicial, the product of undue pressure from India and the US, with the pricing of electricity and ownership of waters both proving contentious. A Joint Project Office set up in 1999 failed to resolve the cross-border dispute and was dissolved in 2002. Another Joint Group of Experts was set up in 2004, but political unrest in Nepal has derailed its progress. Today, Maoists are now a part of the Nepalese government and are strongly opposed to the dam. Can it then be clear who will be the net beneficiaries of the dam and how they will benefit, nor who will recognise or compensate those likely to lose out as a result of its construction?

Details of planned advantages from the Pancheshwar Dam are elusive, but can be compared with the Tehri Dam. The Pancheshwar Dam will be three times larger in area than the Tehri Dam (the Tehri Dam submerged an area of 51.7 square kilometres, whereas the Pancheshwar Dam will inundate 134 square kilometres) and will cost five times as much to build. In the absence of clear published details of the Pancheshwar scheme, comparison with the Tehri Dam provides a sense of scale.

Various published sources (including for example the UN's World Commission on Dams 2000 report *Dams and Development* and also Patrick McCully's 2001 *Silenced Rivers*) highlight that planned benefits such as energy generation, irrigation and flood relief may not be realised in practice. Energy generation and water for irrigation, industrial and urban uses has commonly been found to be unevenly distributed, benefiting economically- and politically-influential stakeholders with the needs of many people omitted from consideration or seen as inconveniences to a narrow model of industrially-focused progress. By storing seasonally high flows, dam schemes are claimed to reduce flood surges. However, if they overtop, the buffering capacity of habitat inundated by dam filling will not be available to moderate overtopping water. Furthermore, when people and industries settle on former floodplain and lower-lying land now assumed to be safe, they may put themselves more at risk particularly since the dam has a limited design life that may in practice be shorter than planned. We have also to be aware that no major dam has yet been designed with decommissioning in mind, compounding the potential for such future risks.

A range of human rights, environmental and local interest groups and individuals address multiple foreseen disadvantages. Indeed, various websites raise the question, "*Does Uttarakhand need another big dam?*" A number of private interests and NGOs are pursuing Public Interest Litigation (PIL). PIL, in Indian law, means litigation for the protection of public interest and is a process opened upon the 1980s as the Indian Government sought to make legal redress on issues of overriding public interests accessible to more people. PIL is litigation introduced in a court of law, not by the aggrieved party but by the court itself or by any other private party. It is not necessary, for the exercise of the court's jurisdiction, that the person who is the victim of the violation of his or her right should personally approach the court. PIL has been successful in making official authorities more accountable to civil society organisations.

Various issues of local concern raised by information sources used in this study are listed in Table 1.3.

Table 1.3: Perceived problems arising from the Pancheshwar Dam

The following issues were derived from structured internet searches and from publications and discussions with stakeholders referred to in the body of this document.

- Officially, 82 Indian villages and 33 Nepalese villages would be completely submerged and 11,361 families would be fully displaced as a result of the filling of the Pancheshwar Dam. (By comparison, the Tehri Dam submerged 33 villages and Tehri town, completely displacing only 5,421 families; the promised compensation has yet to materialise.) These figures are hotly contested by local NGOs which claim that, once completed and functional, the Pancheshwar Dam will displace around 80,000 people. Since the trauma of the 'Tehri refugees' has still not ended, they argue, why would we want to create 80,000 more homeless people?
- Much of the length of the five rivers joining close to Pancheshwar and their important Sangams will be inundated by the new reservoir. This may eliminate opportunities for Kriya Karam (cremation) ceremonies, which must take place shortly after death by flowing water. Local people will have to travel substantial distances over difficult topographies to dispose of their dead with dignity, ideally on the day of death before sunset or soon thereafter. A wide range of other water and natural resources issues are probable.
- About 15 kilometres of the fertile Saryu floodplains will be completely submerged, in addition to limited but important floodplain extent downstream.
- Dry riverbeds around the town of Pithoragarh will be filled by lake water, threatening connectivity to Pithoragarh. Indeed, some NGOs claim that this hill town may become an island.
- Like the Tehri Dam, the Pancheshwar Dam lies in Zone 4 of Seismic Activity. Between 1992 and 2006, over 10 earthquakes with a magnitude exceeding 5 (on the Richter scale) have had their epicenter within a radius of 10 kilometres around the site of the proposed Pancheshwar Dam, making the Pancheshwar Dam much more vulnerable to damage in an earthquake than the Tehri Dam (http://hydropowerstation.com/?p=200, accessed 30th April 2010).
- The proposed life of the project is claimed to be 100 years but, according to Dr Bidur Upadhaya (head of the Meteorology Department at Tribhuvan University, Kathmandu), it is more likely that the lifespan of the Dam would be 25 years since 68 million tons of sediment is released by the hills around Mahakali into the river

(http://www.pandeyji.com/uttarakhand/1.cfm, accessed 3rd May 2010). Big dams are invariability constructed without decommissioning in mind. Furthermore, there will be a probable increase in erosion in above-water areas of the Himalayas to which displaced communities may be resettled, potentially shortening dam life substantially with a commensurate loss of associated lifetime value.

- Reduction of monsoon flooding of villages in Uttar Pradesh and Bihar may bring advantages in terms of damage to infrastructure, but the trapping of silt and changed hydrology of rivers is not universally advantageous and likely to degrade ecological and agricultural value and destabilise habitats.
- The proposed creation of a new hill station is seen as resulting from enormous environmental and human costs.
- Afforestation carried out to compensate the loss of Uttarakhand's forests is not taking place within the state of in Uttarakhand but in Jhansi and Lalitpur Districts of Uttar Pradesh, raising questions about the appropriateness of the mitigation and its benefits to the people of Uttarakhand.

Political signals remain confused. Opposition by the current Nepalese government has already been referred to above. In India, the Chief Minister gave an assurance in early 2007 that no new big dams would be built in Uttarakhand, learning from the bad experience of the Tehri Dam. However, this was superseded by a new statement on 27th May 2007 in Delhi, on the sidelines of the Chief Minister's Conference of the Power Sector, which emphasised the need for early completion of the Pancheshwar Dam. It remains unclear whether the State Government now agrees with the need for big dams, or else now considers the Pancheshwar Dam (potentially the world's second-tallest dam) to be small. A further confounding factor is that the army is considering investing in a railway network to help it better police the Nepalese border, which would conflict with plans for the dam as well as competing for funding.

India's central government has already spent Rs. 780.90 Crores (7,809 million Rupees, equivalent to £114 million or US$176 million at May 2010 conversion rates) over the last five years on the project. The project is now stuck because the present Nepalese Government has not agreed with the Detailed Project Report prepared by India. Without the support of Maoists now in power as part of the Nepalese government, the Mahakali Project cannot proceed.

Notwithstanding the impetus provided by the vested interests of economically-powerful sectors, the future of the dam remains both contested and uncertain. Perhaps this will provide a pause for reflection about unanswered questions and overlooked issues.

1.9 Unanswered questions

The paucity of information readily accessible about the Pancheshwar Dam proposal is worrying, raising a number of issues in addition to those already discussed above:

- The periodicity of water releases from the dam is not known, but this will obviously have significant impacts on the geomorphological processes affecting the downstream catchment. This will be exacerbated substantially

by the almost complete blockage of sediment flows observed in large dam schemes around the world which can be expected to deplete floodplain, habitat and nutrient availability, particularly given the high sediment load carried by the glacial-fed Kali/Sharda River. It is assumed that water releases from the dam be near-continuous to optimise generation of electricity, further moderated by re-regulating dams.

- Conflicts between water availability and hydroelectric generation at the proposed dam, and the management regime that will balance the two, remains unclear. This has been a problem at the Tehri Dam, as it is in most large dam schemes around the world, due to competing demands for water and energy.

- Whilst levels of water extraction and energy generation have been calculated, the distribution of the broader costs and benefits from the scheme has not been addressed. There is understandably a perception that the Pancheshwar Dam will follow the outmoded 'elite project' model, which is precisely what the UN World Commission on Dams was set up to avoid. This occurs when planned benefits are likely to accrue disproportionately to clearly-identified influential beneficiaries, whilst wider implications for ecosystems and both identified (villages and families scheduled for displacement) and overlooked stakeholders at the dam site and in the wider catchment are excluded from decision-making. Sustainability is an unlikely consequence of this oversight, the eventual consequences of which have, where assessed in large dam schemes around the world, often proven disastrous environmentally, ethically and economically.

- There is no evident consideration of alternatives, either in terms of turbine type (Archimedean screw, etc.) or indeed whether the energy needs of people, and particularly the local people widely distributed over the mountainous landscape, are not better met with alternatives to dams (i.e. solar power, wind, microhydropower, etc.) The same oversight applies to alternatives to water use, including for example the benefits or existing terraced farming conserving both soil and water and supporting local people for millennia, capture from hill springs, etc.

- Neither is there any clear analysis of how this proposed dam scheme will halt or reduce power outages in the larger urban centres, including Delhi. Dam-based hydropower schemes work most efficiently providing baseload power through continuous operation, but may lack the capacity and agility to provide 'swing power' (marginal generation) to address peaks and troughs in demand. Neither is it clear what specific demand this hydropower scheme is addressing, nor the generation plant or other options that it might displace.

- The economics of energy seem not to have been addressed in any published documentation. Dynamic pricing, for example applying higher marginal costs during periods of peak demand, has proven effective in smoothing consumption of energy, water and other services. India operates substantial energy subsidy schemes: a World Bank study conducted by Larsen and Shah (1992) noted that Indian subsidies totalled US$2.6 billion,

or about 1.1% of total world energy subsidies, ranking it the 8th largest subsidiser of energy globally. This World Bank report highlighted that subsidies are widely misused as targeting subsidies to the poor has not been possible, with vested interests and corruption skewing support to protect industry and employment. Overall, notwithstanding wider arguments and commitments in favour of rights to energy, the outcome has commonly been to ration it to the rich. Overall, the International Energy Agency (EIA) estimates overall welfare loss due to subsidy was Rs. 201 billion (cited in the World Bank report), suggesting that India does not apply energy subsidies or allocations favourably with respect to sustainability or equity. The United Nations (2003) estimate that electricity subsidies in India "...encourage waste and hold back investment in power sector – a major constraint on economic development".

- Nepal is not planning for power generation to serve domestic consumption, intending it instead for export and raising revenue principally from India. This raises issues of ethics and long-term sustainability, raising funds by eroding ecosystem services without necessarily benefitting the majority of people.

- How many people will be displaced, directly or indirectly, and what are the 'knock-on' effects of this? Information from the Nepalese EIA indicates that 41,330 people (21,621 displaced by the Pancheshwar project and an additional 1,144 and 18,565 by the re-regulatory dams at Rupaligadh and Purnagiri projects) will be directly displaced. However, further secondary displacement, not yet accounted for, will result from communities affected by resettlement of displaced people, cleared for compensatory habitat, or affected by changes in downstream habitat including dam infrastructure, newly-irrigated areas and riverine habitat change. The final number of people thus affected is uncertain, but is likely to substantially exceed those directly displaced.

- It is interesting and relevant that the Nepalese EIA was sponsored by the Department of Electricity Development (DED), which is the chief proponent of the dam scheme on the Nepalese side, raising questions about the independence of the study.

- The Nepalese EIA also proposes a Detailed Resettlement and Rehabilitation Plan and another Detailed Environment Management Plan to recommend impact minimisation. It is notable that this is very late in the planning cycle, and is therefore not likely to impact on scheme design or decisions about whether to proceed or not.

- We await equivalent assessments from India, emphasising the many entrenched decisions in the Pancheshwar Multipurpose Project and how unlikely any serious efforts will be taken to address any social and environmental impacts exposed were such studies to proceed.

- Quantifying the numbers of people potentially affected by the Pancheshwar Dam scheme on the basis of published data is complex. However, outline numbers of people are affected are outlined in Table 1.4, together with the broad assumptions applied, comprising: 82,660 people in the immediate

area of the proposed Pancheshwar Dam; and as many as 8,461,643 affected in the wider catchment. It is accepted that these figures are crude and uncertain, but they do establish 'ballpark' values to understand the scope of potential impacts.

The biggest issues arise from what is simply not know or at least not communicated about the dam proposal, for example in the absence of an India or a published Nepalese EIA, the lack of alternative options, no assessment of the 'do nothing' scenario to justify the single engineered option, nor indeed any indication as to what precisely the problems are for which this is the only solution. There are also clear areas of disagreement, such as whether the life of the project is 25 or 100 years, numbers of displaced people, etc. Without a current assessment of the state of the present environment, it is also not possible to offer a fully informed critique of marginal impacts. Neither is there any published substantiation of the claimed generation of 'thousands' of jobs, nor a strategy for realising the claimed tourism benefits which, by comparison with other Indian reservoirs, seem to be massively exaggerated. All of these factors confound any firm assessment of likely impact.

Table 1.4: Approximate population affected by the proposed Pancheshwar Dam

- 82,660 people in the immediate area of the proposed Pancheshwar Dam, comprising:
    - 41,330 people (21,621 directly displaced by the Pancheshwar project and an additional 1,144 and 18,565 by the re-regulatory dams at Rupaligadh and Purnagiri projects as outlined in Table 1.3) which is considered by NGOs to be an overly conservative estimate
    - An equivalent number of people accounted for by 'secondary displacement' (affected by resettled communities and land cleared for habitat mitigation) in addition to those moved for dam/generation/transport/water infrastructure.
- 8,461,643 affected in the wider catchment comprising:
    - 106,000 reflecting 25% of people in the estimated 5% of Kumaon District of Uttarakhand state comprising the catchment of the Kali/Sharda river below Pancheshwar, based on the 2001 census 8,480,000 people
    - 53,000 reflecting an extra 50% of this (106,000) Indian total reflecting impacts in Nepal, where census data are not readily available
    - 8,302,643 reflecting 25% of people in the estimated 20% of Uttar Pradesh state comprising catchment of the lower Sharda river, based on a 2001 census which recorded that Uttar Pradesh is India's most highly-populated state with 166,052,859 people

2 Ecosystem service impacts of the Pancheshwar Dam

This report outlines the background and methods used to assess changes in ecosystem services likely to result from construction of the Pancheshwar Dam. All changes to the river ecosystem potentially affect broad societal constituencies who benefit from the multiple 'services' provided by the river system. The ecosystem services approach helps identify the groups and communities connected with and potentially affected by these schemes.

2.1 About ecosystem services

The term 'ecosystem services' describes the multiple benefits derived by society from ecosystems. These services are many and substantial, underpinning basic human health and survival needs as well as supporting economic activities, the fulfilment of people's potential, and enjoyment of life. The essence of the 'ecosystems approach' – management of whole ecosystems and their benefits using the framework of ecosystem services – is to consider these multiple benefits simultaneously, so that the realisation of one benefit is not achieved at cost to other benefits and their beneficiaries.

The developed world's history of industrial development has largely overlooked many of these ecosystem services, founded instead on an 'exploitation economics' model focused on limited and generally immediate benefits to the exclusion of broader consequences. Progress has consequently been accompanied by a 'shadow' legacy of unintended consequences which are now threatening to undermine further progress, eroding the often unrecognised or unvalued supportive capacities of the ecosystems that underpin human health, economic activities and realisation of potential. Current trends in ecosystem degradation demand greater recognition and improved stewardship of essential ecosystems if human wellbeing is not to be systematically undermined. Therefore, by definition, studies that select only a limited subset of ecosystem services, overlooking potential conflicts with other services and their beneficiaries, are not consistent with the ecosystems approach. (Many merely use 'new' terminology to perpetuate the outmoded 'exploitation economics' model, which exploits or manages ecosystems to optimise one or a few economically-valued services such as food production, water yield, power, timber, etc.)

Since the very concept of ecosystem services is based on the multiple benefits that ecosystems provide to society, it is inherently amenable to economic valuation. Environmental economics provide a common and transferable basis for assessing the different categories of benefits and disbenefits associated with the changes in ecosystem services that come from interventions in environmental systems. We will consider economic approaches and their associated difficulties later in this section. However, a key consideration to bear in mind is that, if the services provided by ecosystems are not valued, important aspects of those ecosystems themselves are inherently considered worthless in

decision-making processes. This explains much of the unintended but systematic historical decline in ecosystems of all types and scales across the world.

The ecosystem services concept recognises and potentially provides a means to quantify benefits to society, allowing ecosystems to be brought into planning and other decision-making processes, linking ecological with social and economic considerations.

Many parallel strands of ecosystem services science have evolved since the late 1980s, and have proven effective in advancing the understanding and management of various ecosystem types in different places across the world. In order to provide a uniform basis to assess the status of all major global habitats across all of the world's bioregions, the UN's Millennium Ecosystem Assessment (MA, 2005) combined these diverse 'ecosystem services' typologies into a consistent classification scheme. The MA classification groups ecosystem services into four main categories:

- 'Provisioning services' are those that can be extracted from ecosystems to support human needs, more or less synonymous with 'ecosystem goods' in some prior classification schemes, including such tangible assets as fresh water, food and fibre;
- 'Regulatory services' include those processes that regulate the natural environment, including the regulation of air quality, climate, water flows, erosion and pests;
- 'Cultural services' include diverse aspects of aesthetic, spiritual, recreational and other cultural values; and
- 'Supporting services' do not necessarily have direct economic worth but include processes essential to the maintenance of the integrity, resilience and functioning of ecosystems, and so the delivery of all other benefits. They include services such as soil formation, photosynthesis and water recycling.

The complete MA classification of ecosystem services is listed in Table 2.1.

Table 2.1: Millennium Ecosystem Assessment classification of ecosystem services

Provisioning services
Fresh water
Food (e.g. crops, fruit, fish, etc.)
Fibre and fuel (e.g. timber, wool, etc.)
Genetic resources (used for crop/stock breeding and biotechnology)
Biochemicals, natural medicines, pharmaceuticals
Ornamental resources (e.g. shells, flowers, etc.)
Regulatory services
Air quality regulation
Climate regulation (local temperature/precipitation, greenhouse gas sequestration, etc.)
Water regulation (timing and scale of run-off, flooding, etc.)
Natural hazard regulation (i.e. storm protection)
Pest regulation
Disease regulation
Erosion regulation
Water purification and waste treatment
Pollination
Cultural services
Cultural heritage
Recreation and tourism
Aesthetic value
Spiritual and religious value
Inspiration of art, folklore, architecture, etc.
Social relations (e.g. fishing, grazing or cropping communities)
Supporting services
Soil formation
Primary production
Nutrient cycling
Water recycling
Photosynthesis (production of atmospheric oxygen)
Provision of habitat

It is also valid to use locally-appropriate addenda services where appropriate, as we will do in this study to recognise the importance of the (provisioning) services of aggregate extraction and energy harvesting.

Although neither perfect nor complete, the MA typology provides a broadly inter-comparable set of services across bioregions and ecosystem types. It exposes the complexity and diversity of interactions between society and natural systems, the knowledge gaps about how all ecosystem services are ‘produced’, and the need for methods to monitor them.

2.2 Assessing likely ecosystem service impacts

Ecosystem services address the multiple benefits provided by ecosystems, and also the multiple beneficiaries of those services. Many of these services and

beneficiaries have historically been overlooked in decision-making, which has generally favoured politically- and economically-powerful interests likely to benefit from optimisation of selected services, including fresh water, energy, navigation and other generally narrowly-framed benefits flowing from dam schemes (World Commission on Dams, 2000). Since the Pancheshwar Dam is such a major construction, profoundly changing the nature and functioning of the wider Kali River system and its environs including influence for many kilometres upstream and downstream, it was important not merely to derive information on likely consequences from the few accessible official reports but also to reach out to hear the voices of as many stakeholders as possible, many of whose interests appear not to have been considered in scheme design.

This aspiration towards an inclusive approach was frustrated by a lack of resources to undertake bespoke surveys, failure to secure a Nepalese visa to assess Nepalese stakeholders, and the lack of a structured means to reach out to the diversity of stakeholders (particularly marginalised people) in the region.

Many of the pieces of information in this document, as well as that specifically used to inform likely ecosystem service impacts arising from the Pancheshwar Dam, were determined by a range of methods and from diverse sources listed in Table 2.2.

Table 2.2: Sources of input to the Pancheshwar Dam evaluation

- Various literature sources particularly including:
  - Mark Everard's (currently unpublished) review book *Dammed if we do, damned if we don't*;
  - UN's World Commission on Dams 2000 report *Dams and Development*;
  - International Commission on Large Dams and its publications (including ICOLD, 1981 and 2008);
  - The UNEP Dams and Development Programme and its various web and printed resources; and
  - Patrick McCully's 2001 *Silenced Rivers.*
- Structured internet searches, including informative web forums such as:
  - The 'My Uttarakhand' website http://www.pandeyji.com/uttarakhand/1.cfm, which contains a diversity of often conflicting views some of which are summarised in Table 2.3
- Official reports
- Online newspapers/media (citied throughout this report where relevant)
- Angling/ecotourism operators, including
  - www.india.angling.com; and
  - http://www.asianadventures.net/
- Observations and live interviews with a range of local stakeholders during an eight-day visit to Pancheshwar in April 2010 including:
  - D.P. Joshi MA, LLB, M/S Shaunak Construction, Saraswati Vihar Colony,

Pithoragarh, Uttarakhand, India

- Anurag Kumar, president of the *India Vision* NGO based at Dudwa National Park
- Local shop owners
- Tourism and hospitality staff at all levels from management to cleaning and cooking staff, to obtain views from all strata of society
- Angling ghillies
- Camp and resort cooks, drivers and managers
- Local people, including:
    - Polling local people in Pancheshwar village, Ghat village (20 kilometres up the Saryu from Pancheshwar), and Rameshwar at the Sangam of the Saryu and Eastern Ramganga Rivers
    - Discussion with attendees of various Kriya Karams (Hindu cremations) at the Pancheshwar Sangam
- Observations of infrastructure and activities at the very large Nanak Matta Dam, situated at Nanak Matta (Uttarakhand) on the N125 road between Rudrapur and Tanakpur. Although the website www.india9.com (accessed April 2010) claims that it is "...a beautiful picnic spot where one can enjoy boating and fishing", there was no evidence of any use or suitable facilities at the time of our two summertime inspections in April 2010. Recreational angling was neither observed nor referred to on websites, though government licenses were allocated for commercial fishing

- Email discussion with various other interested partners
- NGOs
    - Tiger Watch
    - Vision India (Dudwa Chowk, Bansinagar)
- Media:
    - John Sarkar, environmental journalist, Delhi, India
    - Gary Newman, angling journalist, UK
- Other UK professionals:
    - Dr Jacqueline Vale, environmental scientist
    - William Watts, Senior Economist, Environment Agency
    - Raphael Calel, PhD researcher, London School of Economics
    - Dr Debbie Pain, Director of Conservation, Wildfowl and Wetlands Trust
    - Janina Gray, Head of Science, Salmon and Trout Association
    - Prof. David Lerner, Catchment Science Centre, the University of Sheffield
    - Prof. Bob Harris, Catchment Science Centre, the University of Sheffield
    - Ed Shaw, Catchment Science Centre, the University of Sheffield

- Prof. Malcolm Newson, Tyne Rivers Restoration Trust
- Charlie Falzon, natural resources and international development consultant

- Other international specialists
  - Myles Mander, Eco-futures, South Africa
  - Dr John Colvin, Khanya-aicdd, South Africa
  - Sam Chimbuya, Khanya-aicdd, South Africa

Table 2.3: Selected citizen entries on the forum of the 'My Uttarakhand' website

Selected extracts from http://www.pandeyji.com/uttarakhand/1.cfm (reviewed 25th April 2010, with some clarifications of English but much left as written):

- Bharat Bahadur Kunwar (4th March 2010): "In the name of development we are destroying the nature. In recent past the flood in bihar is because of such dams..."
- Manoj Kumar Suteri (12th February 2010): "This project will make our state able to withstand with other developed states. It will surely make India feel proud as its the 2nd highest dam in all over world and strengthen the Indian infrastructure."
- Lt. Col.(Retd) JC Joshi (26th January 2010): "The Dam will come up as the Central Govt. is interested. In order to rehabilitate displaced people and to make Uttarakhand(UK) look like Switzerland of the East, Strategic Action Plan(SAP) JAGRITI was submitted to the state govt."
- Anand Prakash (07th November 2009): "It is really unfortunate that we are opposing such a nice project which will bring revolution in our life. Mighty River Mahakali/Sharda has great potential & we are not harnessing it just in the name of ENVIRONMENT. All developed countries has made such big Dams & now they are trying to stop India to harness its Natural Resource given by the ALMIGHTY."
- Gautam Joshi (11th August 2009): "Please do not even think of implementing such a project , cause the number of lives which will be displaced cannot be judged. It will also spoil the natural beauty of the place. Rather the government should focus on small dams. We have already seen the Tehri disaster... plspls don't do it again."
- Arvind Singh Chand (18th December 2008): "To protect one population of our country from flooding how can submerge the lives and dreams of 115 Villages. Tehri has already shown the misery of hills and doing it again in such an eco-fragile zone will be like - learning no lessons from our previous mistakes."
- BCK Mishra (14th November 2008): "There is no life without water and power. Hence development of power projects with storage facility is a must."
- Asha Pandey (5th August 2008): "Uttarakhand is not in a state to effort the ecological harm caused by such big dams.... its better to go for mini hydro power projects....to cope up various environmental maladies."
- Raman (03rd August 2008): "What the hell has done by tehri dam???? the area for which GANGA River has stopped is completely dried out... government is playing with the sentiments of hindus.. how dare one to stop GANGA... the consequences will be right in front of each one that GANGA will take revenge over that..."
- Aniruddha Khanwalkar (21st May 2008): "As this project is not going to materalize now for which maoist are to be blamed, but who will answer about the huge loss incurred in terms of governmental fund of rupees 780 crore, who will answer to it. This a big question in front of all of us as we should seek answers from our loyal polititians about them."
- Rajendra Kandari (24th July 2007): "When i hear uttarakhand will get benefit from

the project like tehri dam and we will get lot of electrisity from the projects. but when I went to my native place Garhwal their I find no electrisity in the village." • Renu (16th June 2007): "When will our Government give up uprrooting ppl to make dams? Plz keep up the gud fight!"

Comments in Table 2.3 express a common polarisation of views:

- Some see the Pancheshwar Dam as symbolic of industrialised progress, and that it must progress as a right. ("*This project will make our state able to withstand with other developed states. It will surely make India feel proud as its the 2nd highest dam in all over world and strengthn the Indian infrastructure*", "*Mighty River Mahakali/Sharda has great potential & we are not harnessing it just in the name of ENVIRONMENT. All developed countries has made such big Dams & now they are trying to stop India to harness its Natural Resource given by the ALMIGHTY*", "*There is no life without water and power. Hence development of power projects with storage facility is a must*")

- Others highlight environmental ("*In the name of development we are destroying the nature*", "*To protect one population of our country from flooding how can submerge the lives and dreams of 115 Villages*") and social or equity concerns ("*Please do not even think of implementing such a project , cause the number of lives which will be displaced cannot be judged*", "*...government is playing with the sentiments of hindus*", "*When i hear uttarakhand will get benefit from the project like tehri dam and we will get lot of electrisity from the projects. but when I went to my native place Garhwal their I find no electrisity in the village*").

This dichotomy between 'environmental and social concerns' and 'progress' is of course revealed as false, when viewed from the perspective of sustainability. As made clear in the UN's report *Our Common Future* (World Commission on Environment and Development, 1987), the Millennium Ecosystem Assessment (2005), extensively reviewed in the book *The Business of Biodiversity* (Everard, 2009) and many other sources, the supportive capacities of the environment are fundamental to human health, economic activities and realisation of potential which, if omitted from consideration of 'progress', call into question the very nature and long-term viability of development projects.

It is interesting to note that only one comment considers alternatives means of achieving planned benefits from the dam. ("*Uttarakhand is not in a state to effort the ecological harm caused by such big dams.... its better to go for mini hydro power projects....to cope up various environmental maladies*"). This is one option for providing power to the highly scattered communities distributed across huge areas Himalayas in difficult terrain, for which the costs, resource requirements and vulnerabilities to frequent landslides, monsoons and other extreme weather may make traditional wired distribution systems inefficient for anything other than larger towns and villages.

Issues of mistrust about government intentions to distribute power are also raised. ("*When i hear uttarakhand will get benefit from the project like tehri dam and we will get lot of electrisity from the projects. but when I went to my native place Garhwal their I find no electrisity in the village*"). There are also issues of

significant transmission losses entailed in such wide area distribution, raising further questions about the appropriateness of the nature of the generating capacity (good for serving major conurbations but not dispersed communities though perhaps this is the primary design intent) and the energy needs of local people which may be better served by providing them with, or subsidising, solar panels in this well-irradiated region backed up by battery storage for after-dark powering of lights, radios and other domestic equipment.

It was evident from discussions with many of these stakeholders that there was poor understanding of how the dam might impact them. For example, a group of attendees who had come from a village 30 kilometres distant for one of the Kriya Karam (cremation ceremonies) at Pancheshwar collectively expressed support for the dam project on the grounds that they might get an electricity supply although, on our enquiry, they were uncertain as to whether their village would be inundated by dam filling. This focus on a single anticipated benefit with little or no consideration of the many other potential direct and indirect impacts on the village, including for example the loss of sacred Sangam sites where they might have to go to dispose of their dead by flowing water or even inundation of whole village and homes, emphasises the polarised and disinterested nature of local concerns about the wider implications of the project.

Obtaining official information about the proposed Pancheshwar Dam project and assessment of its likely outcomes was also extraordinarily difficult. For example, how will the water be diverted to Delhi and where are the formal project plans stored in ways that mean that it is possible for the wider public to scrutinise and query them? Are there large elements of infrastructure that are not in the public domain (for example we could find no information on how water from the dam would be channelled to Delhi as intended), or else are they only poorly communicated, and do any stakeholders beyond design consultants and vested interests have easy access to such details?

2.3 Weighting likely ecosystem service impacts

Given the magnitude of the Pancheshwar Dam scheme and the area and breadth of stakeholders it will affect, compounded by a lack of resource for more detailed bespoke studies, it was decided early in this study that full quantification of impact was not an attainable goal.

This lack of effective quantification, as well as cultural differences relative to established developed world economic methods, also meant that economic valuation could not be applied. This is unfortunate as environmental economics provides a common and transferable basis for assessing the different categories of benefits and disbenefits associated with changes in ecosystem services that come from interventions in environmental systems. Ecosystem services themselves are largely amenable to economic valuation as they relate to different categories of human benefit.

Nevertheless, likely changes to ecosystem services need not be fully quantified or valued in order to be useful in decision-making. Given the large number of stacked assumptions entailed in economic valuation, calculated figures

generally have no absolute meaning but indicate tendency and magnitude. Other methods to achieve this may therefore be equally valid and useful in analysing complex issues and determining solutions where perfect information is unavailable. To streamline decision support processes, and identify the most significant likely impacts or uncertainties that may need to be further explored or quantified, Defra (2007) developed a 'likelihood of impact' weighting score which is reproduced in Table 2.4.

Table 2.4: Defra 2007 'likelihood of impact' weighting system

Score	Assessment of effect
++	Potential significant positive effect
+	Potential positive effect
O	Negligible effect
-	Potential negative effect
--	Potential significant negative effect
?	Gaps in evidence / contention

The Defra (2007) report summarises a case study in which this weighting system was applied to the problem of coastal defence infrastructure is Wareham Harbour (Dorset, England) which had reached the end of its effective life. A number of options were considered with a range of affected stakeholders and, using the Defra weighting system, a unanimously preferred option emerged (managed realignment entailing the setting back of defences and restoration of intertidal habitat) with no need for the expense of delays entailed in quantification and full benefit-cost assessment.

Therefore, the Defra (2007) weighting system is applied in this study to learn about some of the diverse likely impacts of the proposed Pancheshwar Dam.

2.4 Limitations of this study

It was not possible to determine gross projected lifetime benefits from the Pancheshwar Dam, and therefore to calculate a likely benefit-to-cost ratio arising from the substantial investment of Rs 21,780 Crores. Nor was it possible to find a published or reported analysis of associated risks. We have also already acknowledged practical difficulties with monetisation of ecosystem service benefits and disbenefits. This is unfortunate as economic assessment has been helpful in determining the balance of opportunities and risks in many other schemes (see for example Defra, 2007; Everard, 2009; Everard, 2010; Everard and Jevons, 2010).

We lacked a budget for any of this work, all of which was self-funded by the authors. Given a budget for this work, we would ideally have undertaken more stakeholder engagement to ensure that all affected views were represented and that, therefore, no ecosystem services were overlooked or underrepresented. This would have enabled us better to quantify and, ideally, monetise impacts to advance the analysis.

Wider stakeholder engagement would also have been consistent with evolving good practice in the mainstreaming of collaboration with communities and stakeholders in flood risk management and other environmental decision-

making, as mandated by the UNECE Aarhus Convention of 1998 (UNECE Aarhus Convention, 1998) and supported by a report on mainstreaming stakeholder engagement in flood risk management produced for the UK's Environment Agency (Colbourne, 2009).

Other issues yet to be researched include the scale of impact of some of these ecosystem services, some of which may diminish over relatively small distances (for example fall-out of sediment) but others of which may have considerably wider ramifications across the catchment (for example recruitment of fish, support for other wildlife and a contribution to river water quality) and more broadly (such as though enhancement of air quality or regulation of climate-change gases).

3 Results of the ecosystem services assessment of the Pancheshwar

This section summarises key findings about the likely impacts of the proposed Pancheshwar Dam, summarised from a detailed ecosystem service analysis in Annex 1. Likely positive and negative impacts and uncertainties are assessed for each MA ecosystem service, taking account both local impacts and catchment-scale impacts. For this purpose, 'local' can cover an extensive area including the dam and reservoir site (which will be large but the full extent of which is uncertain) as well as the 'command area' for which planned benefits of supplies of water and power are targeted. 'Catchment-scale' considers the ramifications of this major dam proposal on the Kali/Sharda catchment, including its tributaries both upstream and downstream, as well as wider impacts such as on microclimate and wider climate regulation.

3.1 Assessment of likely ecosystem services impacts of the proposed Pancheshwar Dam

Table 3.1 summarises conclusions derived from detailed analysis of likely ecosystem service impacts from the proposed Pancheshwar Dam in Annex 1.

Table 3.1: Summary of results for impacts of the Pancheshwar Dam

MA ecosystem service category	Overall assessment of likely ecosystem service impacts
Provisioning services	**The overall balance of benefits of the proposed Pancheshwar Dam scheme are equivocal or negative across the provisioning services, when implications for diverse ecosystems and their dependent stakeholders are assessed in parallel across local and catchment scales. The picture emerging is that some local gains are balanced by other local impacts. However, catchment-scale impacts, which seem not to have framed scheme design, are likely to be overwhelmingly negative. This raises issues of equity in access to the various benefits and costs of the dam scheme, and the extent to which wider ramifications beyond narrowly-defined benefits have been considered along with alternative methods for their achievement**
Regulatory services	**Assessment of regulatory service impacts, both at the dam site and at catchment scale, reveals substantially negative likely consequences for ecosystems and the interests of the many people dependent upon them, even for the planned benefits for local populations**

Cultural services	**Assessment of impacts of the dam on cultural services suggests almost unanimous significantly negative outcomes at both dam and catchment scales**
Supporting services	**Assessment of impacts of the dam on supporting services suggests unanimous significantly negative outcomes at both dam and catchment scales, degrading ecosystem integrity and functioning and the wider resilience and societal benefits that it is able to provide**

These impacts accrue from a substantial estimated project cost of Rs 21,780 Crores (217,800 million Rupees) in 2007 prices.

4 Ecosystem service implications of the sustainability of the proposed Pancheshwar Dam

The World Commission on Dams (WCD) produced their comprehensive and authoritative report *Dams and Development* in 2000 to avert the widespread unsustainable outcomes of large dams often repeated across the world. *Dams and Development* proposed a set of seven 'strategic priorities', each supported by a set of policy principles, to guide water resource management programmes recognising human rights, the right to development and the right to a healthy environment. These 'strategic priorities' are reproduced in Table 4.1.

Table 4.1: The seven 'strategic priorities' of the WCD (2000)

1. Gaining public acceptance. The public acceptance of key decisions is essential for equitable and sustainable water and energy resources development, recognising rights, addressing risks, and safeguarding the entitlements of all affected people.

2. Comprehensive options assessment. This entails assessing all available options, including alternatives to dams, in addressing clearly-defined water, food and energy objectives. This requires a comprehensive and participatory assessment of needs and options, within which social and environmental factors have the same weight as economic and financial factors.

3. Addressing existing dams. Opportunities are not limited to new dams but extend also to the design and operation of existing stock which may be revised to better address social issues, environmental mitigation and restoration, evolving technology, and changes in land and water use in the river basin.

4. Sustaining rivers and livelihoods. The integrity, resilience and functioning of catchment water systems provides the basis for life and the livelihoods of local communities, so ecosystem protection and/or restoration is central to equitable human development. Avoidance, minimisation and mitigation of harm through dam site, design and operation can safeguard elements of ecosystems and resource-dependent livelihoods.

5. Recognising entitlements and sharing benefits. The needs and implications of dam-affected people need to be included at all stages, with a presumption in favour of 'development' improving their livelihoods.

6. Ensuring compliance. All commitments made for the planning, implementation and operation of dams must be adhered to in order to ensure public trust and cooperation, including an appropriate mix of regulatory and non-regulatory measures incorporating incentives and sanctions.

7. Sharing rivers for peace, development and security. Transboundary rivers can be a focus for tension but also cooperation between and within countries, with the disruptive impact of dams requiring constructive cooperation to promote mutual self-interest and peaceful collaboration.

The Commission's criteria and guidelines were produced to help governments, developers and owners meet emerging societal expectations when faced with the complex issues associated with dam projects. Adopting this framework is intended to allow states to take informed and appropriate decisions, thereby raising the level of public engagement and acceptance and so improving development outcomes. These priorities and principles are intended to come to life when applied within a practical project planning cycle, involving all stakeholders from planners to states, consultants and development agencies, developers and affected communities.

For this reason, the World Commission on Dams' seven 'strategic priorities' are used as a framework to structure this assessment of the proposed Pancheshwar Dam, informed by the information and ecosystem service analysis in this report, and taking into account subsequent developments such as evolving understanding about ecosystem services and their implications for human wellbeing.

4.1 WCD priority 1: Gaining public acceptance

Much controversy and uncertainty still surrounds the proposed Pancheshwar Dam. Although driven largely by political agreements rather than clear local needs, with the Government of Nepal opposing further development at the present time, the likely impacts of the Pancheshwar Dam are substantially broader than the scope of stated benefits. All of this has impacts, some of them profound, on the wider catchment ecosystem both downstream and upstream and potentially affecting a very wide range of stakeholders.

Communication and engagement of stakeholders in decision-making has been wholly inadequate. This is clear from difficulties in locating official projections of dam benefits and assessments of wider impacts. Some relevant studies have yet to be commissioned late in the planning process, seemingly ruling out any alternative options. There is also a widespread lack of understanding amongst affected and adjacent populations about the scheme and its implications.

It is therefore not possible to support the view that public acceptance of key decisions has been secured, nor indeed that the proposed Pancheshwar Dam can be assumed to represent equitable and sustainable water and energy resources development. Indeed, it fails to recognise rights, address or even recognise risks, and safeguard the entitlements of all affected people.

4.2 WCD priority 2: Comprehensive options assessment

There is no readily-accessible evidence that suggests that any, let alone comprehensive, options assessment has been undertaken. For example, although projections have been made for energy generation with a 13% allocation to the state of Uttarakhand, it is not clear that this big centralised generation can realistically meet the needs of communities that are widely scattered across difficult terrain. Conventional wire transmission over such extensive and mountainous terrain to deliver power to the communities

scattered across it would be infeasible for many reasons, including such basic considerations as the amount of metal required for wiring. In practice, small-scale, distributed renewable power – particularly solar, but also conceivably wind, small-scale hydro, etc. – backed up by battery storage to operate lights and other low-demand domestic and other appliances may be more appropriate and economically more efficient for the day-to-day needs of the local community. Other issues around the sale of energy by Nepal in preference to meeting domestic needs, and of lack of analysis of how the dam-derived energy might address unspecified energy demands from elsewhere in India, reinforce the conclusion that options appraisal of energy solutions have not been undertaken.

Neither does the balance of water stored for irrigation versus agricultural land lost in valley bottoms and lower slopes, as well as opportunities for grazing and cropping from hill forest, appear to have been considered. Food and energy security issues pre- and post-dam have yet to be clarified, though it is clear that a large dam might favour powerful economic interests associated with downstream irrigation and potential industrial development rather than the wellbeing of scattered rural communities.

Also addressed previously, there is no evidence of how conflicts between water demand for irrigation, industrial and urban demands will be resolved with water use in hydroelectric turbines.

A comprehensive and participatory assessment of needs and options, within which social and environmental factors have the same weight as economic and financial factors and all stakeholders are considered on an equitable basis, as required by this WCD ‘strategic priority’, has evidently not been undertaken.

4.3 WCD priority 3: Addressing existing dams

Although we are considering the proposed Pancheshwar Dam, the reported experience and forum feedback on the Tehri Dam on the Bhagirathi River, also in the state of Uttarakhand, is less than favourable. Compensation has not thus far been given to those to whom it is promised, and NGOs claim that impacts upon people are far wider than formally identified. The prognosis is less than good for the rigour with which the proposed Pancheshwar project might be progressed.

4.4 WCD priority 4: Sustaining rivers and livelihoods

The detailed ecosystem services assessment of available evidence suggests that the river and catchment ecosystem, and the many ways in which it supports human wellbeing, will be significantly undermined by the proposed dam project. If the supportive capacities of the river ecosystem are degraded, with a loss of integrity, resilience and functioning, the implications for the wellbeing and livelihoods of communities, both locally and at catchment scale, are worrying.

There is a published commitment to plant forest to offset the loss of that which would be inundated. However, this afforestation is not taking place within the state of Uttarakhand but in the Jhansi and Lalitpur Districts of Uttar Pradesh.

This raises questions about the appropriateness of the mitigation and its benefits to the people of Uttarakhand. Experience from the Tehri Dam and Vishnu Prayag Hydro Project, mirroring experiences repeated in many case studies in *Dams and Development* (World Commission on Dams, 2000) and reflecting the exclusion of many stakeholders in the decision-making process, suggests that sustaining the livelihoods of all people has been marginalised in the Pancheshwar Multipurpose Project.

In the absence of evidence of recognition and mitigation of ecological and human impacts in dam design, net degradation of ecosystems and the livelihoods and wellbeing of people is certain to result were dam construction and operation to proceed.

4.5 WCD priority 5: Recognising entitlements and sharing benefits

This WCD strategic priority recognises that the needs and implications of dam-affected people should be included at all stages, with a presumption in favour of 'development' improving their livelihoods. There appears to be only a narrow consideration of people 'affected' by the dam, including only villages and families displaced by dam filling with NGOs contesting the numbers actually displaced. An indeterminate but larger number of people will be affected by 'secondary displacement', due to impacts on communities into or close to which displaced people are translocated, and further displacement can be expected in land scheduled for habitat mitigation as well as newly-irrigated farmland.

The ecosystem service assessment, particularly the overwhelmingly significant likely negative consequences for currently non-marketed regulatory, cultural and supporting services, reveals substantial changes in the nature and functioning of ecosystems which will have substantial implications for many more people and their human rights, rights to development and enjoyment of a healthy environment.

There is no evidence that anyone other than economically- and politically-influential people have been included in identification and assessment of options, design and development phases. Entitlements and benefit-sharing have therefore been comprehensively overlooked.

4.6 WCD priority 6: Ensuring compliance

There are few readily-accessible commitments to which compliance can be monitored. However, experiences from the Tehri Dam and Vishnu Prayag Hydro Project, and from the general lack of recognition of the rights of the environment and people in the Pancheshwar Dam project to date, does not bode well for new dam proposals in Uttarakhand. Little or no effective public communication and engagement has occurred.

The support of the United Nations for the World Commission on Dams and its recommendations, and their subsequent promotion through the UNEP Dams and Development Programme (www.unep.org/dams), effectively constitutes an

additional set of criteria to which large dam schemes should comply. The proposed Pancheshwar Dam clearly fails on all counts of the seven WCD ‘strategic priorities’.

4.7 WCD priority 7: Sharing rivers for peace, development and security

This strategic priority recognises that transboundary rivers can be a focus for tension but also cooperation between and within countries, with the disruptive impact of dams requiring constructive cooperation to promote mutual self-interest and peaceful collaboration. The proposed Pancheshwar Dam across the Kali River, which divides India and Nepal, is one such transboundary river, with the neighbouring Indian states downstream also potentially significantly affected. The Kali is also a major tributary of the Ganges, but the implications of the proposed Pancheshwar Dam scheme on Bangladesh on the Ganges delta is less certain, although the cumulative impact of the many dams on the Ganges system may be significant for sediment, water and other services supporting Bangladeshi livelihoods.

Some of the planned benefits of the proposed Pancheshwar Dam, in terms of energy and water, are assessed. However, failure to recognise and account for wider impacts on ecosystems, with significant ramifications for people both locally and more distantly, must call into question the contribution of the dam to peace, development and security both within and between countries.

The lack of agreement between Nepal and India suggests that the opportunity for sharing in the benefits, and avoiding the pitfalls, of this proposed scheme have yet to be grasped.

5 General conclusions

The overall impacts of the proposed Pancheshwar Dam have simply not yet been addressed in the planning process. EIAs and similar studies, arriving or planned only late in the planning cycle when major sunk costs have proceeded down only one narrow 'big technology' route, suggests that these wider impacts are unlikely to influence scheme design. This replicates much of the myopia and many of the oft-repeated mistakes of big dam schemes around the world, for which the UN established the World Commission on Dams (WCD). It is then far from surprising that the proposed Pancheshwar Dam scheme conflicts profoundly with all seven of the WCD's 'strategic priorities', underlining its failure to respect principles of both equity and sustainability.

5.1 Environmental consequences

The Himalayan ecosystem within which the dam is planned is characteristic and supports a diversity of wildlife, much of which is threatened. Dam construction and operation will inevitably destroy or degrade this ecosystem across a wide geographical range, including the blockage of migration of fish and other aquatic taxa as well as disturbing flows of sediment, water and biota. The migration routes of terrestrial fauna will also be impeded. It will also be harmed by increased human pressure arising from both dam-related activities and from higher densities of people displaced to less ideal land.

However, environmental impacts will not be limited just to the dam site or the wider Himalayan region within which it is located. The substantial flows of sediment and associated nutrients in the currently turbid waters of the Kali/Sharda River will be arrested, starving the lower catchment right down onto the Gangetic Plain, the Ganges itself and adjacent high-priority habitats of soil fertilisation and habitat-forming materials, exacerbated by the replacement of a naturally seasonal hydrology with smoothed flows driving quite different habitat-forming processes and favouring other organisms. This tends to favour 'weedy' species and lower biodiversity, progressively swamping native ecosystems and processes adapted to more variable flow regimes. This threatens priority wildlife sites such as National Parks, as well as natural resources such as soil, water quality and fish stocks.

5.2 Social consequences

Environmental consequences are, of course, not merely of concern for altruistic reasons but because they affect the livelihoods of many people through the multiple beneficial services that they provide both directly and indirectly. Over and above the direct and indirect impacts of displacement of people, and the loss of traditions, sacred sites and lifestyles for which money can't compensate, ecosystem-related impacts across the wider catchment can be expected to reduce the quality of life of a large number of rural communities omitted from consideration.

Notwithstanding the crudeness of methods and assumptions used in Table 1.4 to derive a 'ballpark figure' of the level of human population potentially affected by the proposed Pancheshwar Dam scheme (82,660 people in the immediate area of the proposed Pancheshwar Dam and as many as 8,461,643 affected in the wider catchment), it is certain that we are dealing with very large numbers of people, most of whom appear to have no voice in decisions potentially radically affecting their livelihoods. The democratic mandate of the people promoting the dam scheme remains unclear.

Serious questions are therefore raised not only about the wider impacts on people of the proposed dam scheme but on the vitality of ecosystems essential to support the health, livelihoods including economic activities, and the potential of all people into the future.

5.3 Economic consequences

Whilst the planned benefits of the scheme are easy to articulate and cost – more water for irrigation, industry and urban use and energy generated for consumption and sale – the net impacts upon bordering States within India and Nepal, and for national interests, have yet to be considered. This preliminary ecosystem service-based assessment is a first step, circumscribing some of the broader context of dam impacts and their ramifications for net sustainability and public value.

When overlooked impacts for the vast majority of ecosystem services, and the many beneficiaries that depend upon them, are taken into account then the huge and long-lasting costs that they entail are likely to be substantial. Further risks with substantial economic implications include the (currently overlooked) implications of the dam coming to the end of its useful life, and of course the potential harm that might arise from the failure of what may be the second-tallest dam in the world built in a place prone to the world's strongest earthquakes.

These costs – identified through ecosystem services, scheme end-of-life and risks of failure – have not been quantified for the reasons stated earlier in this report, but can nonetheless be assumed to be very substantial. Furthermore, it remains to be identified who will bear the costs: government, businesses gaining advantage from this scheme design, or the affected individuals? This has implications for their wellbeing in many ways, including risks to life and limb but also in terms of the costs of resources and services (such as insurance or interest on loans for projects in less secure locations). And, let us remind ourselves, the numbers of people potentially affected are very substantial which would have a massive influence on costs were it possible to calculate them in future studies.

It is far from clear who will pick up the costs of fixing these diverse impacts on people's lives arising from direct and indirect dam impacts or a catastrophic seismic-driven failure as described above.

5.4 Net value to Nepal, India and beyond

Counting only the value of energy generated for use or sale, and of water for industrial, urban and irrigation schemes, could give the impression that the proposed Pancheshwar Dam will deliver substantial benefit. However, this would be to ignore the many unintended or overlooked costs observed generally from big dam schemes around the world, and the specifics of this proposal as articulated above.

The statement by the Nepalese project-in-charge officer Dilli Bahadur Singh, reported in Table 1.1, typifies the myopia of political interests driving such schemes:

- "Although the negative side of the project cannot be sidelined, the project in itself is one of the most viable and cost-effective";
- "The rate of return is estimated at 25.4 percent, which means the country will reap returns within three to four years"; and
- "The entire Pancheshwar site can be developed as a tourism destination".

Singh is also reported as adding that thousands of people will find employment, a 300 km ring road will be built, a cable-car line can be erected, 9,000 hectares of forest area can be developed and another 100-150 km south-north road will be built.

Whilst these conclusions may be true if one overlooks wider ramifications, the many case studies summarised in the *Dams and Development* report (World Commission on Dams, 2000) and UNEP's subsequent Dams and Development Programme (www.unep.org/dams) highlight the substantial costs externalised in both decision-making and evaluation in major dam schemes around the world. Given the scale of likely ecosystem services impacts arising from the proposed Pancheshwar Dam, these costs are again likely to raise deep and unanswered questions above the net, long-term value of the scheme at local, state and national scales. Neither can we safely overlook implications for the wider Ganges system into which the Kali/Sharda discharges and which runs into neighbouring states and the also for Bangladesh on the Ganges delta.

5.5 Governance issues

The drivers for this scheme remain unclear, but evidence from marginalisation of stakeholders in the decision-making process, 'lock in' to a single large-scale engineering solution and late development of EIAs and other studies based only on this option points to a blinkered 'top down' process. The influence of politically- and economically-powerful players, primarily large-scale users of energy and water (be they private/industrial, metropolitan or other government interests) is impossible to ignore.

With such a centralised governance system, ignoring impacts upon the wellbeing of a large mass of people directly displaced or marginalised from governance processes but framed only on one 'big technology' solution, far-sighted decisions addressing all likely dam impacts are a remote possibility.

5.6 Political consequences

Failure to observe UN-backed 'strategic priorities' and evidence that the decision-making process is opaque and favours already-advantaged stakeholders with large-scale energy and water demands supports accusations that Indian government, both state and national, is undemocratic and therefore subject to nepotism, patronage and corruption. This has ramifications for the perception of India on the world stage.

Ignoring basic engagement with stakeholders and overlooking implications for so many ecosystem services and the many beneficiaries that depend upon them also has radical implications for human rights. Again, this opens Indian government institutions to accusations of hegemony and infringements of the rights of a sizeable disempowered body of people. It also puts it outside of the spirit and letter of international conventions (such as the UNECE Aarhus Convention on public participation in environmental decision-making and the UN's Universal Declaration of Human Rights) and near-statutory agreements (such as the 'strategic priorities' of the World Commission on Dams).

All of these political failures have ramifications for the confidence and criteria required by international funding agencies and other donors including national development aid funds and the World Bank.

Private financial institutions may also be dissuaded from making loans for schemes for which adequate risks assessment has been bypassed, and which attract legitimate ethical and environmental concerns and their associated reputation issues.

There is clear evidence to underline these substantial political risks, raising searching questions about the net public value of the proposed Pancheshwar Dam development scheme in its current form. Without radical reassessment and appraisal of options on the basis of the principles used to frame this study, it is clearly a short-term and unwise investment by the state which looks certain to undermine the short-term interests of many people and the long-term prospects of all citizens.

5.7 Recommendations for sustainable investment

So might the development proposal be put on a sustainable footing? We have tried to answer this question in the flow of this study, which includes:

- The ecosystem service assessment to assess the broad implications of options (noting that only one option has thus far been presented); and
- Checking for consistency with the rights-based 'strategic priorities' advanced by the World Commission on Dams.

Rights to development are accepted. However, we advise against undermining people's long-term wellbeing, however good the short-term intentions may be, from doing so unsustainably.

If we accept the two driving objectives behind the current proposed Pancheshwar Dam scheme – energy generation and water security – then we must also add the caveats that the ways that these are developed must reflect real and identified needs and also be achieved without undermining the ecosystems that underwrite the long-term interests of all people.

Given the exposed serious flaws in the current Pancheshwar proposal, this reassessment would have to start from a 'clean sheet of paper' to consider how aspects of the proposal or its alternatives can address these broader objectives. The kinds of steps and questions that need to be addressed, framed around the WCD 'strategic priorities' and informed by implications for ecosystem services, are noted in Table 5.1.

Table 5.1: Steps and questions towards sustainable water and energy development

Identify development objectives.

- Water, energy, and protection of ecosystem services for public wellbeing, respecting the importance and rights of all people

WCD priority 1: Gaining public acceptance.

- Develop outreach processes to engage with all affected stakeholders
- Share all relevant documents and details with stakeholders
- Co-creation of solutions addressing agreed objectives

WCD priority 2: Comprehensive options assessment.

- Open-minded consideration of alternative options for meeting these objectives
- How do all stakeholders use water and energy, and how can this best be served?
- Identify and agree with all stakeholders evaluation criteria to select optimal option

WCD priority 3: Addressing existing dams.

- Review existing dams and schemes in development to retrofit lessons learned

WCD priority 4: Sustaining rivers and livelihoods.

- Ecosystem integrity and functioning should be a priority to protect the ecosystem services supporting the long-term livelihood needs of people

WCD priority 5: Recognising entitlements and sharing benefits.

- Evidence-based statement of how the preferred option sill benefit all stakeholders

WCD priority 6: Ensuring compliance.

- Transparent commitments to obligations, with monitoring regime in place

WCD priority 7: Sharing rivers for peace, development and security.

- Collaboration with all neighbouring states and countries around agreed objectives

We commend this revised approach to government departments tasked with advancing development. This should be supported by comprehensive assessment tools such as ecosystem services analysis, in preference to confrontational (i.e. perceived 'pro-development' versus 'environmental and social concerns') approaches based on a narrow framing of objectives and solutions.

Ecosystem service assessment informs us about the widespread likely consequences for ecosystems, people and the economy. This can expose the short-sightedness and inequity of narrowly-conceived proposals and failure to engage people in their development. However, it can also provide guidance on what could constitute sustainable, equitable and beneficial solutions acceptable to most, if not all, stakeholders, achieving optimal value in the longer term.

Annex 1: Assessment of impacts of the Pancheshwar Dam

This Annex contains detailed considerations of ecosystem services impacts of the Pancheshwar Dam. Likely positive and negative impacts and uncertainties are assessed for each MA ecosystem service, taking account both of local impacts and catchment-scale impacts. For this purpose, 'local' can cover an extensive area including the dam and reservoir site (which will be large but the full extent of which is uncertain) as well as the 'command area' for which planned benefits of supplies of water and power are targeted. 'Catchment-scale' impacts include the ramifications of the major dam on the Kali/Sharda catchment, including its tributaries both upstream and downstream, as well as wider impacts such as on microclimate and wider climate regulation.

These ecosystem service assessments draw upon the various information sources and background material in the body of this document. Explanations of each assessment, using the Defra (2007) weighting system, are outlined in Tables A1.1–A1.4 respectively for provisioning, regulatory, cultural and supporting services.

Table A1.1: Provisioning service impacts of the Pancheshwar Dam

Provisioning Service Overall weighting (Defra, 2007)	**Local impact** Weighting and explanation	**Catchment-scale impact** Weighting and explanation
Fresh water **0**	**++** Much of the justification for dams in general is that they hold back water for agricultural, industrial and/or urban supply, smoothing supplies across seasons. This dam will deliver this benefit locally as well as serving Delhi, although implications of the loss of water retention techniques (i.e. terraced agriculture) and other options have not been set as a benchmark	**--** Many reviews of dams schemes around the world (see table of 'Sources of Information') highlight catchment-scale impacts for many users of water, other than target and often influential beneficiaries, as well as catchment-scale disruption of hydrology and water availability and quality
Food (e.g. crops, fruit, fish, etc.) **0**	**+** Akin to the benefits of stored 'fresh water', areas scheduled for irrigation tend to benefit (unless the common warm climate problem of salinisation of irrigated land occurs or indeed build-ups of arsenic or other problem substances are encountered), though floodplains and the prevalent water- and soil-conserving terraced farming systems at the dam site will be inundated. Fisheries can also be implemented in reservoirs, though this is offset by the loss of riverine fisheries, cropping from forests, wildfowling and other indigenous food sources	**-** Loss of fisheries and catchment crops (harvested and grown) not only on the dam site but through habitat simplification, blockage of fish migration, loss of floodplain soil fertilisation due to sediment starvation, and other impacts on the functioning of the wider river ecosystem compromise food productivity for substantial distances downstream outside of areas targeted for irrigation

Fibre and fuel (e.g. timber, wool, etc.) **-**	**0** Farmed production of timber, straw, wool and other fibre will mirror observations for food production, but there will be a considerable loss of forest and terraced farming resources providing timber, fuelwood, straw and fodder	**--** Farmed production of timber, straw, wool and other fibre will mirror observations for food production above, but habitat simplification in the lower catchment is likely to further reduce opportunities for fibre and fuel cropping
Genetic resources (used for crop/stock breeding and biotechnology) **--**	**--** There is a massive simplification of habitat in a deep reservoir compared to the diverse ecosystems that it inundates, and communities displaced to adjacent land will further degrade genetic resources	**--** Dams tend to have major impacts on the flow of sediment and habitat-forming processes, water and ecosystems in river systems with an inevitable substantial suppression of genetic resources
Biochemicals, natural medicines, pharmaceuticals **--**	**--** This mirrors the observations for genetic resources above	**--** This mirrors the observations for genetic resources above
Ornamental resources (e.g. shells, flowers, etc.) **--**	**--** This mirrors the observations for genetic resources above	**--** This mirrors the observations for genetic resources above
Addendum service: energy yield from river flows **0**	**+** Power from dams delivers substantial benefits to the recipients of that power, often enabling novel industrial and other economic processes possible for targeted beneficiaries. However, issues are inevitably raised by the access to those energy benefits by all stakeholders in society, including those displaced by the dam and its infrastructure. Often, dams attract energy-intensive industries (smelters, etc.) consuming at favourable prices much of the generated load	**-** By tapping the potential energy of water flows at the dam, stream energy available for harnessing downstream in the catchment will tend to decline
Summary of impacts on provisioning services	**The overall balance of benefits of the proposed Pancheshwar Dam scheme are equivocal or negative across the provisioning services, when implications for diverse ecosystems and their dependent stakeholders are assessed in parallel across local and catchment scales. The picture emerging is that some local gains are balanced by other local impacts. However, catchment-scale impacts, which seem not to have framed scheme design, are likely to be overwhelmingly negative. This raises issues of equity in access to the various benefits and costs of the dam scheme, and the extent to which wider ramifications beyond narrowly-defined benefits have been considered along with alternative methods for their achievement**	

Table A1.2: Regulatory service impacts of the Pancheshwar Dam

Regulatory service Overall weighting (Defra, 2007)	**Local impact** Weighting and explanation	**Catchment-scale impact** Weighting and explanation
Air quality regulation **--**	**--** The major reservoir formed behind the proposed dam would inundate substantial areas of land including its diverse habitats, with their capacity to	**--** Habitat simplification downstream of the proposed dam is likely to reduce the capacity of the catchment to moderate air quality

	moderate air quality by trapping particulates and metabolising pollutants	
Climate regulation (local temperature/precipitation, GHG sequestration, etc.) **-**	**?** This issue is contentious as the CO_2 offset from energy generation relative to an equivalent fossil fuel-powered station may, in practice, be substantially or completely offset by methane generation from organic matter in the deep water layers of the dam (see Graham-Rowe, 2005). Implications for carbon sequestered in the reservoir bed are equivocal. Furthermore, the inundation of habitat at the dam site is likely substantially to is reduce the scheme's capacity to regulate microclimate	**--** Habitat simplification, including loss of floodplain due to sediment starvation in river water, is likely to remobilise carbon sequestered in soils and biota
Water regulation (timing and scale of run-off, flooding, etc.) **-**	**?** By storing seasonally high flows, dam schemes are claimed to reduce flood surges. However, if they overtop, the buffering capacity of habitat inundated by dam filling will not be available to moderate overtopping water. Furthermore, when people and industries settle on former floodplain and lower-lying land now assumed to be safe, they may put themselves more at risk. This complex of benefits and costs is therefore equivocal in terms of overall local outcomes for people, particularly where development encroaches on former valley bottoms assumed safe from further flooding and when consequences following the design (or actual) life of the dam are exceeded	**--** The hydrology of the river downstream will change profoundly from its natural regime, affecting the life cycles of organisms and the natural sediment renewal and uses of riparian habitats by dependent stakeholders
Natural hazard regulation (i.e. storm protection) **--**	**--** Loss of habitat inundated by the dam will reduce its capacity to absorb storm energy and other natural hazards	**--** Habitat simplification in the catchment downstream will also diminish the capacity of the lower catchment to regulate natural hazards
Pest regulation **--**	**--** Loss of habitat through inundation by the dam will suppress populations of crop pest predators	**--** Habitat simplification downstream of the dam will suppress populations of crop pest predators
Disease regulation **--**	**--** The experience of dam schemes in India and around the world is that they tend to promote the spread of waterborne human diseases (including bilharzia, malaria and Japanese encephalitis) as well as livestock diseases, though it is noted that the altitude of this dam may preclude malaria if climate change does not increase rapidly	**--** Habitat simplification and the buffering of flows downstream of dams throughout the world has generally been found to promote the vectors of waterborne disease (such as snails carrying bilharzias, mosquitoes bearing malaria and stock pest vectors)
Erosion regulation **-**	**-** Erosion of soil in the dam itself will have a net neutral impact. However,	**--** 'Aggressive water', depleted in terms of suspended sediment and so highly

	degrading watershed quality is likely due to the pressure of substantial numbers of displaced communities on less than ideal higher land, which could also substantially reduce reservoir longevity	erosive, erodes riparian habitat for distances substantially downstream of major dams
Water purification and waste treatment --	-- Loss of habitat inundated by the dam eliminates considerable natural water purification potential. This will not be appreciably compensated by purification processes in deep dams with narrow and impoverished littoral habitat that vary in extent of dam filling throughout the year	-- Habitat simplification in the river channel and corridor for substantial distances downstream are highly likely to suppress natural purification processes
Pollination --	-- Loss of habitat through inundation by the dam will suppress populations of natural pollinators	-- Habitat simplification for a substantial distance downstream of the dam will suppress populations of natural pollinators
Summary of impacts on regulatory services	**Assessment of regulatory service impacts both at the dam site and at catchment scale reveals substantially negative likely consequences for ecosystems and the interests of the many people dependent upon them, even for the planned benefits for local populations**	

Table A1.3: Cultural service impacts of the Pancheshwar Dam

Cultural service Overall weighting (Defra, 2007)	**Local impact** Weighting and explanation	**Catchment-scale impact** Weighting and explanation
Cultural heritage --	-- Inundation of culturally-valued landscapes and sites is compounded by the loss of 82 Indian villages and 33 Nepalese villages, including 11,361 families (although these figures are fiercely contested as substantial underestimates by NGOs)	-- The erosion of catchment landscapes will also degrade cultural heritage
Recreation and tourism --	-- Benefits envisaged from dam creation include (mainly commercial) fishing, tourism potential and other reservoir uses. However, there will be an overall loss of the significant and valuable local recreational angling, wildlife and cultural tourism attraction of the region, largely dependent upon native mahseer and other fishes which have been established since Colonial times. In practice, observation and discussion about use and infrastructure at the Nanak Matta Dam suggests that these tourism benefits are exaggerated. The substantial current value of long-established river fisheries and ecotourism opportunities, and the uncertain magnitude and lead-in time for the future potential of the dam, accounts for the overall significantly negative rating	-- Loss of catchment habitat resulting from the dam will also degrade the fishery, ecotourism and cultural tourism potential, and the natural characteristics and beauty, of the wider river system

Aesthetic value **-**	**-** Whilst some people express a liking for reservoirs and open water, the natural beauty of the stunning Himalayan landscape of the catchment that will be inundated by the reservoir represents a loss significant in extent and cultural depth. Perhaps over-generously, the perceived benefit of standing water is offset against the natural aesthetics of characteristic and stunning Himalayan habitat	**--** Loss of catchment habitat resulting from the dam will also degrade the natural characteristics and aesthetic value of the wider river system
Spiritual and religious value **--**	**--** Sangams (meetings of rivers) have high spiritual importance in the Hindu tradition, particularly this unique 'Lord of five rivers' site. Inundation would eliminate many other culturally- and spiritually-important village temples and natural features. Furthermore, Kriya Karam (cremation) sites will be lost for very large distances around	**--** In the wider catchment, degradation of habitat, natural river characteristics and erosion of land around riparian temples will have a significantly net negative impact on the wellbeing of local people and communities
Inspiration of art, folklore, architecture, etc. **--**	**-** Mirroring observations for aesthetic value, whilst some people find inspiration in reservoirs and open water, the natural beauty of the catchment that will be inundated by the reservoir represents a significant loss	**--** Across the wider catchment, degradation of habitat, natural river characteristics and erosion of land around settlements and long-lived infrastructure will have a significantly net negative impact on the inspiration of local people
Social relations (e.g. fishing, grazing or cropping communities) **--**	**--** New social relations may form around new tourism, commercial fishery and dam-related industries. However, there will be substantial losses to villages and families displaced by the dam, including the community events around Sangams and of associated trades such as farming, harvesting of timber, food and other natural resources, etc.	**--** Social relations across the wider catchment will also be compromised due to erosion of riparian habitat, changed hydrology, and the viability of long-established practices and traditions
Summary of impacts on cultural services	**Assessment of impacts of the dam on cultural services suggests almost unanimous significantly negative outcomes at both dam and catchment scales**	

Table A1.4: Supporting service impacts of the Pancheshwar Dam

Supporting service Overall weighting (Defra, 2007)	**Local impact** Weighting and explanation	**Catchment-scale impact** Weighting and explanation
Soil formation **--**	**--** Siltation of the dam is considered likely to exceed projected rates, but deep underwater silt does not constitute soil formation. Natural soil-forming processes in the catchment area inundated by the dam will be lost. Furthermore, degraded upland soil is likely due to communities displaced onto less than ideal higher land	**--** Erosion of catchment habitat will reverse soil-forming processes for substantial distances downstream of the dam itself

Primary production --	-- Loss of primary production by diverse habitats inundated by the reservoir will not be compensated by planktonic algal production in the photic zone of the dam, nor by the dam's thin riparian zone subject to draw-down as the dam empties and fills	-- Habitat and ecosystem erosion downstream of the catchment will also suppress primary production
Nutrient cycling --	-- Nutrient cycling in deep reservoirs is an inefficient process, with some nitrogen fixing by algae in the photic zone of open waters and methanogenesis from anoxic deep water and sediment, trapping of sediment associated with particulate matter entering the water body in inflow streams, but little other nutrient cycling processes compared to natural catchment habitats	-- Erosion of catchment habitat and ecosystems will compromise efficient natural nutrient cycling processes
Water recycling --	-- Loss of complex habitat inundated by the dam will eliminate natural water recycling processes within catchment landscapes (i.e. evaporation and recapture of mists), for which engineered flow management is an inadequate mitigation	-- Simplified habitat in the river valley for a substantial distance downstream of the dam will diminish local recycling of water through complex vegetation communities
Photosynthesis (production of atmospheric oxygen) --	-- Loss of photosynthetic activity performed by diverse habitats inundated by the reservoir will not be compensated by photosynthesis by planktonic algae and riparian reservoir communities	-- Habitat and ecosystem erosion downstream of the catchment will also suppress net oxygen generation from photosynthesis
Provision of habitat --	-- Habitat simplification in a reservoir, relative to the diverse habitats that it inundates, results in substantial loss of habitat and conservation interest. Dams also seriously disrupt the migratory habits of fishes and other aquatic taxa as well as obstructing the movements of terrestrial animals. Invasion of generalist species in simplified habitats may also further displace native species and ecosystems	-- Habitat simplification in the river valley for substantial distances downstream of the dam is highly likely to result in substantial loss of habitat and conservation interest. Invasion of generalist species in simplified habitats may also further displace native species and ecosystems
Summary of impacts on supporting services	**Assessment of impacts of the dam on supporting services suggests unanimous significantly negative outcomes at both dam and catchment scales, degrading ecosystem integrity and functioning and the wider resilience and societal benefits that it is able to provide**	

End of Annex 1

References

Bustard, H.R. (Undated). *Indian Crocodile Conservation Project*. http://oldwww.wii.gov.in/envis/crocodile/bust.htm.

Chen, H. (2009). Lessons learned from Wenchuan earthquake for seismic safety of large dams. *Earthquake Engineering and Engineering Vibration*, 8(2), 241-249. DIO: 10.1007/s11803-009-9066-8.

CISEAU, iptrid and FAO. (2005). *Management of Irrigation-induced Salt-affected Soils*. UN Food and Agriculture Organisation, Rome. (ftp://ftp.fao.org/agl/agll/docs/salinity_brochure_eng.pdf.)

Colbourne, L. (2009). *Mainstreaming Collaboration With Communities and Stakeholders for FCERM*. Science Report – SC060019, Improving Institutional and Social Responses to Flooding. Environment Agency, Bristol.

Defra. (2007). *An introductory guide to valuing ecosystem services*. Department for Environment Food and Rural Affairs, London.

Everard, M. (2009). *Ecosystem services case studies*. Environment Agency Science report SCHO0409BPVM-E-E. Environment Agency, Bristol.

Everard, M. (2009). *The Business of Biodiversity*. WIT Press, Ashurst.

Everard, M. (2010). *Ecosystem services assessment of sea trout restoration work on the River Glaven, North Norfolk*. Environment Agency Evidence report SCHO0110BRTZ-E-P. Environment Agency, Bristol.

Everard M, Jevons S. (2010). Ecosystem services assessment of buffer zone installation on the upper Bristol Avon, Wiltshire. Environment Agency Evidence report SCHO0210BRXW-e-e.pdf. Environment Agency, Bristol. (http://publications.environment-agency.gov.uk/pdf/SCHO0210BRXW-e-e.pdf.)

Everard, M. (currently unpublished). *Dammed if we do, damned if we don't*.

Graham-Rowe, D. (2005). Hydroelectric power's dirty secret revealed. *New Scientist*. (http://www.newscientist.com/article/dn7046.)

Hindustan Times. (2010). Arsenic blinds Bhojpur's babies. Hindustan Times, 26th April 2010. (http://www.hindustantimes.com/Arsenic-blinds-Bhojpur-s-babies/H1-Article1-525634.aspx.)

HM Treasury. (Undated). *Appraisal and Evaluation in Central Government: Treasury Guidance*. (The 'Green Book'). http://www.hm-treasury.gov.uk/data_greenbook_index.htm

International Commisson on Large Dams (ICOLD). http://www.icold-cigb.net/

ICOLD. (1981). Dam Projects and Environmental Success. ICOLD Bulletin, 37. International Commission on Large Dams, Paris.

ICOLD. (2008). Dams and the World's Water: An Educational Book that Explains how Dams Help to Manage the World's Water. ICOLD, Paris. www.icold-cigb.org.

Jai Bihar. (2010). 18 born blind in arsenic hit Bhojpur district. News Desk, 31st March 2010. (http://jaibihar.com/18-born-blind-in-arsenic-hit-bhojpur-district/201018622.html.)

McCully, P. (2001). *Silenced Rivers: The Ecology and Politics of Large Dams*. Zed Books, London.

Millennium Ecosystem Assessment (MA). (2005). *Ecosystem and Human Well-being: General Synthesis*. Island Press, Vancouver.

República. (2010). Pancheshwar Multipurpose Project to displace 21,621 souls. República Social Affairs, 20th February 2010. (http://www.myrepublica.com/portal/index.php?action=news_details&news_id=15401.)

Shah, A and Larsen, B. (1992). *Carbon taxes, the greenhouse effect, and developing countries*, Policy Research Working Paper Series 957, The World Bank.

The Tribune. (2008). Rehabilitation policy for dam oustees demanded. The Tibune, online edition. 14th November 2008. (http://www.tribuneindia.com/2008/20081115/dun.htm#3.)

UNECE Aarhus Convention. (1998). *Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters*. http://www.unece.org/env/pp/

UNEP. (2003). *Energy Subsidies: Lessons Learned in Assessing their Impact and Designing Policy Reforms*. UNEP Report UNEP/ETB/2003/1, United Nations Environment Programme, Geneva.

UNEP Dams and Development Programme. www.unep.org/dams

UNEP Dams and Development Programme: Compendium on Relevant Practices. www.unep.org/dams/inventory/

United Nations Environment Programme. (2007). Dams and Development: Relevant Practices for Improved Decision Making. UNEP – DDP Secretariat, Nairobi. www.Earthprint.com

World Commission on Dams. (2000). *Dams and Development*. Earthscan, London.

World Commission on Environment and Development. (1987). *Our Common Future*. Oxford University Press, London.

Everard, Mark and Kataria, Gaurav. (2010). *The proposed Pancheshwar Dam, India/Nepal: a preliminary ecosystem services assessment of likely outcomes*.

An IES Research report. The report expresses the views of the authors and not necessarily those of the Institution of Environmental Sciences.

Available online:

www.ies-uk.org.uk/resources/papers/pancheswar_dam_report.pdf