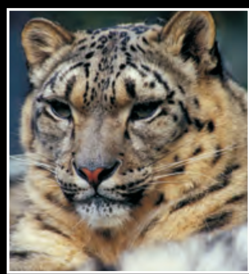
Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand

Cumulative Environmental Impact Assessment








भारतीय वन्यजीव संस्थान
Wildlife Institute of India
2012

Photo Credit

Front Cover

K. Sivakumar

K. Sivakumar

Milan Trykar ISLT

K. Ramesh

J Howman WPA

Ishwari Rai

H.B. Naithani

J.A. Johnson

Back Cover

K. Sivakumar

WII RS&GIS Cell

Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand

The Team

Project Coordinator

Dr. V.B. Mathur, Dean

Project Advisors

Mr. B.C. Choudhury
Dr. V.K. Melkani
Mr. V.K. Uniyal

Component	Investigator	Research Personnel
Vegetation Ecology	Dr. G.S. Rawat	Ajay Maletha Dr. Manish Khandwal
Mammals and Birds	Dr. S. Sathyakumar Dr. K. Ramesh	Nand K. Dimri
River Ecology and Fishes	Dr. K. Sivakumar Dr. J.A. Johnson	P. Gangaiamaran
Cumulative Environmental Impact Assessment	Dr. Asha Rajvanshi Dr. Vinod B. Mathur	Roshni Arora

Credits:

Cover	:	Rajeev Thapa
Desktop Publishing	:	Narinder Bist
Maps	:	Dr. Panna Lal

Citation: Rajvanshi, Asha; Roshni Arora; Vinod B. Mathur; K. Sivakumar; S. Sathyakumar; G.S. Rawat; J.A. Johnson; K. Ramesh; NandKishor Dimri and Ajay Maletha (2012) Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand. Wildlife Institute of India, Technical Report. Pp 203 plus Appendices.

Contents

List of Figures

List of Boxes

List of Plates

List of Appendices

Chapter I – Introduction

The State of Uttarakhand came into existence on 9th November 2000 as 27th State of Indian Republic. It lies between 28°44' to 31°28' N Latitudes and 77°35' to 81°01 E Longitudes. It was carved out from the State of Uttar Pradesh by separating the hill region with a geographical area of 53,483 km^2 constituting 1.63% of the land area of the country (FSI, 1999). The State has 13 districts sub divided into 49 tehsils and 95 development blocks. The State is well known for its rich natural resources and varied ecosystems both terrestrial and aquatic. Four major rivers flowing through north India originate from the State, *viz.*, Ganga, Yamuna, Ramganga and Sharada.

The State is endowed with a rich array of forest types from tropical to alpine. The recorded forest area of the State is 3.47 m ha which constitutes about 65% of the State's geographic area. These forests can be further categorized into Reserved Forests (68.74%), Protected Forests (0.36%) and Unclassed Forest (30.9%). The recorded forest cover (Fig. 1.1) of the State is 34,651 km^2, which constitutes 64.79% of its geographic area (FSI, 2009).

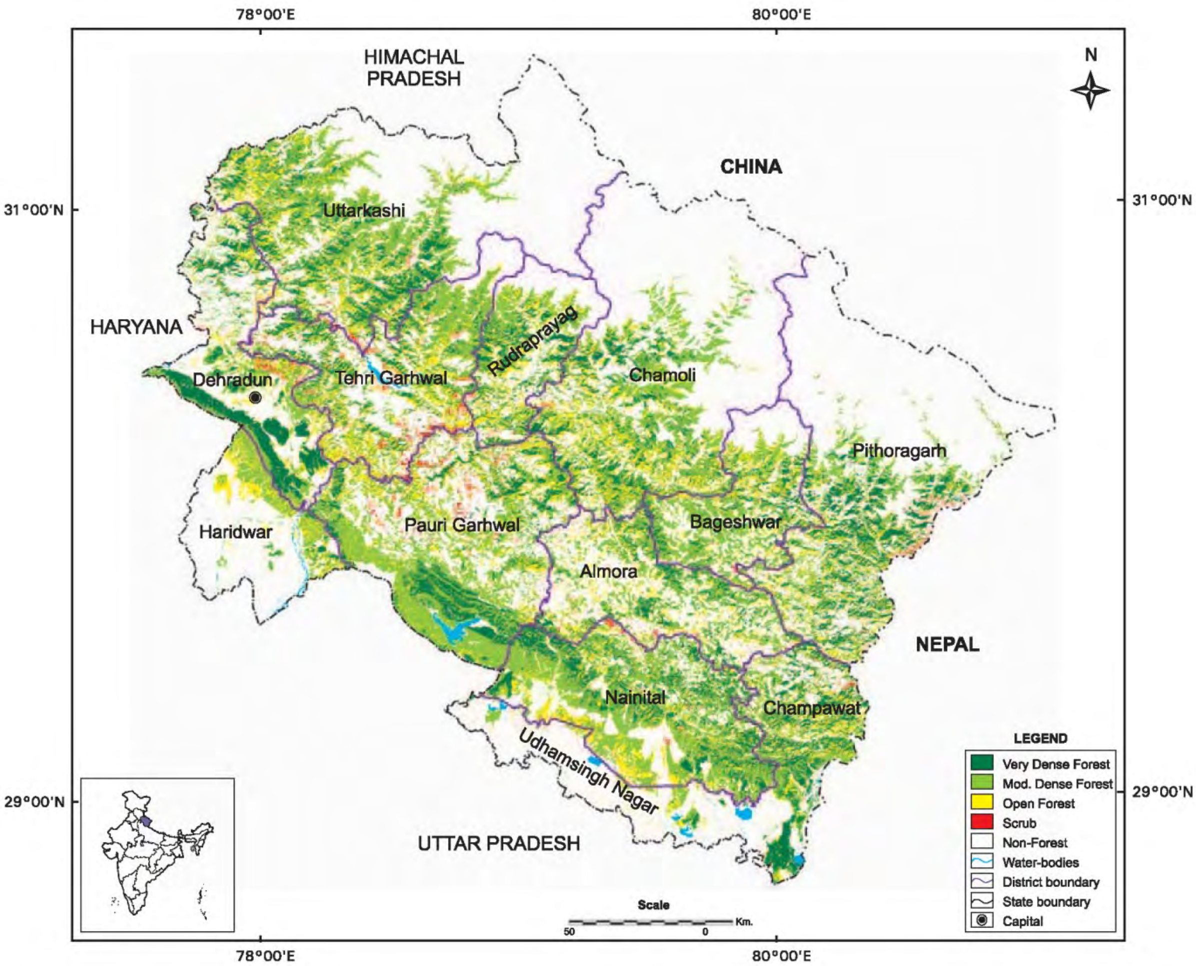


Figure 1.1 Forest cover map of Uttarakahand (*Source: FSI, 2009*).

1.1 Hydropower potential of Uttarakhand

The Indian Himalayan Region (IHR) spanning from Arunachal Pradesh in the east to Jammu and Kashmir in the west and covering 530,795 km^2 has irreplaceable values as one of the important mountain ecosystems of the world (Singh, 2006). These young and fragile mountains of the Himalaya command high conservation significance due to their floral, faunal, geo-hydrological, ecological, socio-cultural and aesthetic values. Also known as the water tower of the Earth (Valdiya, 1997), the Himalaya provides water to a larger part of the Indian subcontinent.

The State of Uttarakhand, which is carved out of the upper reaches of Uttar Pradesh, is one of the many States that form a part of the IHR. The hilly tracts of the State namely Foothills, Lesser Himalaya, Greater Himalaya and Trans-Himalaya form the eastern most part of the western Himalaya (Negi, 1995). This State uniquely endowed with glaciers and rain fed monsoonal rivers following the natural incline/gradient has good hydro power potential and is thus recognized as a future Energy State (Joshi, 2007). Uttarakhand has a hydropower potential of the order of 20,000 MW against which only about 3,164 MW (16% approx.) has been harnessed so far through 45 Hydro Electric Projects (HEPs) of varying capacities being implemented by State and Central Government agencies and public and private sectors (IIT, 2011). Hydropower potential is one of the most important strategic assets of the State for the development of the economy (World Bank, 2011). With little or no fossil fuel resources, it is currently a net importer of power, but generates a seasonal surplus power. Since its creation, the new State, has been witnessing a sharp increase in energy demand. As the power consumption of the State has grown more than five times in the last eight years (2002-10), only 52 percent of its power needs are met from its natural resources. The State therefore plans to expand its hydropower generation capacity to become self reliant and a net exporter of surplus power (IIT, 2011). To meet this objective, a large number of Hydro Electric Projects are already in the advanced stages of planning/execution and many more projects are being proposed in the important river basins *viz.,* the Alaknanda and Bhagirathi basins, of the State. Among the various allotted Hydro Electric Projects in these two basins, 17 are commissioned Hydro Electric Projects with total installed capacity of 1851 MW; 14 projects of 2538 MW capacity are in the advanced stage of construction and 39 projects with installed capacity of 4644 MW are in different stages of planning.

1.2 Biodiversity profile of Uttarakhand

The State is well known for its rich natural resources and varied ecosystems, both terrestrial and aquatic. Four major rivers flowing through north India originate from the State, *viz.,* Ganga, Yamuna, Ramganga and Sharada. The State is endowed with a rich and diverse array of forest types from tropical to alpine types. The recorded forest area of the State is 3.47 m ha which constitutes about 65% of the State's geographic area. These forests can be further categorized into Reserved Forests (68.74%), Protected Forests (0.36%) and Unclassed Forest (30.9%). The forest cover of the State is estimated to be about 44%, two third of which is dense and the rest is open forest (FSI, 2007).

The major categories of forests in the State are: (i) Tropical Moist Deciduous Forests in the Terai and Bhabar tracts dominated by Sal (*Shorea robusta*) and associates *viz., Adina cardifolia, Anogeissus latifolia, Terminalia tomentosa* and a rich assemblage of shrubs interspersed with patches of bamboo, climbers and grasses; (ii) Subtropical Pine Forests with Chir Pine (*Pinus roxburghii*) as the dominant species are primarily found in the lower regions of the Himalaya (iii) Himalayan Moist

Temperate Forests occurring between 1600-2900 m altitude in the Himalaya are further divisible into temperate broad leaved and conifer forests. Broad leaved forests are dominated by one or other species of oak (*Quercus* spp.) while the coniferous species are *Cedrus deodara, Picea smithiana, Abies pindrow,* and *Pinus wallichiana;* (iv) Sub-alpine and Alpine Forests exist at altitudes of 2,900 m to 3,500 m above sea level in the middle and upper Himalaya and is characterized by stunted birch-rhododendron forests, alpine scrub and meadows locally called “Bugyals”. In addition, a considerable area of the State is under tropical and temperate grasslands. The grasslands or the *chaurs* of Rajaji and Corbett National Parks that can grow up to 2m, form as an ideal habitat as ambush cover for predators and also provide forage and fawning cover for herbivores. The major species of grasses in the area include *Arundo donax*, *Phragmites karka*, *Apluda mutica* (Bassi), *Themeda arundinacea* (Ulla), *Cymbopogon* spp. (Jarakush), *Bothriochloa bladhii* (Sindhur), *Imperata cylindrica*, *Sachharum spontaneum*, *S. benghalense* and *S. narenga* among others.

The State has considerable area (13.68% of its geographic area) under protected area network as compared to the national average of 4.8%. There are six National Parks, six Wildlife Sanctuaries, one Biosphere Reserve, and two Conservation Reserves. The Nanda Devi NP and Valley of Flowers NP have been inscribed on the UNESCO World Heritage List. In terms of floral wealth, the State harbours about 4500 species of vascular plants, of which 29 species are endemic.

The mammalian diversity of Uttarakhand represented by more than 75 species is one of the richest in the country (Paramanand et al. 2000; Uniyal & Ramesh 2004; Chandola et al. 2008; Bhardwaj & Uniyal 2009 and Bhardwaj et al. 2010, Maheshwari & Sharma 2010). Species falling under lower risk category represent a little more than 50% indicating that the species with threatened status represent nearly half of the total species found in the State. Some of the threatened/vulnerable mammals in the State include Musk deer (*Moschus chryogaster)*, Snow leopard (*Panthera uncia*), Himalayan brown bear (*Ursus arctos isabellinus*) and Asiatic black bear (*Ursus thibentanus)*. A detailed analysis of the data shows that 37.80% of species fall under lower risk least concern category and 19.51% under lower risk not threatened status. It is estimated that about 650 species of birds (51% of India’s avifauna) occur within the State (Vasudevan & Sondhi, 2010). Some of the threatened birds in the State include Western Tragopan *(Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichi*) and Sarus Crane (*Grus antigone*).

The reptile diversity in Uttarakhand encompasses over 60 species including crocodiles, turtles, tortoises, snakes and lizards. One of the endangered reptiles of the State is the Gangetic Gharial (*Gavialis gangeticus*).

The State of Uttarakhand which is a home for many perennial rivers of the country also has a good fish diversity represented by about 125 species (Badola, 2001). The Bhagirathi and Alaknanda river basins represent two important riparian ecosystems that have significantly contributed to the richness of the biodiversity of the State.

1.3 Conservation - Development dilemma

Among all types of development projects, hydroelectric dams are often seen as the most controversial. Issues linked to dams and especially to the “large dams” are often highly polarized.

Critics of Hydro Electric Projects express their concerns about the wide range of negative environmental and related social impacts, from the destruction of unique biodiversity to the displacement of vulnerable human populations. Defenders of dams emphasize that these are often the economically least-cost source of electric power available from renewable source. However, like most other power generation technologies hydropower development also has adverse environmental impacts (Ledec and Quintero, 2003).

Diversion of rivers from their channels has enabled the expansion of human civilization to inland areas that were otherwise unproductive (from the economic standpoint) or too remote to provide adequate water for essential life processes. Opponents of water resource developments charge that dams cause significant damage to human and natural resources resulting in the impoverishment of human populations and loss of plant and animal species and their habitats. Available worldwide literature on consequences of dam development (Goldsmith and Hildyard, 1984; Graf, 1999; Adams, 2000; Berkamp *et al.*, 2000;) reveals that the impacts of dams on ecosystems are profound, complex, varied, multiple and mostly negative. By storing or diverting water, dams alter the natural distribution and timing of stream flows. This in turn, changes sediment and nutrient regimes and alters water temperature and chemistry resulting to impacts on ecosystems and biodiversity elements that these streams support and on their attendant socio-economic aspects. These ecosystem impacts may result in consequent changes in freshwater biodiversity which is already threatened on account of several other factors (Berkamp *et al.,* 2000).

1.4 Cumulative Environmental Impact Assessment

1.4.1 The conceptual basis

Concerns are often raised about the long term changes in the environmental quality, not only as result of a single action or development, but as the combined effects of many actions over time. Environmental Impact Assessment (EIA) has traditionally focused primarily on examining the direct environmental effects of a single development. Each individual development, when assessed for its potential to impact, may produce impacts that are ecologically and socially acceptable. However, when the effects of the numerous individual developments are combined, impacts may become larger, additive, or even new and therefore significant.

In recent years, there has been a growing realisation that the EIA process essentially adopted to portend the impacts of each development initiative on its individual standing may not be the best approach to assess the combined impacts of several projects (Court *et al.*, 1994). This has led to the development of procedures, known as Cumulative Effects Assessment (CEA) or Cumulative Environmental Impact Assessment (CEIA), for evaluating the consequences, sources and pathways of cumulative impacts of multiple activities (Canter, 1999). Instead of focusing on the effects of a given action – a project, plan, or individuals' behaviour – this approach focuses on the assessment of changes on different components of the receiving environment and considers all of the effects on a given receptor (Therivel and Ross, 2007).

Although the terms ‘cumulative impacts’ and ‘cumulative effects’ were introduced as early as the 1970s in several countries’ EIA legislation and practice guidelines, it was not until the mid-to-late

1980s that these terms began to be incorporated in impact assessment practice. The terms 'cumulative impacts, cumulative effects and cumulative environmental changes' are often used interchangeably. Several definitions of 'cumulative impacts' or 'cumulative effects' are available in the literature (e.g. Horak *et al.,* 1983; Dickert and Tuttle, 1985; Sonntag *et al.,* 1986; Hegmann *et al.,*1999). Cumulative effects assessment has been broadly defined by Smit and Spaling (1995) as the practice of systematically analyzing cumulative environmental change. The Council on Environmental Quality (CEQ) regulations defines cumulative impacts aptly as: *"Impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what [government] agency or person undertakes such other actions."*

Although there may be variations and refinements in the definitions associated with cumulative impacts, most efforts to incorporate CEIA within the EIA or SEA process have concentrated on addressing combined effects from the proposed actions on the environmental systems subsequent to appropriately defining baseline conditions and considering proposed actions in relation to surrounding projects (Canter, 1999). The principles of cumulative impact assessment have been derived from the definition of 'cumulative effects' in the CEQ regulations, from surveys of EIA practitioners and from a review of published literature. These principles are summarized (Box 1.1) and are meant to be considered in the planning and conduct of CEA within EIA process.

Box 1.1: Generic principles of Cumulative Environmental Impact Assessment (CEIA)
• Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions; • They include both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken; • They are analyzed in terms of the specific resource, ecosystem, and human community being affected, rather than from the perspective of the proposed action; • Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries; • They may result from the accumulation of similar effects or the synergistic interaction of different effects; • They may last for many years beyond the life of the action that caused them; and • Each affected resource, ecosystem, and human community must be analyzed in terms of its carrying capacity or threshold for environmental stress.

Source: Canter, 1999

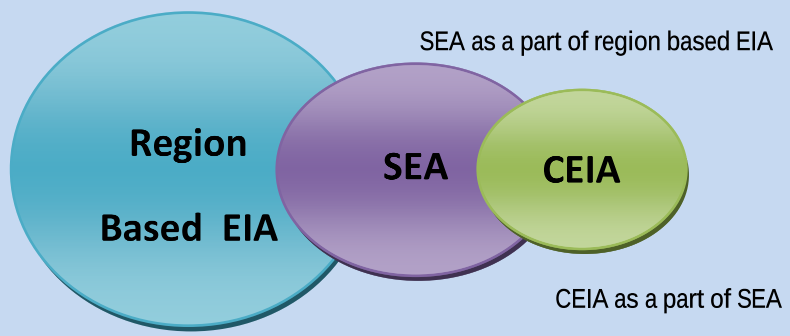
1.4.2 Merits of adopting Cumulative Environmental Impact Assessment

Because of the narrow focus of EIA and its inability to provide clarity on the criteria for identifying and assessing cumulative effects (DEAT, 2004), it is desirable to assess cumulative effects within the EIA. It is through cumulative assessment, project specific EIAs can be placed into a broader spatial and temporal perspective to aid in the assessment of "the net result of environmental impact from a number of projects and activities".

Cumulative impact assessment provides valuable and important inputs as an element of Strategic Environmental Assessment (SEA). SEA has been labeled as being a relatively efficient planning and decision support tool than EIA as this evaluation approach allows consideration of cumulative effects of the series of projects. Lawrence (1994), Sadler and Verheem (1996), Habib (2005), believe that the scope of SEA is more appropriate to the time and space scales at which cumulative effects are expressed.

Depending on whether the assessment of cumulative effects is built upon environmental assessments (e.g. as part of the EIA) or will feed into Strategic decisions, the CEIA is an ideal, regional based approach which is closely linked to concepts of 'limits of acceptable change' and 'thresholds of significance', which appear to be strongly emerging tools in SEA. Addressing cumulative effects in SEA can provide early warning system, sign-post specific requirements for project specific EIA and highlight the relevance or futility of mitigation measures based on pre and post project environmental reviews (Box 1.2).

Box 1.2: Regional EIA, SEA and CEIA linkages



1.5 Application of Cumulative Environmental Impact Assessment in the context of hydropower planning

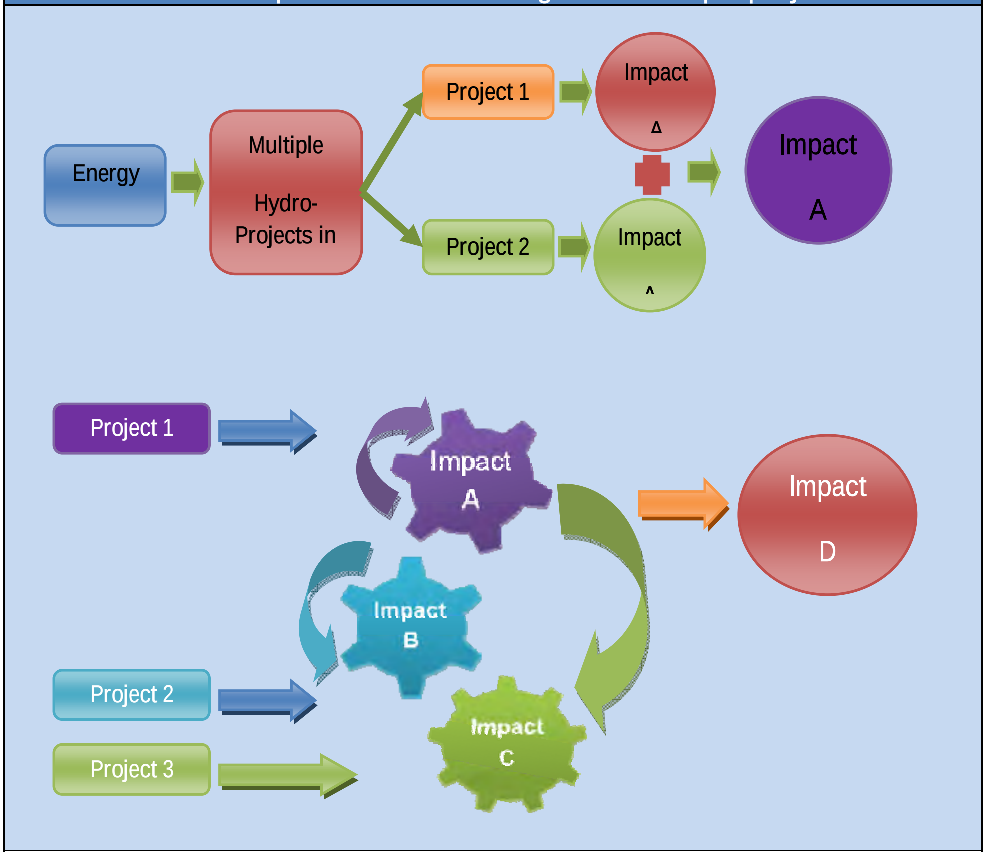
Conflicts over dams have heightened in the last two decades largely due to the social, ecological and environmental impacts of dams that were either ignored in the planning process or were not adequately evaluated (WCD, 2000). Development outcomes require a substantially expanded and reliable basis for decision making, a basis that reflects a full knowledge and understanding of environmental consequences and their spatial and temporal dimensions.

A range of planning tools for example, sectoral environmental assessments (EA), basin-wide EAs, regional EAs, and cumulative EA can be used to innovate and improve impact assessment outcomes for aiding decision support to provide a new direction to hydropower planning processes.

Assessment of cumulative effects is being increasingly seen as representing best practice in conducting environmental assessments. As cumulative impacts can result from individually minor, but collectively significant actions taking place over different temporal and spatial scales, their overall effect often exceeds the simple sum of previous effects (Cada and Hunsaker, 1990; DEAT, 2004). In the context of hydropower development, cumulative impacts can result from (i) multiple actions at a given site associated with a single project, or (ii) can be additive or synergistic in nature when potential impacts of multiple dams are taken into account and are concentrated in time or space, for example, the impacts of series of small dams constructed on a single stream or on streams within a single river basin (Ortolano and Shepherd, 1995). Such impacts may occur when the affected system is being perturbed repeatedly and increasingly by the same local agent with sufficient frequency so that it does not have time to recover between events (time-crowding), or the affected system is being perturbed by several similar activities or different activities having similar effects, in an area too small to assimilate the combined impacts (space-crowding) (Canter, 1999).

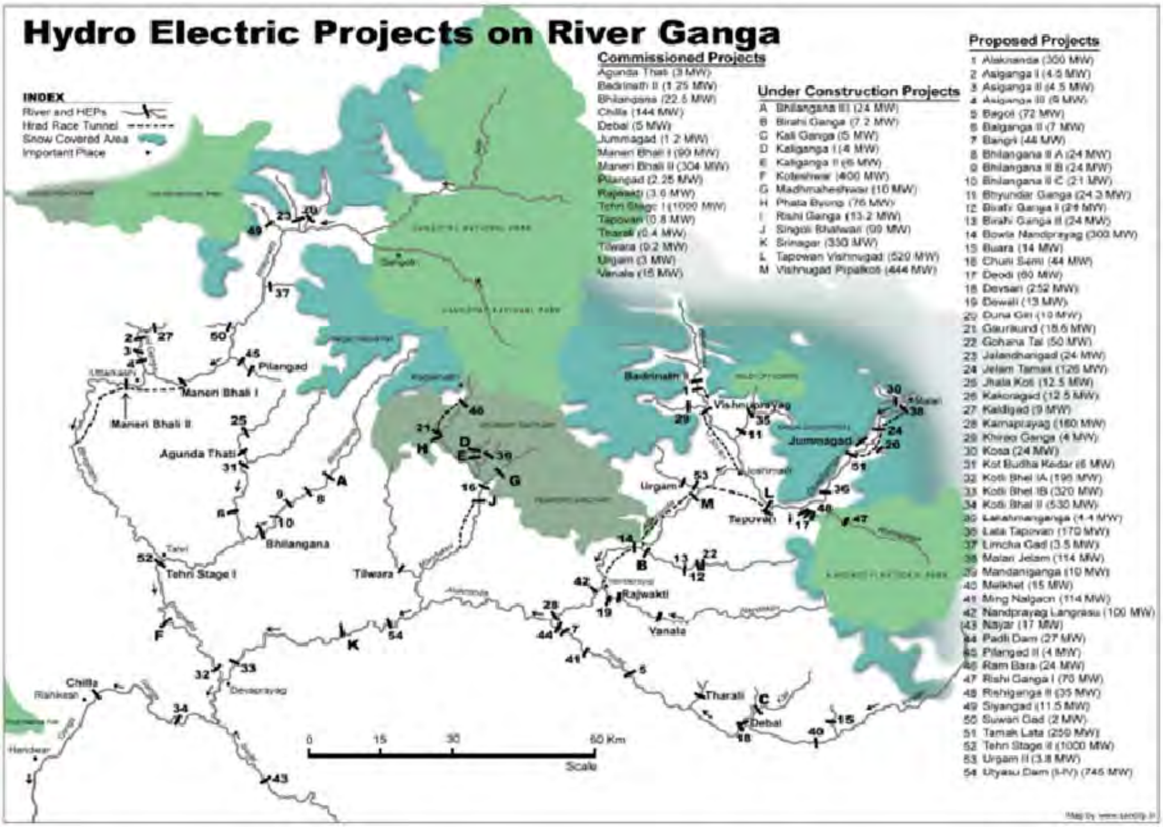
Synergistic or interactive effects are generally the result of interactions between effects of two or more projects that result in combined effects that are greater than the sum of the individual project's effects and typically more complex and difficult to assess than additive effects (Box 1.3).

Box 1.3: Impact scenarios arising out of multiple projects



1.6 Relevance of CEIA in the context of hydropower planning in Uttarakhand

The State of Uttarakhand has an estimated hydropower potential of 20,236 MW against which only about 1,850.8 MW has been harnessed so far. The hydropower development in State is being recognised to have critical significance in meeting the State's energy demand for economic implications for sustainable development. Over the next decade a major expansion in hydropower generating capacity is therefore planned to meet this demand (Fig. 1.2).



Source:www.sandrp.in

The developments in the hydropower sector in the State of Uttarakhand are therefore in a very expansive phase (particulars are described in Chapter 2). From the energy plans prepared to date, it is evident that as many as 70 Hydro Electric Projects are largely concentrated in two river basins *viz.* Alaknanda and Bhagirathi.

It is well understood that land clearing, anthropogenic disturbances in the landscape, combined with increasing water withdrawals and alterations of river systems can result in adverse effects to the sustainability of natural resources (Schindler, 2001; Gleick *et al.*, 2007). Environmental effects on river systems are largely cumulative in nature, caused by individually minor but collectively significant actions that accumulate over space and time. Within a basin, the greater number of dams leads to greater fragmentation of river ecosystems (Berkamp *et al.,* 2000). Hence, there is a growing recognition of the need to assess the cumulative effects of river development (Reid, 1998; Brismar, 2004; Schindler and Donahue, 2006). On the same premise, it becomes relevant to adopt cumulative impact assessment approaches in assessment of the impacts of hydropower development on the ecology of the two major river basins.

1.6.1 CEIA of aquatic biodiversity

Hydro Electric Projects often have major effects on fish and other aquatic life. Reservoirs positively affect certain fish species (and fisheries) by increasing the area of available aquatic habitat. However, the net impacts are often negative because the dam blocks upriver fish migrations and the downriver passage through turbines or over spillways is often unsuccessful (Ledec and Quintero, 2003).

Dams serve as a physical barrier to movement of migratory species, notably fish. This prevents brood-stock from reaching their spawning grounds during the breeding season, resulting in massive failure of recruitment and eventual extinction of the stock above the dam (Berkamp *et al.,* 2000). Many river adapted fish and other aquatic species cannot survive in artificial lakes; changes in downriver flow patterns adversely affect many species and water quality deterioration in or below reservoirs can kill fish and damage aquatic habitats. Freshwater molluscs, crustaceans, and other benthic organisms are even more sensitive to these changes than most fish species, due to their limited mobility.

The other important environmental impacts of dams are changes in sediment transport and water quality. Reduction in sediment transport in rivers downstream of dams which influences channel, floodplain and coastal delta morphology, alters habitat for fish and other groups of plants and animals and through changes in river water turbidity may affect populations of biota directly (Berkamp *et al.,* 2000). Water quality deterioration in reservoirs or in river stretches downstream kills fish and damages aquatic habitats. As multiple dams on a river significantly aggravate the impact on ecosystems and biodiversity, assessing impacts on aquatic biodiversity is a vital component of the CEIA.

Riparian vegetation is also an important component of the aquatic ecosystem. Riparian vegetation in the project area is very important for providing shelter and cover for the fish. It also provides shade to regulate the temperature. There are some specific pockets in the Alaknanda river and its tributaries especially the Birahi River in which a considerable riparian vegetation cover is present and which provides conducive habitat for fish.

1.6.2 CEIA of terrestrial biodiversity

Filling of the dam/ reservoir results in permanent flooding of riverine and terrestrial habitat, and depending upon the topography and habitats of the river valley upstream from the site of the dam, these impacts can vary greatly in extent and severity. The effects of inundation are especially severe when the reservoirs are situated close to mountains, in dry areas, or at higher latitudes where the river valleys are usually the most productive landscape elements. Due to impoundment, all terrestrial animals disappear from the submerged areas and populations decrease within a few years in proportion to the habitat area that is lost (Dynesius and Nilsson, 1994). Flooding can result in both local and global extinctions of animal and plant species. Particularly hard hit are the species dependent upon riverine forests, and other riparian ecosystems, and those adapted to the fast-flowing conditions of the main river course. From a biodiversity conservation standpoint, the terrestrial natural habitats lost to flooding are usually much more valuable than the aquatic habitats created by the reservoir (McAllister *et al.,* 1999).

Dams can have significant and complex impacts on downstream riparian plant communities. An important downstream manifestation of river impoundment is the loss of pulse-stimulated responses at the water-land interface of the riverine system. High discharges can retard the encroachment of true terrestrial species, but many riparian plants have evolved with, and have become adapted to the natural flood regimes. Species adapted to pulse-stimulated habitats are often adversely affected by flow-regulation and invasion of these habitats by terrestrial weeds is frequently observed (Malanson, 1993). Typically riparian forest tree species are dependent on river flows and shallow aquifers.

When dams are constructed the variability in water discharge over the year is reduced; high flows are decreased and low flows may be increased. Reduction of flood peaks reduces the frequency, extent and duration of floodplain inundation. Reduction of channel-forming flows reduces channel migration. Truncated sediment transport (*i.e.* sedimentation within the reservoir) results in complex changes in degradation and aggregation below the dam. These changes and others directly and indirectly influence a myriad of dynamic factors that affect the diversity and abundance of invertebrates, fish, birds and mammals downstream of dams (Berkamp *et al.,* 2000). Moreover, human disturbances during construction and operational phases of hydro projects would keep away several shy wild animals from the vicinity.

1.6.3 Minimum environmental flows

Rivers are part of the hydrological cycle and it is the variable nature of runoff processes that give rivers their dynamic characteristics. The ecological integrity of river ecosystems is dependent on the variation in flow regime to which they are adapted. Floods cause hydraulic disturbance that determines the composition of biotic communities within the channel, the riparian zone and the floodplain (Junk *et al.*, 1989; Webb *et al.*, 1999). The spatio-temporal heterogeneity of river systems is responsible for a diverse array of dynamic aquatic habitats and hence ecological diversity, all of which is maintained by the natural flow regimes (Berkamp *et al.,* 2000).

Flow regimes, including volume, duration, timing, frequency and lapse time since last flooding, are the key driving variables for downstream aquatic ecosystems and are critical for the survival of communities of plants and animals living downstream. Small flood events may act as biological triggers for fish and invertebrate migration, major events create and maintain habitats, and the natural variability of most river systems sustains complex biological communities that may be very different from those adapted to the stable flows and conditions of a regulated river (Berkamp *et al.,* 2000). Therefore, minimum environmental flows can be defined as: *"Environmental flows describe the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems" (Brisbane declaration 2007).*

.

Hence, it is essential to incorporate assessment of environmental flow requirements to ensure the amount, timing, and conditions under which water should be released by dams, to enable downstream river ecosystems to retain their natural integrity and optimum productivity. It is important to recognize that these assessments focus on evaluating impacts on releases are specifically from environmental standpoint and not for assessing minimum flows necessary for supporting downstream commercial activities and water supply (Acreman and Dunbar, 2004; Petts, 1996). A large number of river flow diversion type Hydro Electric Projects in Himalayan region are in different stages of planning and implementation. Assessment of impact of changed flow regime on river bed and river bank ecology and provision of environmental flows has therefore become a critical requirement in development of Hydro Electric Projects.

1.6.4 Social/cultural issues

People living in the region depend on the agriculture that provides major support to the population and with the rise in population; individual landholdings have significantly shrunk over the years (Rana *et al.,* 2007). In addition to the expansion of urban areas, road building activities and in recent times the Hydro Electric Projects have further marginalized the individual landholding in Uttarakhand (Rana *et al.*, 2007; Gaur, 2007). These projects are certainly going to engulf the already marginalized productive agricultural fields, thus implying more hardship to the local population in times to come (Bhatt, 1997).

Natural ecosystems (including riverine ecosystems) and their biological components provide a range of services that are of substantial ecological, economic and cultural values to society. The changes in the riverine ecosystem due to impairment of its provisioning, regulating, cultural and supporting functions that are linked to the dam construction often lead to substantial economic and social impacts (Berkamp *et al.,* 2000). Apart from providing life's basic needs, changes in river flows influence livelihoods, income, and local migration, which in turn may sometimes lead to unrest and even political conflicts (McCully, 1996). The consequent impacts on economy and physical security, freedom, choice and social relations have wide-ranging impacts on well-being and health (WHO, 2005).

1.7 Expected outputs from this study

While it is acknowledged that energy is essential for economic progress and well-being of the people of the State, the loss of biodiversity cannot be compensated by economic growth. It is essential to ensure that water demands for energy and irrigation do not become a cause of the decimation of forested areas, receding wildlife habitats and loss of biodiversity resources that may ultimately become compounding factors for accelerated impoverishment of natural resource dependent people. Development of water resources in a sustainable manner is therefore essential for the continued improvement in the quality of life for humans throughout the world.

This cumulative impact study encompasses the combined effects of multiple developments or activities on a range of receptors. These include landscape, habitats and species. The objective of the study is to contribute in strategic assessments to achieve 'green decisions' which according to Fischer (http://www.twoeam-eu.net/role.pdf accessed on 21st January 2012) is *'one that is more environmentally sustainable, in terms of leading to greater conservation of biodiversity'*.

In sync with this, the study aims to generate 'alerts' for safeguarding priority areas for conservation from impacts of hydropower schemes (existing, underway and proposed) in the two basins; provide a 'risk forecast' for specific biodiversity values (Rare, Endangered and Threatened (RET) Species and critical habitats) in the event of developments proceeding as planned and finally present a menu of scenarios for decision makers to approve options that best help in aligning energy planning with biodiversity conservation for sustainable developments in energy sector.

Chapter 2 – Environmental and Technical Considerations

2.1 Project background

The Government of Uttarakhand had submitted proposals to the Ministry of Environment & Forests, (MoEF), Government of India to grant environmental and forestry clearances for construction of Kotlibhel Stage IA, Kotlibhel Stage IB and Kotlibhel Stage-II Hydro Electric Projects on river Bhagirathi and Alaknanda in the State of Uttarakhand.

The MoEF vide letter No. F 8-9/2008-FC dated 23rd July, 2010 (Appendix–2.1) requested the Wildlife Institute of India (WII) to conduct a study on the cumulative environmental/ecological impacts of Hydro Electric Projects in the Bhagirathi and Alaknanda river basins on the riverine ecosystem including terrestrial and aquatic biodiversity in collaboration with specialized institutions.

The MoEF also entrusted the Alternate Hydro Energy Centre (AHEC), IIT Roorkee to study the cumulative impacts on the environmental side of the projects in Bhagirathi and Alaknanda river basins in Uttarakhand. Th broad objectives of the study conducted by AHEC were:

a. To assess the cumulative impact of commissioned, under construction and proposed Hydro Electric Projects in Alaknanda and Bhagirathi basins.

b. To estimate the extent to which hydropower potential identified in the basins should be developed without risking stability of landforms and environment. At the same time ensuring that the quality, quantity, and timing of water flows required to maintain functions, assimilative capacity and aquatic ecosystems that provide goods and services to people are maintained.

c. Restrictions, if any, that need to be placed in the development of hydropower in the two basins.

The Terms of Reference (ToR) for the AHEC study are given in Appendix–2.2.

2.2 Objectives of the WII study

In response to this directive, the Wildlife Institute of India submitted its technical and financial proposal to MoEF for undertaking the desired study. The broad objectives of WII study as agreed under Terms of Reference (Appendix–2.3) are:

a) To assess the baseline status of rare, endangered and threatened (RET) species of flora and fauna dependent on riverine habitats and floodplains of Alaknanda and Bhagirathi river basins.

b) To identify the critically important habitats along the existing and planned Hydro Electric Projects located on rivers Alaknanda and Bhagirathi upto Devaprayag.

c) Delineate river stretches critical for conservation of rare, endangered and threatened (RET) aquatic species.

d) To assess the key habitat variables for RET species, including minimum flows and volume of water for ecological sustainability of the two rivers.

The proposal for the study was approved by MoEF vide letter No. 8-9/2008-FC dated 16/11/2010 (Appendix–2.4) and it was indicated that the cost of the study would be borne by the concerned User Agencies whose proposals seeking diversion of forest land for construction of Hydro Electric Projects in Ganga river basin were presently pending before the MoEF. These costs for the study were determined by MoEF based on the proportion to the area of forest land applied for forest diversion by the different project proponent and are presented in Table 2.1.

Table 2.1 Details of contribution of cost to be recovered from five Hydro Electric Projects in Uttarakhand State.

S. No.	Name of the Project	Developer	Capacity	Forest Area Proposed to be Diverted	Amount to be recovered (Rs.)
1.	Kotlibhel Hydro Electric Project - (Stage-IA)	NHPC	195 MW	258.737 ha	5,26,316.00
2.	Kotlibhel Hydro Electric Project - (Stage-IB)	NHPC	530 MW	496.793 ha	10,10,562.00
3.	Kotlibhel Hydro Electric Project - (Stage-II)	NHPC	530 MW	658.252 ha	13,39,059.00
4.	Vishnugad-Pipalkoti Hydro Electric Project	THDC	444 MW	80.607 ha	1,63,969.00
5.	Alaknanda-Badrinath Hydro Electric Project	GMR	300 MW	60.513 ha	1,23,094.00
Total				1554.932 ha	31,63,000.00

Accordingly, the Government of Uttarakhand received funds amounting to Rs. 31.63 lakhs from the 3 User Agencies *viz.* NHPC, THDC and GMR and provided these funds to the WII for carrying out this study vide letters issued by Watershed Directorate (Nos. 1528/IG-1131 () dated 14.12.2010 and 1805/IG-1131 dated 19.01.2011).

2.3 Study tasks and implementation schedule

Based on the objectives of the study, an elaborate scope of work was developed to generate information relevant for developing information and knowledge base with reference to the different biological components included within the purview of consideration for this study. Table 2.2 provides an overview of the specific thrust areas and the tasks envisaged.

Table 2.2 Details of scope of work under various components of the study.

S.No.	Study Components	Scope of Work
1.	Vegetation Science	• Generation of baseline data and characterization of the river basins on the basis of floral attributes, plant association and community structure; • Assessment of likely impacts of hydropower development on vegetation, composition and habitat quality due to anticipated changes in hydrology and river flows, alteration in land use, creation of impoundments and rehabilitation of human population; • Defining conservation priorities for addressing threats to RET taxa, important plant communities and forest based resources in the two river basins in the State of Uttarakhand.
2.	Terrestrial Ecology *(Mammals and avifauna and their habitats)*	• Generation of baseline data and characterisation of the forest areas within the two river basins on the basis of faunal richness and delineation of suitable habitats, migratory/dispersal corridors in the context of RET species of aquatic and terrestrial birds and mammals known to occur in the Alaknanda and Bhagirathi river basins of Uttarakhand; • Assessment of impacts on species distribution and integrity of habitats of RET species as a result of changes in hydrology and land use and submergence of natural habitats under existing and proposed hydropower development schemes in Uttarakhand; • Defining conservation priorities and propose mitigation oriented plans for addressing threats to conservation of RET species.
3.	Aquatic/River Ecology *Aquatic mammals and fishes and their habitats*	• Generation of baseline data through survey of the river stretches for delineating zones of high fish diversity and abundance and characterising special habitats commanding importance as wetland conservation areas in Alaknanda and Bhagirathi river basins of Uttarakhand; • Development of inventories and evaluate production potential of streams and rivers. • Assessment of cumulative impacts of changes in hydrology and river flow on stream characteristics; habitat quality and contiguity; upstream and downstream migration of RET fish species such as golden mahseer and snow trout; spawning and breeding success; • Determining conservation priorities and proposing species/habitat conservation and/recovery/reintroduction plans to avoid and address hydropower development induced threats to conservation of RET species, particularly the golden mahseer.
4.	Cumulative Impact Assessment Focus: upstreaming biodiversity considerations in hydropower planning.	• Collate information from project profiles to assess the impact potential of individual projects • Integrate information on all biophysical aspects of the study area for generating biodiversity values, spatial data at sub-basin. Weight scaling and ranking of key impacts of hydropower development on biodiversity values using sub-basins as the smallest landscape unit in the two river basin • Determine risks associated with changes in habitat size and quality, impacts of river flows on aquatic and terrestrial biodiversity. • Generate alternate scenarios using inclusion and exclusion approaches to profile impacts on biodiversity in different scenarios of hydropower planning.

Table 2.3 Task completion.

Date of Commencement:	14th December, 2010
Inception meeting	14th Jan, 2011
Complete transfer of funds to WII	19th January 2011
Site visit	06th to 12th Jan, 2011
Site visit	07th to 12th Feb, 2011
Joint WII-IIT meeting	06th March,2011
Internal review meeting	08th March, 2011
Internal review meeting	09th March, 2011
Internal review meeting	11th March, 2011
Internal review meeting	23th March, 2011
Presentation on the study before the committee chaired by Hon'ble Minister of Environment & Forests (Independent Charge).	13 th April, 2011
Internal review meeting	14th April, 2011
Site visit	17th to 22th April, 2011
Internal review meeting	27th April, 2011
Meeting of EAC (Hyropower) at MoEF	29th April, 2011
Interim report submission to MoEF based on part study	28th May, 2011
Site visit	15th May to 06th June 2011
Internal review meeting	11thJuly, 2011
Internal review meeting	14thJuly, 2011
Meeting of EAC (Hydropower) at MoEF	15th July, 2011
Site visit	23rd July to 04th Aug, 2011
Internal review meeting	11thAugust,2011
Internal review meeting	08thSep, 2011
Internal review meeting	26thSep, 2011
Site visit	04th to 08th Oct, 2011
Data analysis and report writing	Oct, 2011 to Feb 2012
Draft final report	5th March, 2012
Internal review meeting	29th February, 2012
Internal review meeting	1st March, 2012
Internal review meeting	3rd March, 2012

Chapter 3 – The Study Area and Project Profiles

3.1 The study area

The study area for this assessment encompasses the Alaknanda and Bhagirathi river basins containing the 70 commissioned, under-construction and proposed Hydro Electric Projects (**Fig. 3.1**). The lower limit of the study area is Kaudiyala on river Ganga and upper limits are Gangotri on river Bhagirathi and Badrinath on river Alaknanda.

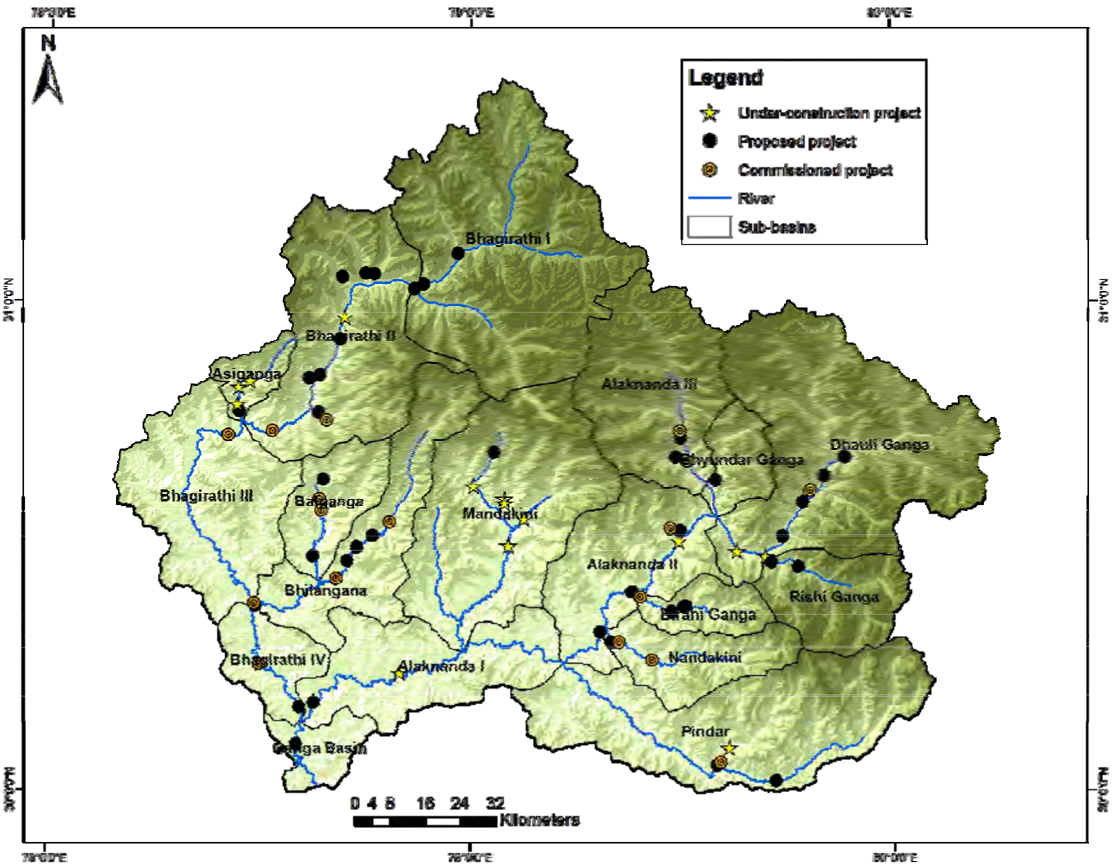


Fig. 3.1 Study area showing Alaknanda and Bhagirathi basins and the locations of Hydro Electric Projects in different stages of planning and implementation.

The Alaknanda and Bhagirathi basins fall in the north-western part of Uttarakhand. The terrain in these two basins is predominantly hilly. The total catchment of these basins upto Devparayag is 19,600 km^2. Both the basins are characterized with rather rugged river drainage, with deep, steep river valleys separated by linear narrow ridges. The slopes are steep and quite unstable in certain regions. The climatic zones vary from tropical zone to perpetually frozen zone according to the altitude, falling in 7 different categories.

3.1.1 Bhagirathi basin

The river Bhagirathi originates from the Gomukh (3900 m) in the Gangotri glaciers and western face of the Chaukamba peaks (within the physical boundaries of district Uttarkashi). The valley has a broad U-shape at higher elevations, characteristic of glacial origin, but at lower elevations the river has cut a narrow V-shaped fluvial valley. Along the 217 km long river, the elevation ranges from 480 m to 3200 m and has an average gradient of 1.25%. The total catchment area of Bhagirathi River is 8846.64 km^2 and the catchment can be further divided into the watershed of Bhagirathi, Bhilangana and Asi Ganga rivers.

Before coming down to Uttarkashi town (1,158m) Bhagirathi receives the Jadganga and Asiganga, other glacial and non-glacial fed streams. During its further course, the Bhilangana (glacial fed originating from the Khatling glaciers-3950m in Tehri district) merges with it at Tehri (630m), goes further downwards at Devprayag (472m), and meets with equally important sister tributary of the Ganga- the Alaknanda. Asiganga and Bhilangana are the major tributaries, among which Bhilangana has its own tributary, Balganga. The Bhagirathi basin is confined within Tehri Garhwal, Pauri Garhwal and Uttarkashi districts (IIT, 2011).

A total of 32 hydropower projects both large (>25 MW) and small (<25 MW and >1MW) with a total installed capacity 4871 MW are being planned within this basin (IIT, 2011). There are 9 commissioned projects, 4 projects are under-construction and 19 are proposed projects.

3.1.2 Alaknanda basin

The Alaknanda River originates from Satopanth and Bhagirath Kharak glaciers and runs a distance of 224 km till its confluence with Bhagirathi at Devprayag (472m). The basin is extended between 30^{o}0’ N - 31^{o}0’ N and 78^o 45’ E - 80^{o}0’ E, covering a total catchment area of about 12587.23 Km^2, representing the eastern part of the Garhwal Himalaya. The Alaknanda catchment can be sub-divided into Alaknanda, Mandakini, Nandakini, Pindar, Dhauliganga and Birahi Ganga sub-catchments.

Table 3.1 Physiographic characteristics of Bhagirathi and Alaknanda rivers and their tributaries.

S.No.	River	Total length* (m)	Elevation Range		Confluence	Confluence Location
			Highest Point	Confluence Point		
Bhagirathi River						
1.	Bhagirathi	217000	3200	480	1.25%	Confluences with Alaknanda at Devprayag
1(a).	Bhagirathi-Asiganga	83500	3200	1120	2.49%	
1(b).	Bhagirathi-Bhilangana	91000	1120	610	0.56%	
1(c).	Bhagirathi-Devprayag	42500	610	480	0.31%	
2.	Asi ganga	20500	2440	1120	6.44%	Confluences at Ganganani Uttarkashi
3.	Bhilangana	109000	3000	670	2.14%	Confluences at Tehri
4.	Bal ganga	37000	1730	814	2.48%	Confluences Bhilangana at Ghansali

Alaknanda River						
5.	Alaknanda	224000	4016	480	1.58%	Joins Bhagirathi at Devprayag
5(a).	Alaknanda-Dhauli ganga	47000	4016	1446	5.47%	Confluences at Vishnuprayag
5(b).	Alaknanda-Pindar	60000	1446	795	1.09%	Confluences at Karanprayag
5(c).	Alaknanda-Devprayag	109000	795	480	0.29%	
6.	Dhauli ganga	50000	2880	1446	2.87%	Confluences at Vishnuprayag
7.	Rishi ganga	38500	4000	1900	5.45%	Confluences Dhauli ganga at Tapovan
8.	Birahi ganga	29500	2160	994	3.95%	Confluences at Birahi village
9.	Nandakini	44500	2200	880	2.97%	Confluences Alaknanda at Nandprayag
10.	Pindar	114000	2200	775	1.25%	Confluences at Karnprayag
11.	Mandakini	81000	3562	640	3.61%	Confluences at Rudraprayag

**Upper reaches of river have not been accounted*

Approximately 5.9% of the total geographical area is under agriculture while only 0.6% of the land is under the horticultural crops. Forest covers about of 65% land area. The basin comprises eighteen development blocks in Bageshwar, Chamoli, Rudraprayag, Tehri and Pauri Districts. Like the Bhagirathi valley, the Alaknanda valley is U-shaped in its upper reaches and becomes V-shaped in its lower reaches. It is characterised by difficult terrain, wide variation in slopes, high rainfall and high humidity, low solar radiation and extreme low (highly elevated regions) to very high temperatures (valley regions during the summer). Thus, the climate ranges from sub tropical to alpine (Sati, 2008).
A total of 38 Hydro Electric Projects both large (>25 MW) and small (<25 MW and >1MW) with a total installed capacity 4163 MW are being planned within this basin. There are eight commissioned projects, 10 projects are under-construction and 20 are proposed projects.

3.2 Profile of the projects

A total of 70 Hydro Electric Projects both large (>25 MW) and small (<25 MW and >1MW) with a total installed capacity 9563 MW are being planned within this basin (Table 3.2 & Appendix 3.1). There are 17 commissioned projects, 14 projects are under-construction and 39 are proposed projects.

Table 3.2 List of 70 Hydro Electric Projects on Alaknanda and Bhagirathi river basins.

S.No.	Project Name	River	Capacity (MW)	River length affected (m)	Forest land take (ha)	Forest area submerged (ha)
1.	Agunda Thati	Dharam ganga	3.00	2000	NA	NA
2.	Alaknanda	Alaknanda	300.00	7000	49.648	NA
3.	Asiganga I	Asiganga	4.50	3000	NA	NA
4.	Asiganga II	Asiganga	4.50	2000	NA	NA
5.	Asiganga III	Asiganga	9.00	4500	NA	NA
6.	Badrinath II	Rishi ganga	1.25	1500	NA	NA
7.	Bal ganga II	Bal ganga	7.00	3250	NA	NA
8.	Bharon Ghati	Bhagirathi	381.00	18500	0	NA
9.	Bhilangana	Bhilangana	22.50	2700	4.949	NA
10.	Bhilangana IIA	Bhilangana	24.00	5000	NA	NA
11.	Bhilangana IIB	Bhilangana	24.00	4500	NA	NA
12.	Bhilangana IIC	Bhilangana	21.00	6500	NA	NA
13.	Bhilangana III	Bhilangana	24.00	6500	82.84	NA
14.	Bhyundar ganga	Bhyundar ganga	24.30	3250	NA	NA
15.	Birahi ganga	Birahi ganga	7.30	2500	NA	NA
16.	Birahi ganga I	Birahi ganga	24.00	6500	NA	NA
17.	Birahi ganga II	Birahi ganga	24.00	4000	NA	NA
18.	Bowla Nandprayag	Alaknanda	300.00	16000	9.09	NA
19.	Debal	Kail ganga	5.00	3500	NA	NA
20.	Devsari	Pinder	252.00	26305	18.658	60
21.	Dewali	Nandakini	13.00	10500	0	NA
22.	Gohana Tal	Birahi ganga	50.00	12000	NA	NA
23.	Jadh ganga	Jadhganga	50.00	2100	NA	8.35
24.	Jalandharigad	Jalandharigad	24.00	3500	12.11	NA
25.	Jelam Tamak	Dhauli ganga	126.00	8500	70	NA

S.No.	Project Name	River	Capacity (MW)	River length affected (m)	Forest land take (ha)	Forest area submerged (ha)
26.	Jhala koti	Bal ganga	12.50	4750	NA	NA
27.	Jummagad	Jummagad	1.20	2000	NA	NA
28.	Kail ganga	Kail ganga	5.00	3000	NA	NA
29.	Kakoragad	Kakoragad	12.50	3500	4.98	NA
30.	Kaldigad	Kaldigad	9.00	4000	NA	NA
31.	Kali ganga I	Kaliganga	4.00	1500	NA	NA
32.	Kaliganga II	Kaliganga	6.00	3000	NA	NA
33.	Karmoli	Jadhganga	140.00	10500	NA	9.94
34.	Khirao ganga	Khirao ganga	4.00	2750	NA	NA
35.	Kot Budha Kedar	Bal ganga	6.00	4750	NA	NA
36.	Koteshwar	Bhagirathi	400.00	20700	2	220
37.	Kotlibhel IA	Bhagirathi	195.00	18400	46.339	211.7
38.	Kotlibhel IB	Alaknanda	320.00	27500	146.05	453.7
39.	Kotlibhel II	Ganga	530.00	28000	57.45	590
40.	Lata Tapovan	Dhauli ganga	170.00	8500	0	NA
41.	Limcha Gad	Limcha gad	3.50	1500	NA	NA
42.	Lohari Nagpala	Bhagirathi	600.00	15000	0	NA
43.	Madhmaheshwar	Mandakini	10.00	5500	NA	NA
44.	Malari Jelam	Dhauli ganga	114.00	6500	NA	NA
45.	Maneri Bhali I	Bhagirathi	90.00	18000	NA	1.42
46.	Maneri Bhali II	Bhagirathi	304.00	22000	NA	NA
47.	Melkhet	Pinder	15.00	8500	NA	NA
48.	Nandprayag langasu	Alaknanda	100.00	8000	NA	NA
49.	Pala Maneri	Bhagirathi	480.00	18642	21.883	19.24
50.	Phata Byung	Mandakini	76.00	13000	2.97	4
51.	Pilangad	Pilangad	2.25	3000	NA	NA

S.No.	Project Name	River	Capacity (MW)	River length affected (m)	Forest land take (ha)	Forest area submerged (ha)
52.	Pilangad II	Pilangad	4.00	2300	NA	NA
53.	Rajwakti	Nandakini	3.60	2500	NA	NA
54.	Ram bara	Mandakini	24.00	8000	NA	NA
55.	Rishi ganga	Rishi ganga	13.20	1000	NA	NA
56.	Rishi ganga I	Rishi ganga	70.00	6025	1.86	6.2
57.	Rishi ganga II	Rishi ganga	35.00	5397	0.83	1.65
58.	Singoli Bhatwari	Mandakini	99.00	14500	NA	NA
59.	Siyangad	Siyangad	11.50	4500	4.96	NA
60.	Srinagar	Alaknanda	330.00	4500	339	68.73
61.	Suwari Gad	Suwari gad	2.00	2000	NA	NA
62.	Tamak Lata	Dhauli ganga	250.00	10500	24	NA
63.	Tapovan Vishnugad	Dhauli ganga	520.00	15500	0	NA
64.	Tehri Stage 1	Bhagirathi	1000.00	44000	2582	4200
65.	Tehri Stage II	Bhagirathi	1000.00	44000	2582	4200
66.	Urgam	Kalpganga	3.00	2500	NA	NA
67.	Urgam II	Kalpganga	3.80	1750	NA	NA
68.	Vanala	Nandakini	15.00	6500	0	NA
69.	Vishnugad Pipalkoti	Alaknanda	444.00	17243	100.39	24.5
70.	Vishnuprayag	Alaknanda	400.00	19400	33.248	NA

Table 3.3 Status of individual projects based on the stages of development.

Commissioned	Under construction	Proposed
ALAKNANDA BASIN		
Badrinath II	Kail ganga	Alaknanda
Birahi ganga	Kali ganga I	Bhyundar ganga
Debal	Kaliganga II	Birahi ganga I
Jummagad	Madhmaheshwar	Birahi ganga II
Urgam	Phata Byung	Bowla Nandprayag
Vanala	Rishi ganga	Dewali

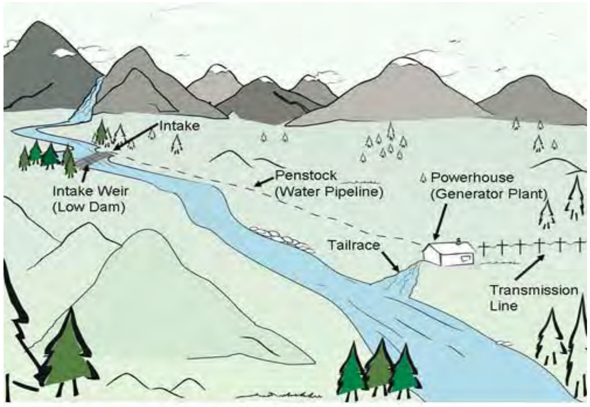
Vishnuprayag	Singoli Bhatwari	Gohana Tal
Rajwakti	Srinagar	Jelam Tamak
Commissioned	Under construction	Proposed
	Tapovan Vishnugad	Devsari
	Vishnugad Pipalkoti	Khirao ganga
		Kotlibhel IB
		Lata Tapovan
		Malari Jelam
		Melkhet
		Nandprayag langasu
		Ram bara
		Rishi ganga I
		Rishi ganga II
		Tamak Lata
		Urgam II
BHAGIRATHI BASIN		
Agunda Thati	Lohari Nagpala	Bal ganga II
Bhilangana	Asiganga I	Bharon Ghati
Bhilangana III	Asiganga II	Bhilangana IIA
Kot Budha Kedar	Asiganga III	Bhilangana IIB
Koteshwar		Bhilangana IIC
Maneri Bhali I		Jadh ganga
Maneri Bhali II		Jalandharigad
Pilangad		Jhala koti
Tehri Stage 1		Kakoragad
		Kaldigad
		Karmoli
		Kotlibhel IA
		Limcha Gad
		Pala Maneri
		Pilangad II
		Siyangad
		Suwari Gad
		Tehri Stage II
		Kotlibhel II

Hydro Electric Projects do impact river ecosystems directly. They also affect terrestrial ecosystems in their zones of influence due to impoundment created for storage of water or because of land take for construction related activities from natural habitats. The degree of impact to which any one project affects a river, varies widely. One of the most important variables is the type of the dam that would be constructed (Box 3.1). Other variables include the size and flow rate of the river or tributary where the project is located; the existing habitat and climatic conditions; the type, size, and design of a project; and whether a project is located upstream or downstream of other projects.

Box-3.1: Type of Hydro Electric Projects.

Diversion (Run-off) the River

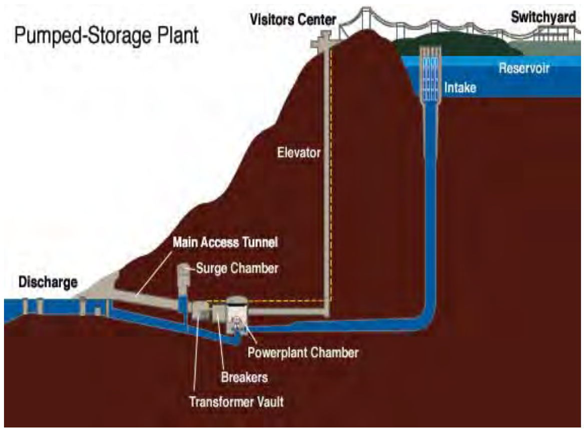
A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock. It may not require the use of a dam.



Typical run-of-river project

Pump-storage

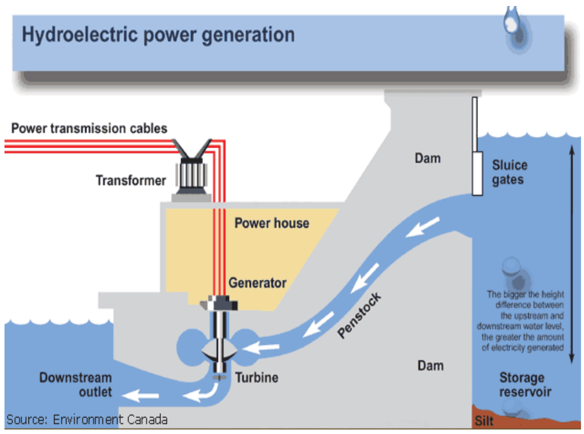
When the demand for electricity is low, pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.



Reservoir (Impoundment)

The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level.

(http://www.poweredbymothernature.com)



In view of the above design considerations in assessing impacts of the Hydro Electric Projects in Alaknanda and Bhagirathi basins, the details of types of schemes proposed is presented in Table 3.4.

Table 3.4 Types of HEPs in different sub-basins.

Sub-basins	Types of Scheme		
	RoR	Storage	Reservoir
Bhagirathi I	01	02	
Bhagirathi II	10	01	
Asiganga	04		
Bhagirathi III	01		01
Bhagirathi IV		02	
Bhilangana	05		
Balganga	04		
Alaknanda Sub-basin I		02	
Mandakini Sub-basin	05	01	
Alaknanda Sub-basin 2	04	01	
Pindar Sub-basin	03	01	
Nandakini Sub-basin	03		
Birahi ganga	04		
Rishi ganga	01	02	
Dhauli ganga	06		
Bhyundar ganga	01		
Alaknanda Sub-basin 3	04		
Ganga Basin		01	

Run-of-river power projects require diversion of water into penstocks (pipes) that bring water to turbines in a power plant at lower elevation. The elevation difference between the intake and the powerhouse provides the kinetic energy that powers turbines that produce electricity. Such projects require that water be diverted from a section ('reach') of the river, which may vary in length from few to several kilometres in length. This water is finally returned into the stream below the powerhouse through a short channel 'tailrace'. These various physical aspects of the project that are sometimes referred to as the project 'footprint' vary with length of river affected by diversions, submergence and downstream releases. The details of affected lengths of Bhagirathi and Alaknanda river are provided in Table 3.5.

Table 3.5 Affected lengths of Bhagirathi and Alaknanda river and its tributaries due to allotted hydropower development.

S.No.	River	Total river stretch (m)	River stretch diverted	River stretch submerged	Affected length	% of river length diverted	% of river length submerged	% of river length affected
Bhagirathi Basin								
1.	Bhagirathi	217000	68031	85400	153431	31%	39%	70.71%
2.	Asiganga	20500	10945	0	10945	53%	0%	53.39%
3.	Bhilangana	109000	20369	19000	39369	19%	17%	36.12%
4.	Bal ganga	37000	14721	0	14721	40%	0%	39.79%
5.	Small tributaries	73000	16401	0	16401	22%	0%	22.47%
Alaknanda Basin								
6.	Alaknanda	224000	60412	47100	107512	27%	21%	48.00%
7.	Dhauliganga	50000	46794	0	46794	94%	0%	93.59%
8.	Rishiganga	38500	10426	600	11026	27%	2%	28.64%
9.	Birahi ganga	29500	21926	0	21926	74%	0%	74.32%
10.	Nandakini	44500	15507	0	15507	35%	0%	34.85%
11.	Mandakini	81000	34875	500	35375	43%	1%	43.67%
12.	Pindar	114000	24974	10000	34974	22%	9%	30.68%
13.	Small tributaries	83000	18780	0	18780	23%	0%	22.63%

** Upper reaches of river have not been accounted*

3.3 Delineation of sub-basins for CEIA

A total of 18 sub-basins were delineated within the study area. These sub-basins provide for unique ecogeographic character and therefore, reflect biodiversity values accordingly. In the study area, the Alaknanda Basin is comprised of 10 sub-basins that are as follows:

A) Alaknanda basin

The Alaknanda Basin is comprised of 10 sub-basins. These are:

1. Alaknanda I sub-basin

The Alaknanda I spans along the stretch of mainstream River Alaknanda between Devprayag and Karanprayag. This sub-basin is drained mainly by Alaknanda River and its major tributary Mandakini that joins Alaknanda at Rudraprayag. This sub-basin mainly falls under lower to middle Himalayan range and has high ridge mountains and a number of side valleys. The variable topography of the area supports wide range of vegetation from subtropical to temperate types. Area has subtropical mixed forests, pine in the lower elevations and temperate forests in the higher elevations. Anthropogenic pressures and developmental activities along this stretch of Alaknanda are high as the main routes to Kedarnath and Badrinath is along this river which includes the major towns such as Srinagar, Rudraprayag and Devprayag.

This sub-basin harbours 2 Hydro Electric Projects Kotlibhel IB (storage), and Srinagar (storage). Among these, Srinagar HEP is under-construction and the Kotlibhel IB is a proposed project. All the projects are planned on the mainstream River Alaknanda.

2. Alaknanda II sub-basin

The Alakananda II sub-basin covers the stretch of mainstream River Alaknanda between Karanprayag to Vishnuprayag. In this sub-basin, tributaries such as the Urgam, Birahi ganga, Mandal river, Nandakini and Pindar drain into the main Alaknanda River. The sub-basin falls within the middle and lower Himalayan regions and encompasses subtropical mixed and chir pine forests at the lower elevations, temperate forests and scattered tree and scrub in the middle elevations (near Vishnuprayag) and oak & coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (Tungnath, Rudranath regions). Patches of riverine forest and scrub occur along the main river.

There are 5 Hydro Electric Projects within the limits of this sub-basin namely Bowla Nandprayag (RoR), Vishnugad Pipalkoti (storage), Nandprayag langasu (RoR), Urgam (RoR) and Urgam II (RoR). Urgam HEP is a commissioned project, Vishnugad- Pipalkoti is under-construction and Bowla Nandprayag, Nandprayag Langasu and Urgam II projects are proposed. The Urgam and Urgam II projects are planned on River Kalpganga, a tributary of River Alaknanda. The other projects are planned on the mainstream River Alaknanda.

3. Alaknanda III sub-basin

The stretch of Alaknanda from its origin up to its confluence with Dhauli Ganga falls in this sub-basin. The River Alaknanda originates from the high peaks near the northern boundary of District Chamoli (also international border), flows along Badrinath and south towards Joshimath. Tributaries such as Khiron ganga and Bhyundar ganga drain into Alaknanda. This sub-basin encompasses the Greater and Trans-Himalayan zones and the transition zones as well. The entire sub-basin is very narrow with steep slopes and rugged terrain in the lower and middle elevations, but opens up into wider valleys in the north towards the Trans-Himalayan regions. The uniqueness of this sub-basin is the gradual transition from Greater Himalayan elements (near Joshimath) to Trans-Himalayan elements (at the border). The famous Badrinath shrine is located in this sub-basin. Major proportion of this sub-basin was included into the buffer zone of Nanda Devi BR.

A total of 4 Hydro Electric Projects at different stages of construction are situated within the sub-basin viz., Vishnuprayag (RoR), Khirao ganga (RoR), Alaknanda (RoR) and Badrinath II (RoR). Of these, Badrinath II and Vishnuprayag are commissioned projects whereas the others are proposed projects. All the projects are planned on River Alaknanda except Khirao ganga project which is planned on River Khirao ganga.

4. Bhyundar ganga sub-basin

The main river of the Bhyundar sub-basin is the Bhyundar River that is recognized by this name from the point where Paspawati River that originates in the Valley of Flowers NP and

Lakshman ganga that originates in the Lokpal Lake meet and later flow down through the Bhyundar Valley for about 15 km to join Alaknanda at Govindghat. This sub-basin is a small narrow Valley with steep terrain. This sub-basin located in the Greater Himalayan and the transition zone between the Greater and Trans-Himalaya. Only one project is planned in this sub-basin the Bhyundar ganga project (RoR). It is a proposed project and is planned on the River Bhyundar ganga.

5. Nandakini sub-basin

The Nandakini sub-basin covers the catchment of River Nandakini. The River Nandakini originates near the high peaks of Nandaghunti and Trishul and as like the Pinder runs east-west to join the Alaknanda at Nandprayag. It is a very narrow sub-basin and similar to Pindar sub-basin in terms of its location, topography, forest types, flora & fauna. Some high altitude areas of this sub-basin fall within the buffer zone of Nanda Devi BR.

This sub-basin has 3 Hydro Electric Projects which are Dewali (RoR), Rajwakti (RoR) and Vanala (RoR) projects. These projects are at different stages of construction with Vanala and Rajwakti being commissioned projects and Dewali project being proposed. All the projects are planned on River Nandakini.

6. Mandakini sub-basin

The catchment of River Mandakini falls under Mandakini sub-basin. The River Mandakini is one of the main tributaries of Alaknanda. Rivers such as Sone ganga, Kali ganga, Mandani ganga, and Madh Maheshwar ganga drain into Mandakini River. The sub-basin extends from middle to the high Himalayan ranges and encompasses subtropical mixed and chir pine forests at the lower elevations (Rudraprayag), temperate forests and scattered tree and scrub in the middle elevations, oak & coniferous mixed sub alpine forests, alpine scrub and meadows, moraines, glaciers and high altitude lakes in the higher elevations. The upper catchment of Mandakini forms the part of the Kedarnath Musk Deer Sanctuary.

A total of 6 Hydro Electric Projects are planned within this sub-basin viz., Singoli Bhatwari (RoR), Madhmaheshwar (RoR), Kaliganga II (RoR), Phata Byung (storage), Kali ganga I (RoR), and Ram bara (RoR). Among these, Ram bara is a proposed project while the others are under-construction. The Kali ganga I and II projects are planned on River Kali ganga (tributary of Mandakini) while the other 4 projects are planned on River Mandakini.

7. Birahi ganga sub-basin

As like Nandakini, the River Birahi ganga originate from the high group of peaks of Trishul and Nandaghunti flows east-west to join Alaknanda near Pipalkoti. Located in the middle and Greater Himalayan ranges, this sub-basin encompasses subtropical mixed and chir pine forests at the lower elevations, temperate forests and scattered tree and scrub in the middle elevations, and oak & coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations.

The catchment of River Birahi ganga forms the Birahi ganga sub- basin. This sub-basin contains Birahi ganga (RoR), Birahi ganga I (RoR), Birahi ganga II (RoR) and Gohana Tal (RoR) Hydro Electric Projects. The Birahi ganga project is under construction whereas Birahi ganga I, Birahi ganga II and Gohana Tal are proposed projects. All the projects are planned on River Birahi ganga.

8. Pinder sub-basin

The River Pinder catchment is covered under Pinder sub-basin. The River Pindar originates from the Pindari glacier in Bageshwar District and flows east-west to join the River Alaknanda at Karnaprayag in Chamoli District. The Pindar catchment falls within the middle and greater Himalayan regions and encompasses subtropical mixed and chir pine forests at the lower elevations (Karnaprayag), temperate forests and scattered tree and scrub in the middle elevations, and oak & coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (near Pindari). Patches of riverine forest and scrub occur along the main river. Some high altitude areas of this sub-basin fall within the buffer and transistion zones of Nanda Devi BR.

There are 4 Hydro Electric Projects planned in the sub-basin namely Devsari (storage), Debal (RoR), Kail ganga (RoR) and Melkhet (RoR) projects. The Devsari and Melkhet projects are planned on the River Pinder and the Debal and Kail ganga projects are planned on River Kail ganga, a tributary of Pinder. The Devsari and Melkhet projects are proposed to be built, Kail ganga project is under-construction whereas Debal is a commissioned project.

9. Dhauliganga sub-basin

The catchment of River Dhauliganga falls within the Dhauliganga sub-basin. The River Dhauli ganga originates from the high peaks along the eastern border of District Chamoli (also the international border) and runs south west to join Alaknanda near Joshimath. The sub-basin encompasses Greater and Trans-Himalayan regions and has high habitat diversity ranging from temperate forests, scattered tree and scrub in lower elevations to subalpine forests, alpine scrub and meadows, glacier moraines, trans-Himalayan scrub and grasslands in the higher elevations. The uniqueness of this sub-basin is the gradual transition from Greater Himalayan elements (near Joshimath) to Trans-Himalayan elements (at the international border).

A total of 6 Hydro Electric Projects are planned within the sub-basin viz., Jummagad (RoR), Tapovan Vishnugad (RoR), Lata Tapovan (RoR), Tamak Lata (RoR), Jelam Tamak (RoR) and Malari Jelam (RoR). Lata Tapovan, Tamak Lata, Jelam Tamak and Malari Jelam are among the proposed projects, Tapovan Vishnugad is under-construction and Jummagad is a commissioned project. All projects are planned on River Dhauliganga except Jummagad which is planned on River Jummagad, a tributary of Dhauliganga.

10. Rishi ganga sub-basin

The Rishi ganga basin covers the catchment of River Rishi ganga. The River Rishi ganga originates at the base of Nanda Devi west peak (7817m) and flows northwest to join Dhauli ganga at Reni village. The Nanda Devi Sanctuary was declared as Nanda Devi National Park in 1982 and closed for all human activities in 1983. In 1988, the Nanda Devi NP was inscribed as UNESCO World Heritage Site. In order to protect the integrity of this site and the sustainable development of the local communities, the Nanda Devi Biosphere Reserve was created in 1988 with a buffer zone surrounding this NP. The Nanda Devi NP is located in the Greater Himalayan region and encompasses the temperate, subalpine, alpine, moraine habitats and many glaciers.

This sub-basin harbours 3 projects which are Rishi ganga (RoR), Rishi ganga I (storage) and Rishi ganga II (storage). All the projects are planned on River Rishi ganga. Rishi ganga I and II are proposed projects whereas Rishi ganga project is under-construction.

B) Bhagirathi basin

The Bhagirathi basin is comprised of 7 sub-basins which are:

1. Bhagirathi I sub-basin

This sub-basin that is drained by Bhagirathi and its main tributary, Jadh ganga fall in the Greater and Trans-Himalayan regions. It encompasses the temperate forests, temperate scattered tree and scrub, subalpine forests and scrub, alpine scrub and meadows, moraines and glaciers. The entire catchment of Bhagirathi forms the Gangotri National Park including a considerable stretch of snow-clad mountains and glaciers. The Gangotri, after which the National Park has been named, is one of the holy shrines of Hindus and located inside the Park. The National Park area forms a viable continuity between Govind National Park and Kedarnath Wildlife Sanctuary of Uttarakhand state. High ridges, deep gorges and precipitous cliffs, rocky craggy glaciers and narrow valleys characterize the area.

There are 2 Hydro Electric Projects located within this sub-basin namely, Karmoli (storage) and Jadhganga (storage). Both these projects are proposed projects and are situated on River Jadhganga.

2. Bhagirathi II sub-basin

The stretch of Bhagirathi from its confluence with Jadh ganga to the location of its confluence with Asi ganga has been categorised as Bhagirathi II sub-basin. This sub-basin falls in the middle and high Himalayan ranges and much of the sub-basin has been degraded due to development and anthropogenic pressures consequently there are no PAs.

A total of 11 Hydro Electric Projects are planned within this sub-basin viz., Lohari Nagpala (RoR), Limcha Gad (RoR), Bharon Ghati (RoR), Kakoragad (RoR), Siyangad (RoR), Jalandharigad (RoR), Maneri Bhali I (RoR), Pala Maneri (storage), Suwari Gad (RoR), Pilangad (RoR) and Pilangad II (RoR). The Pilangad and Maneri Bhali I projects are commissioned, Lohari Nagpala project is under-construction whereas all the other projects are proposed. The Maneri Bhali, Lohari Nagpala, Bharon Ghati and Pala Maneri projects are planned on River Bhagirathi, the Pilangad and Pilangad II projects are planned on River Pilangad and the other projects are planned on smaller tributaries of River Bhagirathi.

3. Bhagirathi III sub-basin

The length of River Bhagirathi between point of confluence of River Bhilangana with River Bhagirathi to that of River Asiganga is covered within the Bhagirathi III sub-basin. This sub-basin falls in lower and middle Himalayan range and has high ridge mountains. The Tehri Dam located at the confluence of Bhagirathi and Bhilangana and its Reservoir extends up to 44 km up stream fall within this sub-basin. The land on both the sides of the river is primarily agriculture land and the vegetation is mostly degraded scattered pine and mixed forests and xerophytic shrubs. Area above the submergence zone is very close to Uttarkashi town and most of it is human settlements.

Only one project, Maneri Bhali II (RoR), is situated in the sub-basin. This project is located on mainstream Bhagirathi and is a commissioned project.

4. Bhagirathi IV sub-basin

This sub-basin includes the area from Bhagirathi-Bhilangana confluence to Devprayag where Bhagirathi joins Alaknanda. It falls in the lower Himalaya and has patches of riverine habitats along the river and mixed sub-tropical forests in the middle and higher slopes. Anthropogenic pressures and developmental activities in whole sub-basin have resulted in degradation of forested habitats.

The section of river Bhagirathi between Devprayag and the point of confluence of River Bhilangana falls within the Bhagirathi IV sub-basin. There are 4 projects are planned in the sub-basin namely, Kotlibhel IA (storage), Koteshwar (storage), Tehri Stage 1 (storage) and Tehri Stage II (storage) among which Tehri stage 1 and Koteshwar are commissioned and Kotlibhel IA and Tehri stage projects are proposed.

5. Asiganga sub-basin

The catchment of River Asiganga lies within the Asiganga sub-basin. The river Asiganga is one of the major tributaries of Bhagirathi. It originates from Dodital lake (2240m) and joins Bhagirathi near Uttarkashi. The sub-basin falls in the middle and high Himalayan ranges and encompasses subtropical pine mixed forests, temperate oak and conifer forests, subalpine forests and scrub, and alpine scrub and meadows. The valley is marked by undulating and rugged terrain and steep slopes with highly mountainous, precipitous ridges interspaced by deep gorges. The valley is seemingly narrow through which the fast flowing Asiganga passes.
A total of 4 Hydro Electric Projects lie within the sub-basin which are Asiganga III (RoR), Asiganga II (RoR), Asiganga I (RoR) and Kaldigad (RoR). The Asiganga I, II and III projects are planned on River Asiganga and the Kaldigad project is planned River Kaldigad, a tributary of Asiganga. All the projects are under-construction except Asiganga III which is proposed to be built.

6. Bhilangana sub-basin

The Bhilangana sub-basin covers the catchment of River Bhilangana. The Bhilangana River originates from Khatling glacier and joined by Balganga at Ghansali. It falls in the middle and greater Himalayan regions and encompasses subtropical mixed and chir pine forests at the lower elevations (Ghansali), temperate forests and scattered tree and scrub in the middle elevations (Ghutu), and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (below Khatling).

The sub-basin constitutes of 5 projects viz., Bhilangana (RoR), Bhilangana III (RoR), Bhilangana IIC (RoR), Bhilangana IIB (RoR), and Bhilangana IIA (RoR). The Bhilangana and Bhilangana III projects are commissioned, whereas the other 3 projects are proposed. All the projects are planned on River Bhilangana.

7. Balganga sub-basin

The Balganga sub-basin is drained by Balganga and its tributary Dharamganga that joins Balganga at Budhakedar. This sub-basin falls in the middle and greater Himalayan ranges and is a broad valley with many lakes and glaciers in the higher altitudes. Habitats such as temperate mixed forests, temperate scattered tree and scrub with open grassy slopes, pine forests are present in this sub-basin including patches of riverine forests along Balganga. A total of 4 projects are planned in this sub-basin namely, Balganga II (RoR), Agunda Thati (RoR), Kot Budha Kedar (RoR) and Jhala koti (RoR). All projects are planned in River Balganga except Agunda thati which is situated on River Dharamganga, a tributary of Balganga. The Agunda thati and Kot Budha Kedar are commissioned projects where as the Balganga II, and Jhala Koti projects are proposed.

8. Ganga sub-basin

The stretch of River ganga between Devprayag and Rishikesh is covered under Ganga sub-basin. The stretch of Ganga from Devprayag to Rishikesh falls in the lower Himalayan range and encompasses the subtropical sal and mixed forests, open grassy slopes and scrub, and patches of riverine forests along the river. One major tributary, the Nayar joins Ganga near Byasi. This stretch of the Ganga is heavily used for adventure activities such as river rafting, camping, rock climbing and also for religious/spiritual purposes. This basin harbours one project which is the Kotlibhel II (storage) project. It is a proposed project which is planned on River Ganga.

Chapter 4 – Approach and Methodology

4.1 Framework for Cumulative Environmental Impact Assessment (CEIA)

The study was designed to assess the cumulative impacts of the Hydro Electric Projects (commissioned, under-construction and proposed) on the biodiversity values of Alaknanda and Bhagirathi basins, in the State of Uttarakhand. The overall goal of CEIA was to assess the impacts of past, present and future hydropower developments on biodiversity values. The major challenge to this kind of assessment is the lack of tailor made methodologies for scoping of cumulative effects and consideration of past or likely future human activities beyond the plan or project in question (Therivel and Ross, 2007). Development of an appropriate methodological framework for conducting CEIA in the context of hydropower development was the foremost requirement. The methodological framework for this study was adopted from standard practices followed globally in the evaluation of cumulative effects (Council on Environmental Quality, 1997; Canter and Sadler, 1997; CEAA,1999; Dube, 2003; Caltran 2005). The specific process of CEIA involved (a) Scoping, (b) Establishing Biodiversity Baselines, (c) Impact Prediction and Evaluation and (d) Decision Support (Fig 4.1). The CEIA was designed to be executed over a nine month period from January to September 2011, but additional time frame upto February 2012 was actually used for analysis and report writing.

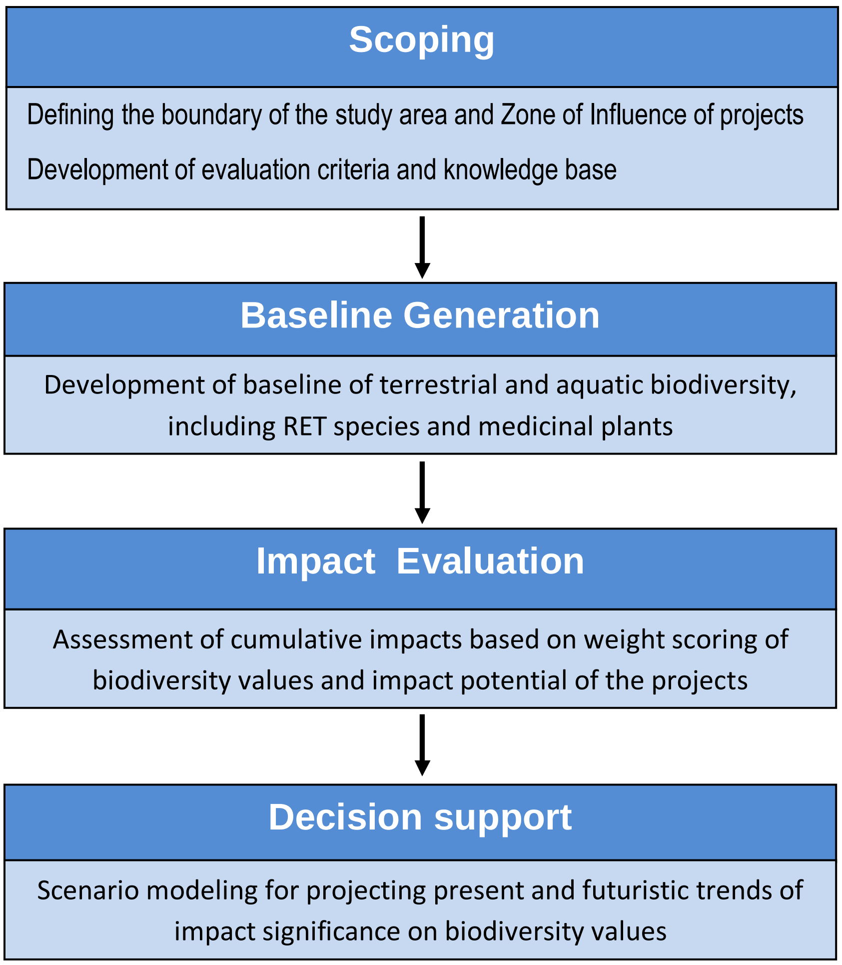


Fig. 4.1 The CEIA framework adopted in the study.

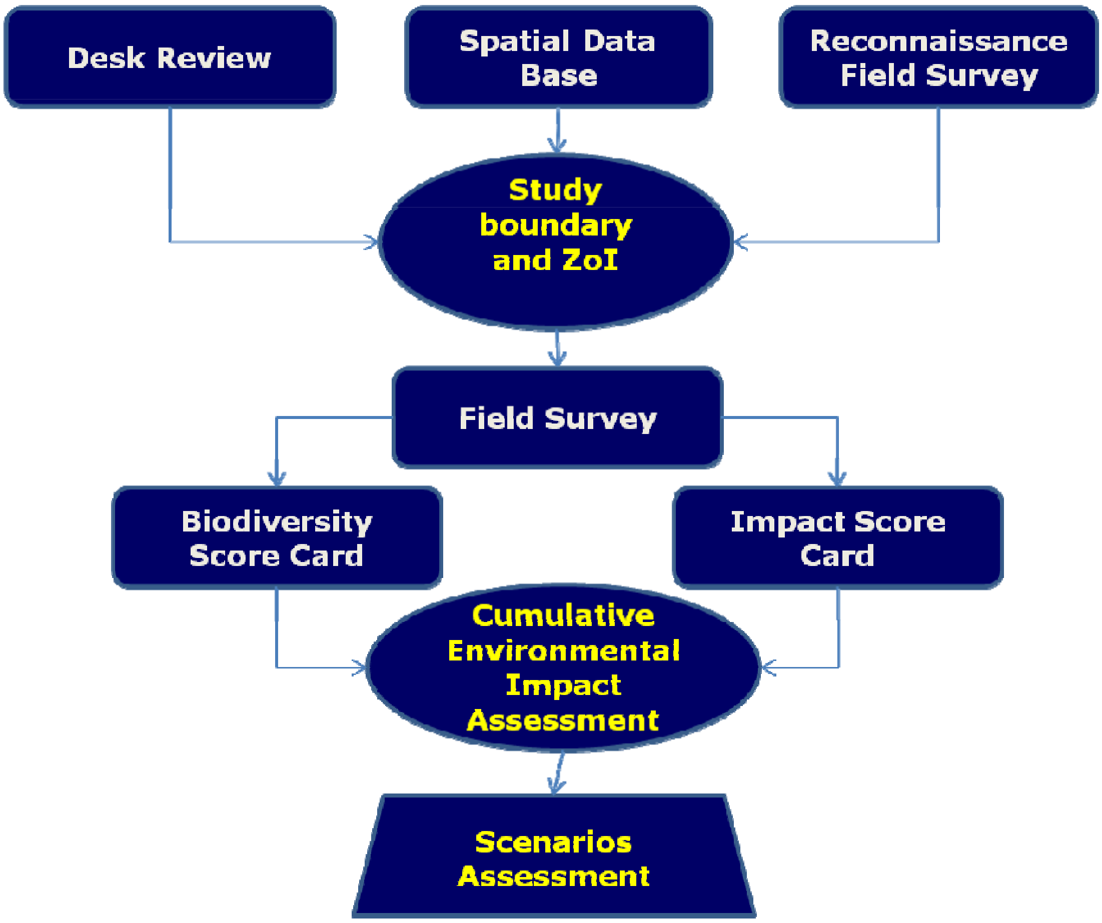


Fig 4.2 Flowchart of methodological framework adopted to undertake the CEIA.

4.1.1 Scoping

Scoping is the most important step in the impact assessment process as it is essentially aimed at identifying the sources of the impacts or "impact stressors" and those receptors that are likely to be subjected to significant cumulative effects and defining the boundary of the study.

In this assessment, scoping effort included (a) desk reviews, (b) preliminary field surveys (reconnaissance) for determining scope of assessment and determining the larger boundary of the study and the Zone of Influence within this boundary, based on the available knowledge, field assessment and impact analysis. The Zone of Influence for each of these projects was defined as an area which will be influenced by the activity centers where all associated infrastructure development is planned and where all physical actions onsite will take place. The Zone of Influence varies thus vary for each project, based on disturbances caused by the size of scheme, submergence zone, diversion of river, area of powerhouse and key construction activities, such as dam, headrace/tailrace tunnels, muck disposal area and infrastructure developments. Therefore, the Zone of Influence is nonlinear, variable in size and shape, depending on the location, length and area of various project activities.

4.1.1.1 Desk Studies

Desk studies involved review and gleaning of information from the detailed project reports (DPRs), EIA reports, the report by IIT, Roorkee for improving the understanding of the project profile and the nature and extent of activities envisaged to visualize the range of impacts. An extensive and elaborate literature survey was undertaken to collect secondary information on floral and faunal (terrestrial and aquatic) values within the study area. Various institutions and organizations working on these aspects were also contacted to supplement information on key study parameters. Literature on CEIA studies conducted globally was consulted.

4.1.1.2 Reconnaissance

The Institute's multidisciplinary team undertook series of surveys in the selected project sites and gathered information on different terrestrial and aquatic biodiversity components. As Hydro Electric Projects have a direct bearing on the habitats of both terrestrial and aquatic species dependent on environmental flows, specific taxa were targeted for conducting impact assessment. Taxonomic groups that have flagship values and keystone effects, and are highly sensitive to changes in the habitat and intensity of disturbance in their habitats were selected for the assessment. In this study, mammals, birds and plants were considered to represent the terrestrial system and fishes were included to represent the aquatic system. During the study period, the biodiversity values of the area within the Zone of Influence were assessed based on qualitative criteria such as cover, habitat diversity and species presence/ absence.

4.1.1.3 Determining the study boundary and the Zone of Influence

As cumulative impacts are considered within spatial (geographic) and temporal boundaries, the boundaries of study area for cumulative impacts analysis are often broader than the boundaries used for the project-specific analysis, which focuses on the immediate project area. These boundaries were identified based on working knowledge of resources, development actions proposed and regulatory mandates. Within these study boundaries, Zones of Influence (ZoI) were identified.

The Zone of Influence is defined as the farthest possible distance of influence of the development project, emanating from various impact sources. Identification of impact sources took into consideration the activities, location and extent of (a) Dam, (b) Barrage, (c) Submergence, (d) Tailrace tunnel, (e) Diversion zone, (f) Muck deposits, and (g) Built-up areas for establishing various infrastructures including road network. These features joined together formed the threshold distance of Zone of Influence and the extent of area was determined based on 500m polygons drawn around the fused features.

4.1.1.4 Defining sub-basins for CEIA

It is known from experience that project-based assessments do not befit the conceptual and operational basis of CEIA (Kennett, 2002; Antoniuk, 2000; Dubé, 2003; Duinker and Greig, 2006). CEIA at the project level remains constrictive, reactive and divorced from broader planning and decision-making contexts (Harriman and Noble, 2008). In other words, it becomes imperative to conduct CEIAs at a larger landscape level. In this study, the two basins Alaknanda and Bhagirathi were the large landscape units within which the sub-basin landscape unit formed the smallest unit for assessing the biodiversity values and the development induced impacts on these. The site level information gathered from the project ZoIs was taken to be useful source of information to collate data at the sub-basin level, specifically for the impact sources.

A total of 18 sub-basins were delineated within the study area (Table 4.1.), based on the extent of the major tributaries of Bhagirathi and Alaknanda basins and also the single stretch of the main streams. Similar classification was also used by IIT Roorkee in their study.

Table 4.1. List of sub-basins in the study area.

Major Basin	Sub-basin	Number of Hydro Electric Projects
Alaknanda	Alaknanda I Sub-basin	2
	Alaknanda II Sub-basin	5
	Alaknanda III Sub-basin	4
	Bhyundar ganga sub-basin	1
	Nandakini Sub-basin	3
	Mandakini Sub-basin	6
	Birahi ganga Sub-basin	4
	Pinder Sub-basin	4
	Dhauliganga Sub-basin	6
	Rishi ganga Sub-basin	3
	Sub-total	38
Bhagirathi	Bhagirathi I Sub-basin	2
	Bhagirathi II Sub-basin	11
	Bhilangana III Sub-basin	1
	Bhilangana IV Sub-basin	4
	Asiganga Sub-basin	4
	Bhilangana Sub-basin	5
	Balganga Sub-basin	4
	Ganga Sub-basin	1
	Sub-total	32
	Total	70

4.1.2 Establishing biodiversity baseline

4.1.2.1 Flora

The broad physiognomic classes of vegetation in the area *i.e.*, forests, scrub (primary or secondary), grasslands and herbaceous meadows (alpine) were characterized in terms of species composition and structure. Remote sensing data (LISS – IV) was interpreted to assess the overall vegetation cover and other land use / land cover (LULC) categories in both the basins. Prior to field surveys, collation of secondary literature, maps, working plans of various forest divisions was done.

Stratified random sampling of vegetation communities was used following standard phytosociological approach (Mueller-Dombois & Ellenberg 1974; Kent & Coker 1992),The following categories of land forms and vegetation (physiognomic classes) occur in the study area:

Land forms: Rocky slope, Gentle slope, Flat alluvial banks, Gorge, Upland Valley, Terminal and lateral moraines, Terraces (old and new), Landslides, Landslips and Debris.

Physiognomic classes of vegetation: Dense Forest, Open Forest, Secondary scrub, Grassy slopes, Alpine scrub, Alpine meadow, Sparse vegetation cover and major communities within each category.

Table 4.2. Environmental and vegetation parameters observed during sampling.

Environmental / Habitat Parameters	Vegetation Parameters
Geographical coordinate /GPS reading Altitude Soil Type Canopy Cover Shrub Cover Ground Cover Moss Cover Lichen Cover Weed Cover Rock Cover (%) Slope Aspect Human Pressure (0,1,2,3)	Tree Species & Number Tree GBH Shrub Species & Number Shrub Height Herb Species & Number NTFP Species and their abundance RET Species and their abundance, if any

4.1.2.2 Fauna

Mammals

Information on mammal distribution and abundance in the study area was collected from various sources such as publications, reports and databases (Bhattacharya *et al.* 2006, Bhattacharya and Sathyakumar 2008, Kala 2004, Maheshwari and Sharma 2010, PSL 2006, Schaller 1977, Prater 1980, Sathyakumar 1994, 2001, 2006a, 2006b, Sathyakumar and Bhatnagar 2002, Sathyakumar *et al.* 1992, ZSI 1995). Field surveys in the project influence zones and informal interviews with local villagers in the project area were carried out in the different project sites to ascertain the presence/absence of mammals, particularly RET species. Status of mammals in the project area was assessed based on visual encounters and indirect evidences (tracks, scats, pellet groups and other signs) following standard methods (Sathyakumar 1993, 1994, WII 1998) and also based on secondary sources including expert knowledge.

Birds

Data on bird distribution and abundance in the study area was collected from different sources (Ali and Ripley 1983, Bhattacharya and Sathyakumar 2007, Sathyakumar and Sivakumar 2007, ZSI 1995). Field surveys in the Zone of Influence and also in other parts of sub-basins were carried out in the different project sites to ascertain the presence/absence of birds particularly RET species. Bird field guides (Ali and Ripley 1983, Grimmette et al 2003) were used for bird identification.

Fishes

For generating baseline of biodiversity resources, the primary data on fish distribution and abundance was collected during field visits spread over a period of six months. This information was adequately supplemented by the the secondary data from different publications and the data sources (Badola 2001, Payne *et al.* 2004, Sinha 2007) to understand the current distribution pattern of fishes in the basin, especially in the Zone of Influence of project sites. Apart from main streams of the rivers Ganga, *viz*., Alaknanda and Bhagirathi, major tributaries of the river were also sampled for fishes. The location of Zone of Influence was also seen in the context of proximity to Protected Areas while assessing the impact.

Samples were collected at all sites during daytime (07:00 – 17:00 hrs). Experimental fishing was carried out in all sampling points by the project team members and locally hired professional fishermen. Fishes were collected with cast nets (mesh 0.6 x 0.6 cm.), drag nets or locally called *mahajal* (mesh 0.7 x 0. 7 mm., L x B = 80 m. x 2.5 m. with varying mesh sizes) and fly collecting nets (indigenous nets using nylon mosquito nets tied with the bamboo in both ends). At each sampling site, all gears were used at least ten times during each sampling occasion.

All specimens were identified based on the classification system of Nelson (2006) and scientific names were verified using www.fishbase.org. The color, spots if any, maximum size and other characters of the fishes caught were recorded in a format developed for this purpose. Fishes not collected during experimental sampling were collected from nearby fish market and landing centre associated with the river system. Taxonomic discrepancies were resolved using the latest database.

4.1.2.3 Assessing site-specific biodiversity values: Use of criteria

I. Rationale for using criteria

The goal of systematic conservation planning is to provide a structured, scientifically defensible and effective framework for protecting biodiversity. The assignment of biodiversity value to land units is a key component of this process. Assessing and assigning biodiversity values to the sites aid in prioritizing sites for conservation. Such assessments can be made using different criteria and thresholds that not only focuses on a single biodiversity component but are also related to ecosystem and environmental diversity (Regan et.al. 2007). Environmental or ecological criteria can be useful for describing baseline environmental conditions and considering potential cumulative effects (Canter 1999).

Criteria (which explicitly and consistently differentiate the factors contributing to significance determination judgments) and thresholds (a clearly defined performance level that explicitly establishes significance) are a crucial component of impact significance determination procedures within the environmental assessment process (Gartner Lee Limited (GLL), 2001; Sippe, 1999). Threshold and criteria application can occur before and after considering mitigation potential (Lawrence 2007). A criterion is a comparative mechanism that facilitates assessment and judgment. There are both generic (e.g., positive/negative, degree of intensity, spatial extent, frequency, duration, reversibility, likelihood, direct/indirect, cumulative effects potential) and feature-specific (e.g., linked to specific setting types, locations, limits and impacts) criteria (Vanclay, 1999). Thresholds refer to the point at which additional system perturbations, no matter how little, will culminate in major system degradation or collapse (Contant and Wiggins 1993). A threshold value can be either a maximum or minimum number or a related qualitative measure, which, if exceeded or not met, causes the predicted effect (Witmer *et al.,* 1987).

Most ecological assessments use a series of criteria to evaluate impact significance and importance either quantitatively or qualitatively. No standard set of criteria has emerged and multitudes have been used in practice (Treweek, 1999). Names used for similar criteria vary from system to system. The idea of evaluating the significance of natural areas for conservation has found wide application and such evaluations are bring used for environmental assessments, planning systems and individual protected areas (Smith and Theberge 1986).

The criteria used in 22 systems for evaluation of natural areas summarized by Smith and Theberge (1986) are given in Box 4.1.

Treweek (1999) generated a set of questions (see Box 4.2) based on some of the criteria given in Box 4.1. These questions help in guiding the derivation of criteria relevant for application in impact assessment.

It should be noted that identification of criteria is somewhat subjective, value driven and dependent on the experience and background of the group (Regan *et al.,* 2007).

Box 4.1: Criterion used for evaluation of natural areas.

Criterion	Number of studies in which used	Type of criterion
Rarity, uniqueness	20	Biotic, abiotic
Diversity	20	Biotic, abiotic
Size	11	Biotic, abiotic, planning and management
Naturalness	10	Biotic, abiotic
Productivity	3	Biotic
Fragility	7	Biotic, abiotic
Representativeness, typicalness	8	Biotic, abiotic
Importance to wildlife, abundance	6	Biotic
Threat	6	Planning and management
Educational value	6	Cultural
Recorded history/research investment	6	Cultural
Scientific value	5	Cultural
Recreational value	5	Cultural
Level of significance	4	Planning and management
Consideration of buffers and boundaries	4	Planning and management
Ecological/geographical location	2	Planning and management
Accessibility	2	Planning and management
Conservation effectiveness	2	Planning and management
Cultural resources	2	Cultural
Shape	2	Planning and management, biotic

[a] Modified from Table 2 of Margules and Usher (1981) with 13 added studies (Nicholson 1968, Man and Biosphere Program 1974 and 1976, Ray 1975, Rabe and Savage 1979, Eagles 1980, Fuller 1980, Theberge and others 1980, Klopatek and others 1981, McCormick and others 1984, Canadian Department of Fisheries and Oceans 1982, Radforth and others 1981, McKinnon 1982, Parks Canada 1982). Only criteria used in more than one study are included in the table.

Source: Smith and Theberge, 1986

Box 4.2: Examples of relevant questions for guiding the evaluation of impact significance.
• Will the loss or redistribution of habitat affect the long term viability of associated species? • Will carrying capacity, stress thresholds of assimilative capacity be exceeded? • If this habitat is destroyed, will the associated species find an alternative habitat? • If this habitat is destroyed, will the remaining habitat be adequate to support associated species? • If this habitat is destroyed, can it be replaced using current technology and within a reasonable timeframe? • Will the ecosystem resilience or stability breakdown? • Will the predicted population reductions for a species result in loss of long-term population viability? • Will significant, irreversible loss of biodiversity occur? • Will the reduced generic diversity result in reduced ability to withstand environmental change on future? • Will the loss of one habitat type be more damaging than the loss of another? • Will the post-development state of an ecosystem be significantly different from its pre-impacted condition? • Should any losses of the ecosystem components or functions be mitigated or compensated for and if so, which ones? • Will proposed mitigation measures guarantee the maintenance of natural resources within acceptable limits, i.e. will the residual condition of ecosystems (post-impact and taking account of mitigation) be acceptable?

(Source: Treweek, 1999 In Rajvanshi et al., 2007)

II. Determination of criteria for the present study

For this study, a set of criteria were identified to assess the biodiversity values of the impacted area at the sub-basin levels. These criteria capture the importance of the ecological/biological characteristics of these areas, especially in terms rarity, vulnerability or irreplaceability of their values. Different set of criteria were evolved for assessing aquatic and terrestrial biodiversity (Table 4.3. and Table 4.4.).

Table. 4.3. Criteria for assessing terrestrial biodiversity values.

S.No.	Criteria	Description	Applicable Taxa
1.	RET (Rare, Endangered and Threatened) Species, as per IUCN and other Global Criteria	Number of RET species present in the sub-basin.	Mammals/Birds/Plants
2.	Schedule Species	Number of species that are listed in the Schedule-I of Indian Wildlife Protection Act (IWPA), 1972, reflecting legal provisions.	Mammals/Birds
3.	Species Richness	Number of different species represented in a set or collection of individuals.	Mammals/Birds/Plants
4.	Medicinal Species	Number of species having medicinal properties hence valuable ecologically and economically.	Plants

Table. 4.4. Criteria for assessing aquatic biodiversity values.

S.No.	Criteria	Description
1.	RET (Rare, Endangered and Threatened) Species, as per IUCN and other Global Criteria	Number of RET species present in the sub-basin.
2.	Endemic Species	Number of endemic species present in the sub-basin, reflecting the irreplaceability, and national importance that the species command
3.	Habitat Diversity	Number of habitat types available. This is a surrogate for habitat heterogeneity and biodiversity richness
4.	Species Richness	Number of different species present in a given land units
5.	Breeding/Congregation	Presence/ absence of breeding sites and congregation opportunities for the target taxonomic group in a sub-basin.
6.	Migratory Pathways/Corridor	Presence/ absence of migratory pathways/corridor for aquatic biodiversity in the sub-basins

4.1.3 Impact prediction

Ecological assessments rely crucially on outcomes of impact prediction. It involves relating the project induced activities with ecosystem characteristics to determine the changes that may result in these charactersitics due to interactions (DEAT 2004).

The evaluation of impacts involves assessing the severity and extent of impacts on ecosystem components relative to the baseline (Treweek 1999).

Information about predicted changes is needed for assigning impact significance, prescribing mitigation measures, and designing and developing environmental management plans and monitoring programme (ADB 1997). This stage in a cumulative environmental process generally involves scenario building to project existing and futuristic trends of impacts and their significance for biodiversity values. This stage thus provides alternative scenarios for decision makers to promote least impacting option (of discouraging or relocating sites) and technology alternative.

4.1.3.1 Identification of impact indicators (impact stressors)

In the current study, the specific impact indicators were used (Table 4.4) based on their potential to cause definite changes in characteristics of receptors. The report by IIT Roorkee formed the basis for obtaining values for specific indicators.

Table 4.5. Criteria for impact indicators (reflecting the disturbance regimes).

S.No.	Indicator	Description
1.	River Length Affected (River dryness and submergence)	The length of river which would be deprived of water by water diversion through head/tailrace tunnel, and the area lost to submergence.
2.	Forest Area Loss	The location, extent and nature of forest area cleared and submerged due to Hydro Electric Projects construction and operation.

4.1.3.2 An overview of impacts of HEP on aquatic and terrestrial biodiversity

This section provides an overview of the major impacts associated with hydropower development. While some impacts occur only during construction stage, most important impacts usually are linked to operation of the dam and reservoir. Other significant impacts can result from complementary civil works such as access roads, power transmission lines, and quarries and borrow pits (modified from Ledec and Quintero 2003). The specific impacts that are significant from the standpoint of this study are:

a) Altered flow regime (volume of diverted water)

There is a growing awareness of the essential role of flow regimes as a key factor shaping the ecology of rivers (Bunn and Arthington 2002). Distribution, abundance, and diversity of stream and river organisms are all determined by the complex interaction between flows and physical habitat (Schlosser 1982, Poff and Allan 1995, Ward and others 1999, Nilsson and Svedmark 2002). Not only on a larger scale, the subtle variations in flow and near-bed velocities can govern the distribution and abundance of particular species of plants and animals at even the smallest spatial scales (e.g., Wetmore and others 1990). Close associations with physical habitat can be found in many stream organisms ranging from algae and aquatic plants to invertebrates and fish. Alteration of flow regimes is therefore affirmed to be the most serious and continuing threat to ecological sustainability of rivers (Naiman and others 1995, Sparks 1995, Lundqvist 1998, Ward and others 1999).

Impacts on aquatic biodiversity: Alteration of river flow affects habitat quality in a detrimental manner. A certain level of downstream flow is needed to maintain a minimum volume and area of habitat, and 'desirable' in-stream conditions (McAllister *et.al*. 2001). The altered seasonal pattern can influence oxygen levels, temperature, suspended solids, drift of organisms, and cycling of organic matter and other nutrients, as well as having direct impacts on biota (Batalla, et al. 2004). Complex interaction between flows and physical habitat is a major determinant of the distribution, abundance, and diversity of stream and river organisms (Schlosser 1982, Poff and Allan 1995, Ward and others 1999, Nilsson and Svedmark 2002). Normal seasonal flow patterns are a key to maintaining river biodiversity.

Flow alteration affects all the trophic levels of the aquatic food chain. The influence of river flows on recruitment and growth of aquatic plants is well established. Spatial and temporal variation in plant assemblage structure is influenced by flooding and scouring, desiccation, substrate stability and localized variations in water velocity, turbulence and shear stress (Chambers and others 1991, Biggs

1996, French and Chambers 1996). Seedling survival, as well as plant growth rates are affected by changes in rates of water level fluctuation and disturbance frequency (floods and spates) and intensity (velocity and shear stress) (Blanch and others 1999, 2000, Froend and McComb 1994, Rea and Ganf 1994, Sand-Jensen and Madsen 1992).

Spatial and temporal dynamics of benthic communities in streams is also majorly dependent on the physical disturbance from floods and droughts (Resh and others 1988). As the macro-invertebrates are vulnerable to rapid diurnal changes in flow, the erratic flow of regulated river downstream, hydroelectric dams can results in the formation of species-poor macro-invertebrate communities in these stretches (Munn and Brusven 1991). In some cases, flow regulation may favour the proliferation of specific taxa (e.g., orthoclad chironomids) (Munn and Brusven 1991).

As with the aquatic flora and invertebrates, the fish faunal composition in the rivers is maintained by the river flow cycle. The richness of the fish fauna often increases as habitat complexity increases, with depth, velocity, and cover being the most important variables governing this relationship (Gorman and Karr 1978, Schlosser 1982, Felley and Felley 1987, Pusey and others 1995). Fish assemblage structure (i.e., taxonomic composition and relative abundance pattern) is also strongly related to habitat structure (Meffe and Sheldon 1988, Pusey and others 1993, 1998, 2000). Associations between fish and their habitat are influenced by flow variability at a range of spatial scales. Poff and Allan (1995) demonstrated regional differences in fish assemblage structure and functional organization in streams of differing flow variability in the northern mid-western United States. Hydrologically variable streams (i.e., those with a high coefficient of variation of daily flows, moderate frequency of spates) were characterized by species with generalized feeding strategies and preference for low water velocity, silt, and general substrata. Modifications to flow regimes affect fish diversity and the functional organization of fish communities in regulated rivers. Flow plays a profound role in the lives of fish with critical life events linked to flow regime (e.g., phenology of reproduction, spawning behavior, larval survival, growth patterns and recruitment) (Welcomme 1985, Junk and others 1989, Copp 1989, 1990, Sparks 1995, Humphries and others 1999). Many of these life events are synchronized with temperature and day length, such that changes in flow regime that are not in natural harmony with these seasonal cycles may have a negative impact on aquatic biota.

Impacts on terrestrial biodiversity: Typically, riparian forest tree species are dependent on river flows and a shallow aquifer, and the community and population structure of riparian forests is related to the spatial and temporal patterns of flooding at a site (McCartney et.al. 1999). Water release protocols can lower water tables lateral to the rivers which may affect vegetation there (McAllister et.al. 2001). This might consequently affect the faunal species dependent on this forest type.

b) Disturbed continuity of the river (diverted river length)

River continuity is essential for the overall functioning of the system. There is ample available evidence indicating the overall importance of connectivity and continuity in the river corridor for regional biodiversity by maintaining the river corridor functioning for meta-populations, gene flow and species dispersal (Gouyon et al., 1987; Johansson et al., 1996; Henry et al., 1996; Andersson et al., 2000; Imbert & Lefèvre, 2003).

Impacts on aquatic biodiversity: As a result of water diversion, the flow of the river below the dam reaches very low levels or becomes nil especially during lean season leaving that stretch deprived of water. Induced desiccation of rivers causes mortality of aquatic flora and fauna thriving in these river stretches. The process also hampers the dispersal of species present upstream or downstream as a result of habitat fragmentation.

Impacts on terrestrial biodiversity: Drying of river stretches also has negative impacts on terrestrial biodiversity. Rivers are the major source of drinking water for the regional terrestrial fauna. Drying of long river stretches might affect the occupancy of the nearby areas by the terrestrial species due to water scarcity leading to degradation of habitat quality, and affects on dispersal of migratory avifauna. The riparian vegetation habitat in these stretches will also get degraded due to water deprivation in turn affecting the dependent floral and faunal species.

c) Submergence (Reservoir Area)

One of the largest upstream impacts of dam construction (both storage and Run of the river type) is submergence. The area flooded by the reservoir is a strong proxy variable for many environmental and social impacts (Goodland, 1997).

Impacts on aquatic biodiversity: The argument that the loss of riverine habitat associated with impoundments is balanced by the creation of lake-habitat is somewhat deceptive as natural lakes and wetlands often function in very different ways. The water levels maintained in large impoundments are generally not constant as a result of which the productive littoral areas are rarely sustained. Moreover, as compared to natural stream levels, water levels in these impoundments are usually significantly elevated, flooding part of the terrestrial–aquatic interface and creating a new littoral zone with steeper banks, less complex aquatic habitat, and different physicochemical conditions for aquatic plants and animals (Walker and others 1992).

Conversion of one quarter of the river to lentic habitat results in the loss of fishes adapted to turbid riverine habitats (Stanford and Ward 1986). Also, introductions of highly competitive exotic fishes that can thrive in impoundments and regulated river reaches contribute to the extirpation of native fishes, posing as a significant threat.

Impacts on terrestrial biodiversity: The most obvious effect of storage reservoirs on terrestrial ecosystems is the permanent destruction through inundation. Terrestrial biotopes are completely destroyed. All terrestrial plants and animals contained previously in the submerged areas completely disappear from the submerged areas. Many animals are caught and drowned during the filling of new reservoirs. Large scale impoundments may eliminate unique wildlife habitats and extinguish entire populations of endangered species especially those preferring valley bottoms (Bardach and Dussart, 1973; Nilsson and Dynesius, 1994). Large reservoirs may also disrupt natural migration corridors.

Upstream impoundment not only affects the river banks and areas in vicinity but its impacts radiate till the farther reaches of the floodplains

d) Barrier influence of dam

The most immediate and obvious impact of dam development is its physical presence as a barrier. Dams pose as a barrier leading to a plethora of impacts on the local biodiversity thereby disrupting the continuity of the riparian ecosystem.

Impacts on aquatic biodiversity: The viability of populations of many species that are strictly aquatic depends on their ability to move freely through the stream network. Anadromous fishes which migrate long distances within the main channels and larger tributaries of rivers are particularly sensitive to barriers to fish passages, which in turn may obstruct their migratory pathways and interfere with the completion of their life cycles. The disappearance or decline of the major migratory fish species often follows river impoundment and the blocking of passage in the system (Bonetto and others 1989; Cadwallader 1986; Harris 1984a,b; Joy and Death 2001; Welcomme 1985, 1992).

Impacts on terrestrial biodiversity: Rivers and their adjoining riparian zones are considered to be the most important corridors for movements of animals in natural landscapes (Forman and Godron 1986; Malanson 1993). Natural riparian zones are also effective pathways for plant dispersal (Jansson et.al., 2000). Dam acts as a barrier to terrestrial animal movement and plant dispersal, particularly reduction of riparian zone as a migration corridor (Deall 2010).

e) Clear felling (forest area diverted/cleared)

One of the primary impacts of dam development in such areas is deforestation or clear felling. Such an activity itself has multitude of impacts on terrestrial species and also on aquatic species.

Impacts on aquatic biodiversity: Following deforestation, the soil in the area becomes loose leading to greater levels of soil erosion. The soil which is being washed away gets deposited in the river which leads to increased siltation of the river. Excess amounts of silt and sediments can deteriorate water quality, an essential component of fish habitat. Moreover, increased silt levels and turbidity might also leads to clogging and abrasion of the gills of fish and other aquatic organisms and behavioural changes, including movement and migration of aquatic fauna especially fishes (Birtwell, 1999). Such impacts have already been noticed in the case of Mekong river system.

Impacts on terrestrial biodiversity: Deforestation leads to direct elimination of crucial habitats for terrestrial species. Several important tree, shrub and herb species are removed from these areas and might lead to extinction of certain endemic species. It also adversely affects the faunal species residing in these areas and which are dependent on these floral species. On a landscape level, deforestation leads to habitat fragmentation and degradation of habitat quality. It also leads to destruction of vital animal/plant corridors which ultimately effects migration and gene dispersal.

4.1.4 Impact evaluation

The significance of an impact is widely accepted to be a function of the magnitude of the impact (i.e. aspects of development likely to bring change) and the sensitivity of the receptor (i.e. components of the site sensitive to such change).

The determination and interpretation of impact significance in cumulative assessments are influenced by many variables, hence demanding greater precision. A cumulative effect on a Valued Ecosystem Component (VEC) may be significant even though each individual project-specific assessment of that same component concludes that the effects are insignificant. This is a fundamental principle in the understanding of cumulative effects. Project-specific assessments that focus on the incremental contribution of the project being assessed can assist in making such conclusions as they must consider the implications of other actions also affecting the VECs. However, this inclusion (and sometimes the analytical approach used) requires the consideration of additional factors influencing determination of significance in (cumulative effects component (Hegmann et. al. 1999)

These are:

- exceeding of a threshold;
- effectiveness of mitigation;
- size of study area;
- incremental contribution of effects from action under review;
- relative contribution of effects of other actions;
- relative rarity of species;
- significance of local effects;
- magnitude of change relative to natural background variability;
- creation of induced actions; and
- degree of existing disturbance

The procedures of assigning impact significance are heavily reliant on expert judgment and technical data, analyses and knowledge (Cloquell-Ballester et al., 2007; Kirk, 2001).

4.1.4.1 Development of impact evaluation matrix

The earliest use of the matrices by Leopold *et al.* (1971), for assessing the impact significance led to subsequent innovation in the use and design of matrices that occured over the four decades of EIA practice (Canter, 2008).

The Argonne Multiple Matrix (AMM) method represents advancement over traditional interactive matrices such as the Leopold Matrix (Leopold *et al.* 1971, cited in Lane *et al.* 1988 for analyzing the cumulative effect of multiple projects. This type of matrix can differentiate additive from interactive processes of cumulative environmental change, and can account for multiple projects of the same type (e.g. hydroelectric dams). Expert opinion is used to establish three types of data: scores that define the level of effect of each project on selected environmental components, weighting coefficients that reflect the relative value of each component, and interaction coefficients that measure the effect of each pair of projects on each component (Smit and Spaling 1995).

The matrix used in this assessment (Appendix 4.1) was adapted based on the concept of AMM.

4.1.4.2 Scoring and weighting of impacts

I. Rationale

Systems of scoring and weighting are used frequently in ecological assessments to measure and adjust criteria and impacts. Scoring enables evaluation criteria to be expressed numerically and used more readily in decision making. Without some form of scoring, measurement endpoints cannot be identified. It also becomes difficult to link assessment and measurement endpoints. Systems of weighting are based on the premise that criteria such as species richness, habitat diversity, stability and naturalness have relative importance that can be quantified. Although weighting generally involves some element of subjectivity (Treweek, 1999), weight scoring for determining impact potential of projects and risks to biodiversity have been extensively used in CEIA (ICEM, 2007, SEIA 2008).

II. Scoring/weighting methodology adopted in present study

i) For impact sources

Scores ranging from 1 to 5 were assigned to Impact Sources with 1 representing the lowest value and the 5 representing the highest value in both the criterion. The scores were given for each of the two criteria. The values obtained for each projects were converted into a cumulative score for the sub-basins, with the maximum attainable score for each sub-basin being 10. The rationale for adding the project-wise values for a sub-basin was in lines with the concept of CEIA which states that the cumulative impacts are generally additive in nature.

After obtaining scores for sub-basins, these scores were classified as low (L), medium (M), high (H) and very high (VH), which take percentage value of 0-25, 26-50, 51-75 and 76-100 respectively. Such categorization was inevitable for score and percentage data and such approach is practiced widely in impact studies, including CEIA.

ii) For impact receptors

Scores ranging from 1 to 5 were assigned to Impact Receptors with 1 representing the lowest value and the 5 representing the highest value in both the criterion. In situation where binary responses were obtained (e.g. whether or not Zone of Influence contains breeding/congregation sites), the site with 'no such value; received a score of 1, while the site with 'such value' received a score of 5. This scoring system allowed for standardization of the values generated for individual indicators, and therefore, it became discernable while arriving at cumulative scores.

As the assessment is based on a sub-basin scale, the biodiversity values were evaluated sub-basin wise directly as opposed to project-wise. However, the raw values were obtained from data collected from the project ZoIs which were pooled for each sub-basin.

The scores obtained for each criteria within a sub-basin were then added to give a total score, the maximum being 30 (6 criteria) for aquatic biodiversity and 15 (3 criteria) for terrestrial biodiversity. These scores were then converted into percentages of the maximum following which they were classified as low (L), medium (M), high (H) and very high (VH) using the same rationale as for impact sources.

iii) Impact significance

As mentioned in a previous section, determination of impact significance is the most important step of the impact evaluation process. The significance of an impact is widely accepted to be a function of the magnitude of the impact and the sensitivity of the receptor (given by biodiversity value here).
Sub-basins identified in the two basins were assigned a score based on the biodiversity value (rated as Very High, High, Medium or Low) and the impact potential of Hydro Electric Projects (rated as Very High, High, Medium or Low).These scores determine the classification of each project into one of four impact significance categories, according to biodiversity values of the affected area(s) and impact potential of Hydro Electric Projects.

For this study, the quantitative scores were ultimately converted into qualitative score (L,M,H, VH) for both impacts sources and receptors. These impact sources scores were then interacted with the terrestrial biodiversity scores and aquatic biodiversity scores in the form of a matrix to give the significance of impacts hence an impact significance statement. The key followed for arriving at interaction values (ICEM, 2007) is given in the table below:

Table 4.6. Matrix showing impact significance based on interaction between biodiversity values and impact potential.

Biodiversity values	Impact Potential			
	Very high	High	Moderate	Low
Very high	Very high	Very high	High	Low
High	Very high	High	Moderate	Low
Moderate	High	Moderate	Moderate	Low
Low	Low	Low	Low	Low

Chapter 5 – Biodiversity Baseline

An important first stage in gaining an understanding of how the system might be changed by the proposed Hydropwer development project is to take a "snap-shot" of the existing conditions – the baseline environment. The profiling of biodiversity is important in the later stages in impact assessment for comparing the baseline scenario with project alternative scenarios that involve changing land and resource use in a given ecosystem, and attempts to establish how these will impact on ecosystem services.

The biodiversity baseline for this study was developed based on expert knowledge of professionals working on different taxa and ecosystems, national and global database, published species records, researched information. Information collected from all of the above sources was assessed for its adequacy and relevance and information gaps where observed were overcome by supplementing specific information through primary data collection efforts during the field visits undertaken during this study.

5.1 Overview of biodiversity values in Alaknanda and Bhagirathi river basins

Riverine habitats generally occupy a small proportion in the total landscape yet play a critical role as corridors and migration pathways for several faunal and floral species. They also serve as 'edge' habitats, facilitate river courses and also assist in prevention of soil erosion. They are often designated as 'sensitive habitats'. The courses of Bhagirathi and Alaknanda support a number of forest formations which are typically riverine in nature such as Khair – sissoo (*Acacia catechu – Dalbergia sissoo*) and Jamun – Putranjiva (*Syzygium cuminii – Putranjiva roxburghii*) in the lower areas, alder (*Alnus nepalensis*), Hippophae – Myricaria and Willow (*Salix*) communities at higher altitudes. The riverine forests support a large number of rare, threatened and endangered (RET) species of flora and fauna. Among fishes, there are several threatened species including golden mahseer, snow trout etc that breed in this landscape. Many species of fish require the riverine habitats as well as the floodplains for their breeding. Some of the threatened taxa of flora typically found along the riverine forests and stream courses of Bhagirathi and Alaknanda include *Datisca cannabina, Itea nutans, Eriocaulon pumilio, Eria occidentalis, Flickingeria hesperis, Nervilia mackinnonii and Cautleya petiolaris*, among others. Several species of medicinal and aromatic plants are also confined to riverine areas. Within the basin, out of a total of over 1000 species of plants (G.S. Rawat *pers. comm.;* 461 species were recorded during the survey; Appendix 5.1) found 55 are RET/endemic species (Appendix 5.2 & 5.3). Among mammals, out of 85 species 6 are RET species, 6 out of over 500 species of birds and 16 out of 76 species of fishes are in the RET category. For all 18 sub-basins, fact sheets giving summary of biodiversity profiles were developed and are presented below, and shown in Plate 5.1.

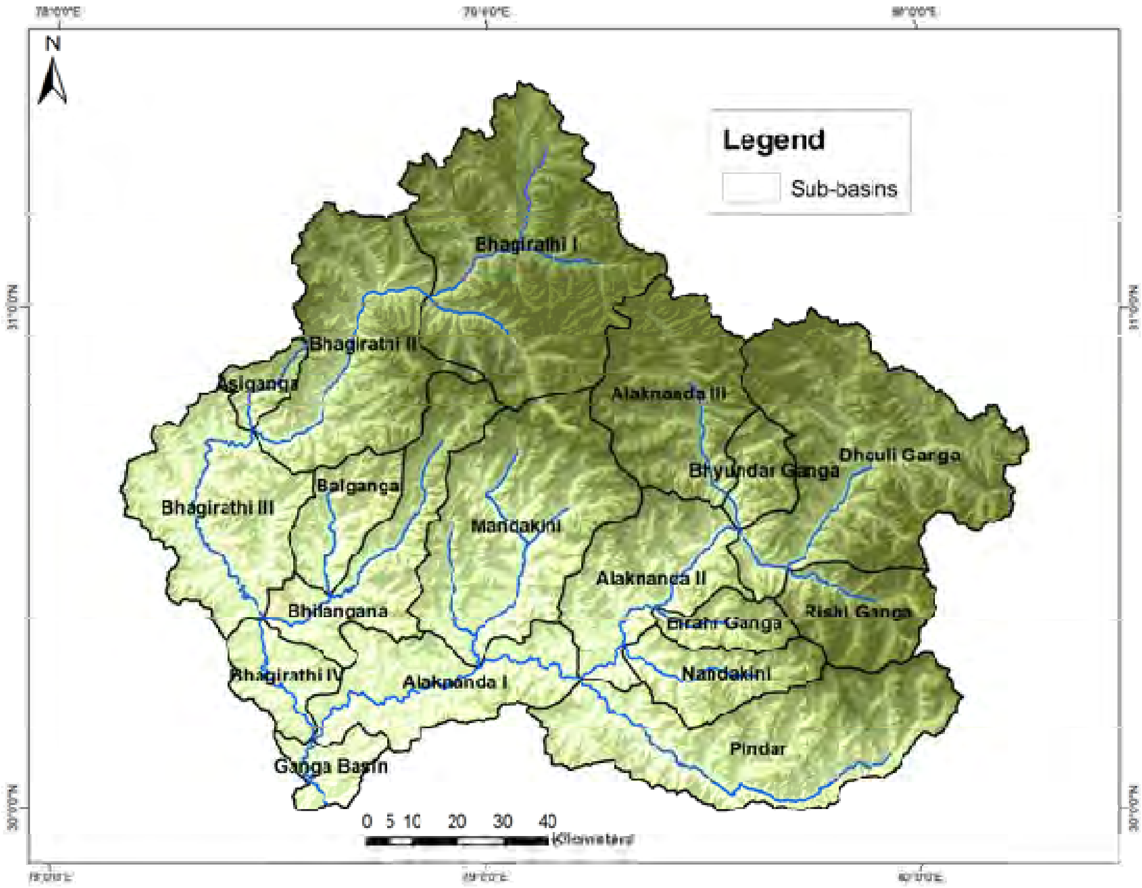
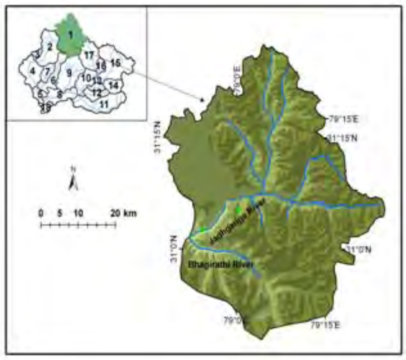


Plate 5.1 Sub-basins within Alaknanda and Bhagirathi basins.

Bhagirathi I (Areas above Bhagirathi- Jadh ganga confluence)

This sub-basin is drained by Bhagirathi River with its main tributary, Jadhganga, Jalandhari gad, Kakara gad and Siyan gad. The head waters of Bhagirathi river takes origin form Gangotri glaciers and the important shrine Gangotri is located along the bank of river. The entire catchment of this sub-basin forms the Gangotri National Park. It falls in the Greater and Trans-Himalayan regions, which encompasses the temperate forests, scattered trees and scrubs, sub-alpine oak forests, alpine scrub meadows, moraines and glaciers.



Fish diversity: Considered as a '*no fish*' zone, as no fish species were reported from this region, this oligotrophic basin has perennial, cooler, cleaner water with low primary producers and aquatic meiofauna.

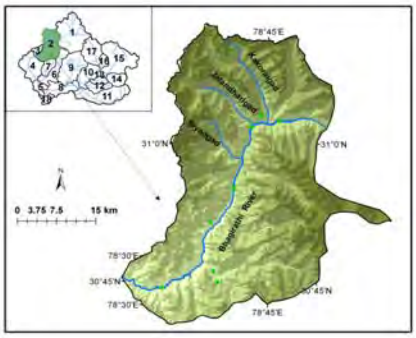
Mammals and Birds: Over 200 birds species are reported, including a critically endangered Indian white-backed vulture; 3 Schedule-I species of IWPA (Indian white-backed vulture, Cinereous vulture and Himalayan monal). This basin also has 29 species of mammal which include 5 RET species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard and Himalayan musk deer) and 8 IWPA Schedule-I species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard, Himalayan musk deer, Himalayan tahr, blue sheep and serow). This sub-basin represents a unique cold, arid ecosystem in Nilang valley which is one of the best habitats for snow leopard and its prey blue sheep (Paramanand et al. 2000; Uniyal & Ramesh 2004; Rasmussen & Anderton, 2005; Chandola et al. 2008; Bhardwaj & Uniyal 2009 and Bhardwaj et al. 2010, Maheshwari & Sharma 2010).

Floristic diversity: Bearing mixed conifer and Himalayan moist forests of temperate environment, the area is floristically diverse. 130 species of flowering plants were recorded during the study. Of these, 74 were herbs, 28 shrub, 16 trees and 12 climbers, 56 species of medicinal value. The common species of the sub-basin are *Picea smithiana, Cedrus deodara, Pinus wallichiana, Euonymus fimbriatus, Populus ciliata, Prunus cornuta,* and *Acer caesium.* Important species of medicinal value are *Aconitum hetrophyllum, Allium stacheyi, Arnebia benthamii, Lilium polyphyllum, Ephedra gerardiana, Nardostachys jatamansi,* and *Picrorhiza kurrooa.*

The **RET species** recorded from this sub-basin are *Acer caesium, Aconitum hetrophyllum, Allium stacheyi, Arnebia benthami, Epipogium aphyllum, Lilium polyphyllum, Nardostachys jatamansi* and *Picrorhiza kurrooa.*

Bhagirathi II (From Bharongati to Asi ganga Confluence)

The stretch of Bhagirathi from its confluence with Jadhganga to the location of its confluence with Asi Ganga has been categorised as Bhagirathi II sub-basin. This sub-basin falls in the middle and high Himalayan ranges and encompasses wildlife habitats such as Himalayan moist temperate forests, coniferous and moist mixed forests and scrub habitat, alpine scrub and meadows. Much of the sub-basin has been degraded due to development and anthropogenic pressures.



Fish diversity: Ecologically the sub-basin is mesotrophic to oligotrophic in nature, in which 19 species of fishes were recorded. It included 11 species of habitat specialists and 4 threatened species. State Fisheries Department has been maintaining a fish farm here.

The threatened species of fishes recorded from this basin are golden mahseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*), and stone suckers (*Garra gotyla gotyla* and *Gara lamta*). The river basin serves as migrated route for golden mahseer and snow trout, whose abundance has now become very low. This sub-basin is also infested with invasive brown trout, which appears to be expanding its range in this sub-basin due to barriers downstream. On account of the presence of existing dam across Bhagirathi River near Uttarkashi, the upward movements of mahseer and snow trout species have also been reduced or stopped.

Mammals and Birds: About 320 birds species have been reported in this sub-basin, out of which 4 are RET species (white-backed vulture, Egyptian vulture, cheer pheasant and western tragopan) and 5 are IWPA schedule-I (white-backed vulture, Egyptian vulture, cinereous vulture, cheer pheasant and western tragopan). This sub-basin encompasses 24 species of mammals, out of which 2 are RET species (i.e. Asiatic black bear and common leopard) and 4 are mentioned in IWPA schedule-I list (i.e. Asiatic black bear, common leopard, Himalayan Tahr and serow). (Paramanand et al. 2000; Uniyal & Ramesh 2004; Rasmussen & Anderton, 2005; Chandola et al. 2008; Bhardwaj & Uniyal 2009 and Bhardwaj et al. 2010, Maheshwari & Sharma 2010).

Floristic diversity: The sub-basin's catchments have dry temperate conifer, moist deodar and mixed forests. 184 species were recorded during the study, of which 94 species were herbs, 41 shrubs, 33 trees and 16 climbers. Among these, 78 species have medicinal values. Prominent species were *Abies pindrow, Alnus nepalensis, Aesculus indica, Populus ciliata, Cedrus deodara, Celtis australis, Pinus wallichiana, P. roxburghii, Picea smithiana, Prunus cornuta, Pyrus malus. Hippophae salicifolia, Aspargus filicinus, Berberis asiatica, Centella asiatica, Prinsepia utilis, Juglans regia, Swertia chirayita, Viola biflora, Zanthoxylum armatum, Datisca cannabina,* and *Lilium polyphyllum* are the important high value medicinal plants.

RET species in this sub-basin are *Acer caesium, Aconitum hetrophyllum, Allium stacheyi, Arnebia benthamii* and *Caragana sukiensis.*

Fig. 5.1 View of Bhagirathi sub-basin I.

Fig. 5.2 View of Bhagirathi sub-basin II.

Asiganga (Asiganga valley)

The river Asiganga is one of the major tributaries of Bhagirathi. It originates from Dodital lake at an altitude of 2240m and joins Bhagirathi near Uttarkashi. The sub-basin falls in the middle and high Himalayan ranges. The Asi Ganga Valley is marked by undulating and rugged terrain and steep slopes with highly mountainous, precipitous ridges interspaced by deep gorges. The valley is seemingly narrow and either slopes are covered with very dense forests falling in the category of Himalayan moist temperate forest, secondary scrub, alpine scrub and meadows.

Fish diversity: Three species of fishes were recorded from this river basin, including a threatened species of snow trout (*Schizothorax richardsonii*) and an invasive brown trout (*Salmo trutta fario*). These two species migrate from downstream to upstream for breeding. This basin seems to be the major breeding ground of brown trout and distributed upto Dodital lake and from here this species expands its range to upstream of the Bhagirathi River. Ecological condition of this basin is oligotrophic to mesotrophic with clean and cooler water.

Mammals and Birds: This sub-basin have about 250 birds species, including 2 RET species (Indian white-backed and Egyptian vulture); 4 Schedule-I species of IWPA (Indian white-backed vulture, Egyptian vulture, cinereous vulture, Himalayan monal). This sub-basin also provides habitat for 32 mammal species which includes 3 RET species (Asiatic black bear, common leopard and Himalayan musk deer) and 4 IWPA Schedule-I species (Asiatic black bear, common leopard, Himalayan musk deer and serow). Upper reaches of sub-basin (>2000m) are recognized as high biodiversity area and it is a transition zone between Govind NP and Gangotri NP and therefore facilitates the movement of large mammals. (Paramanand et al. 2000; Uniyal & Ramesh 2004; Rasmussen & Anderton, 2005; Chandola et al. 2008; Bhardwaj & Uniyal 2009 and Bhardwaj et al. 2010, Maheshwari & Sharma 2010).

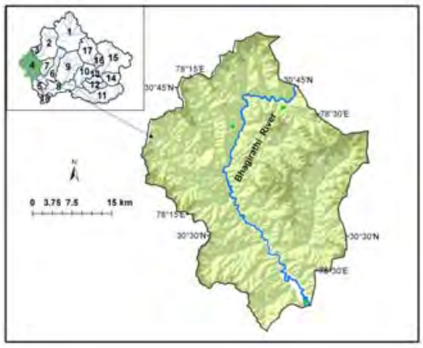
Floristic diversity: The sub-basin encompasses subtropical pine mixed, temperate oak and conifer and sub alpine forests, alpine scrub and meadows. Lower stretches of riverine forests in this area are rich in orchids. The tract beyond Aghora village is dominated by various species of oak, rhododendron, maples and Carpinus viminea, and at higher altitudes temperate oak-conifer mixed forests. Other prominent species on way to Dodital are *Pinus roxburghii, Pyrus pashia, Quercus leocotrichophora, Rhododendron arboreum, Toona ciliata, Juglans regia, Hippophae salicifolia, Prinsepia utilis, Prunus cerasoides, Prunus cornuta, Debregeasia salicifolia, Cedrus deodara* and *Taxus baccata.*

A total of 188 species of vascular plants were recorded from the study sites, of which, 94 are herbs, 46 shrubs, 38 trees and 10 climbers. These also include 54 species of medicinal value. Some important medicinal plants recorded from the area include *Anagallis arvensis*, *Saponaria vaccaria*, *Vernonia anthelmintica*, *Prinsipia utilis*, *Aspargus filicinus, Barleria cristata, Berberis aristata, Berberis asiatica, Berginia ciliata, Centella asiatica, Dactylorhiza hatagirea, Picrorhiza kurrooa, Swertia chirayata, Thalictrum foliolosum*, and *Aconitum hetrophyllum.*

RET species recorded from this basin are *Acer caesium, Aconitum hetrophyllum, Allium stacheyi, Nardostachys jatamansi* and *Picrorhiza kurrooa.*

Bhagirathi III (Uttarkashi to confluence of Bhilangana with Bhaghirathi):

This sub-basin lies in main Bhagirathi between Uttarkashi and confluence of Bhilangana river, which falls in lower and middle Himalayan ranges. The Tehri Dam located at the confluence of Bhagirathi and Bhilangana and the reservoir extends up to 44 km upstream within this sub-basin. The land on both the sides of the river is primarily agriculture land and the vegetation is mostly degraded scattered pine and mixed forests and xerophytic shrubs. Area above the submergence zone is very close to Uttarkashi town and most of it is human settlements.



Fish diversity: This sub-basin has 43 species of fishes, which includes several threatened species. The threatened species include golden mahseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda*) and hill stream catfish *Glyptothorax telchitta*. The isolated population of Golden mahseer *T. putitora* in the upstream of Tehri Dam use the Bhilangana river as the major breeding ground. Ecological conditon of this basin is mesotrophic to eutrophic with medium to rich nutrients presence. Exotic carbs such as Common carp, Silver carbs, Mirror carbs have been introduced in Tehri Dam and they are abundant in the reservoir and the downstream areas.

Mammals and Birds: Bhagirathi-III sub-basin shows comparatively moderate faunal biodiversity with about 220 birds species including 2 RET species (Indian White-backed Vulture and Egyptian vulture) and 3 IWPA Schedule-I species (i.e. Indian white-backed vulture, Egyptian vulture and Cinereous vulture). This sub-basin encompasses 17 species of mammals, out of which 2 are RET (Asiatic black bear and common leopard) and 2 are mentioned in IWPA Schedule-I list (Asiatic black bear and common leopard) (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A relatively drier and disturbed sub-basin, it reported 142 species of vascular plants. Of these, 68 were herbs, 43 shrubs and 31 trees. Among these, 28 species were of medicinal values. Some of the prominent species include *Alnus nepalensis, Pinus roxburghii Acacia catechu, Bauhinia variegata, Celtis australis, Emblica officinalis, Ficus religiosa, Grewia oppositifolia, Mallotus philipinensis, Moringa oleifera, Populus ciliata, Pyrus pashia, Salix wallichiana, Syzium cuminii,* and *Toona serata.*

Medicinal species include *Berberis chitria, Berberis aristata, Cassia fistula, Calotropis procera, Carrisa opaca, Centella asiatica, Cissampelos pareira, Diospyros montana, Hippophae salicifolia, Juglanse regia, Litsea chinensis, Ricinus communis,* and *Zanthoxylum armatum* among others. The RET species reported form this sub-basin is *Datisca cannabina*.

Fig. 5.3 View of Asiganga sub-basin.

Fig. 5.4 View of Bhagirathi sub-basin III.

Bhagirathi IV (From Bhagirathi-Bhilangana confluence to Devprayag):

This sub-basin includes the area from Bhagirathi-Bhilangana confluence to Devprayag where Bhagirathi joins Alaknanda. This sub-basin falls in the lower Himalaya with deep escarbment and has patches of riverine habitats along the river. There are mixed sub-tropical forests in the middle and higher slopes, sub-tropical mixed broadleaf forests and patches of chir pine forests at higher reaches with secondary scrub on either slopes. Anthropogenic pressures and many developmental activities in this sub-basin are high.

Fish diversity: Of oligotrophic nature, this sub-basin in quite rich in fish diversity, due to variety of habitats and confluence of another major river Alaknanda. A total of 48 species of fishes were reported from this sub-basin, including 29 habitat specialist and 12 threatened species. It also inhabits an endemic hill stream catfish, *Glyptothorax alaknandi*, which has a narrow distribution range within upper reaches of the Ganges. Exotic carps such as common carp and mirror carp have also been found in this sub-basin. The important threatened species reported from this region are golden mahseer (*Tor putitora*), Black mahseer (*Tor chilinoides*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda*), hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*), barbs (*Chagunius chagunio*), hillstream loaches (*Botia dario, Nemacheilus multifasciatus* and *Pseudecheneius sulcatus*). Population of migratory species is fragmented due to existing power projects in the area.

Mammals and Birds: Bhagirathi-IV sub-basin also shows moderate faunal biodiversity with about 220 birds species including 2 RET species (Indian White-backed Vulture and Egyptian vulture) and 3 IWPA Schedule-I species (Indian white-backed vulture, Egyptian vulture and cinereous vulture). This sub-basin encompasses 16 species out of which 2 are RET (. Asiatic black bear and common leopard) and 2 are mentioned in IWPA Schedule-I list (i.e. Asiatic black bear and common leopard) (Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: This area has patches of riverine forests along the rivers and mixed sub tropical forests in the upper slopes. A total of 252 species of higher plants were recorded along the survey routes in this sub-basin. Of these 133 were herbs, 60 shrubs, 40 trees and 16 grasses. Notable species in the area were *Acacia catechu, Aegle marmelos, Celtis australis, Delbergia sissoo, Emblica officinalis, Ficus religiosa, F. palmata, Grevellia robusta* (planted), *Grewia oppositifolia, Lannea coromandelica, Mallotus philippensis, Melia azedarach, Moringa oleifera, Pinus roxburghii, Salix acmophylla, Sapium insigne, Syzium cumini.*

As many as 129 species are of medicinal values represented by *Abrus precatorius, Berberis chitria, Berberis asiatica, Centella asiatica, Calotropis procera, Cissampelos pareira, Litsea chinensis, Ricinus communis,* and *Zanthoxylum armatum.* No RET species was recorded from this sub-basin.

Bhilangana (Bhilangana valley)

The Bhilangana River originates from Khatling glacier and is joined by the Balganga River at Ghansali. This sub-basin falls in the middle and greater Himalayan regions and encompasses subtropical mixed and chir pine forests at the lower elevations (*Ghansali*), temperate forests and scattered tree and scrub in the middle elevations (*Ghutu*), and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (below *Khatling*).

Fish diversity: This sub-basin is quite rich in fish diversity, and provides habitats for 43 species of fishes, including 20 restricted range species and 11 threatened species.

The important threatened species reported from this region are golden mahseer (*Tor putitora*), Black mahseer (*Tor chilinoides*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda*), hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*), barbs (*Chagunius chagunio*), hillstream loaches (*Nemacheilus multifasciatus* and *Pseudecheneius sulcatus*). Population of migratory species is fragmented due to existing power project in the area. Most importantly, the lower stretch of this river basin is one of the important breeding habitats for migratory species such as *Tor putitora* and *Schizothroax* spp.

Mammals and Birds: Bhilangana sub-basin encompasses high avifaunal biodiversity which includes around 350 species, out of which 4 species are in RET (Indian white-backed vulture, Egyptian vulture, western tragopan and cheer pheasant) and 6 species are listed in IWPA Schedule-I (Indian white-backed vulture, egyptian vulture, cinereous vulture, western tragopan, cheer pheasant and Himalayan monal). This sub-basin encompasses 32 mammal species which includes 3 RET species (Asiatic black bear, common leopard and Himalayan musk deer) and 4 Schedule-I species of IWPA (Asiatic black bear, common leopard, Himalayan musk deer and Himalayan tahr) (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

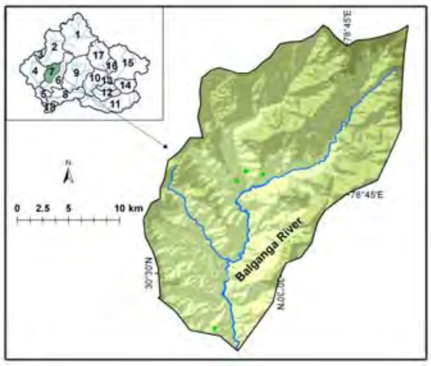
Floristic diversity: 106 angiosperm species were recorded from the project sites, of which 33 are trees, 36 shrubs, and 37 herbs including 29 species having one or other kind of medicinal use. Species frequently seen in the lower parts of Bhilangana are *Acacia catechu, Aegle marmelos, Bombax ceiba, Dalbergia sissoo, Ficus palmata, Grewia optiva, Pinus roxburghii.* Medicinal plants recorded in the sub-basin were *Aconitum heterophylllum, Picrorhiza kurrooa, Nardostachys grandiflora, Swertia chirayita, Angelica glauca* at higher altitudes and *Litsea chinensis, Berberis asiatica, B. aristata, Zanthoxylum armatum, Emblica officinalis, Calotropis procera, Juglans regia, Artemisia nilagarica, Bergenia ciliata, Rubus ellipticus, Colebrookia oppositifolia,* and *Adhatoda zeylanica* at lower altitude. The RET species *Anemone raui*, *Trachyspermum falconeri* was reported from this sub-basin.

Fig. 5.5 View of Bhagirathi sub-basin IV.

Fig. 5.6 View of Bhilanganga sub-basin.

Balganga sub-basin (Balganga valley)

The Balganga sub-basin is drained by the Balganga River and its tributary Dharamganga that joins Balganga at Budhakedar. This sub-basin falls in the middle and greater Himalayan ranges and is a broad valley with many lakes and glaciers in the higher altitudes. Habitats such as temperate mixed forests, temperate scattered tree and scrub with open grassy slopes, pine forests are present in this sub-basin including patches of riverine forests along Balganga.



Fish diversity: Fish faunal assemblage is more or less similar to that of Bhilangana sub-basin. A total of 38 species of fishes, which include 24 restricted range species and 11 threatened species were recorded. The following are the threatened species recorded from this basin: golden mahseer (*Tor putitora*), Black mahseer (*Tor chilinoides*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda*), hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*), barbs (*Chagunius chagunio*), hillstream loaches (*Nemacheilus multifasciatus* and *Pseudecheneius sulcatus*). This river is one of the critically important habitats for mahseers and snow trouts which occurs in Tehri Dam and associated rivers. Many migratory species congregate along the rivers for breeding especially after the monsoon.

Mammals and Birds: The faunal diversity is similar to that of Bhilangana sub-basin and it has over 350 species of birds, out of these 4 species are in RET (Indian white-backed vulture, Egyptian vulture, western tragopan and cheer pheasant) and 6 species are mentioned in IWPA schedule-I list (Indian white-backed vulture, Egyptian vulture, cinereous vulture, western tragopan, cheer pheasant and Himalayan monal). This sub-basin encompasses 32 mammal species which includes 3 RET species (Asiatic black bear, common leopard and Himalayan musk deer) and 4 IWPA Schedule-I species (Asiatic black bear, common leopard, Himalayan musk deer and Himalayan tahr) (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: The sub-basin has trees and scrub with open grassy slopes, pine forests and patches of riverine forests along Balganga. 106 species were recorded from the project sites in the valley, of which 33 are trees, 36 shrubs, and 37 herbs. Of the total plants identified, 29 species were of medicinal values. Common species found at lower parts of sub-basin were *Ficus palmata ,Grewia optiva, Pinus roxburghii, Sapium insigne,* while at higher elevations common temperate species such as oaks, Rhododendrons, maples, wild cherry, birch, fir, and a variety of understory shrubs were seen. Important medicinal plants of the sub-basin are *Berberis aristata, Zanthoxylum armatum, Juglans regia, Bergenia ciliata, Rubus ellipticus, Coleus barbata, Paeonia emodi, Podophyllum hexandrum, Rheum austral, Angelica glauca* and *Aconitum heterophyllum.*

Some RET species *Aconitum heterophyllum, Rheum austral, Angelica glauca, Coleus barbata, Podophyllum* was reported from this sub-basin.

Alaknanda Sub-basin 1 (Devprayag to Karnaprayag)

This sub-basin is drained mainly by Alaknanda River and its major tributary Mandakini that joins Alaknanda at Rudraprayag. This sub-basin mainly falls under lower to middle Himalayan range and has high ridge mountains and a number of side valleys in its catchment. Area has subtropical mixed forests, pine in the lower elevations and temperate forests in the higher elevations. Anthropogenic pressures and developmental activities along this stretch of Alaknanda are high as the main routes to Kedarnath and Badrinath is along this river.

Fish diversity: In terms of fish diversity and aquatic habitat, this sub-basin is one of the richest regions due to oligotrophic condition. It supports about 49 species of fishes, including 2 endemic species namely *Glyptothorax alaknandi* and *Glyptothorax garhwali*. These two species occur only in the upper reaches of Ganga. This sub-basin also has 12 threatened species *viz.* golden mahseer (*Tor putitora*), Black mahseer (*Tor chilinoides*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda*), hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*), barbs (*Chagunius chagunio*), hillstream loaches (*Botia dario, Nemacheilus multifasciatus* and *Pseudecheneius sulcatus*). It also has 31 restricted range species. This sector of river is the major migratory route for golden mahseers and other migrants.

Mammals and Birds: It encompasses about 250 birds species including 2 RET species (Indian White-backed Vulture and Egyptian vulture) and 3 IWPA Schedule-I species (Indian white-backed vulture, Egyptian vulture and cinereous vulture). This sub-basin encompasses 18 species of mammals out of which 2 are RET (Asiatic black bear and common leopard) and 2 are mentioned in IWPA Schedule-I list (Asiatic black bear and common leopard). Presence of otter has been reported from Malyasu and Papdasu based on signs (Dimri 2010). However, there are no confirmed reports on the presence of otters based on visual encounters or photographic records in this sub-basin (Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

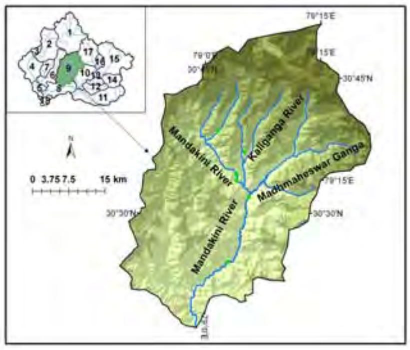
Floristic diversity: A total of about 361 species of higher plants were recorded from the sub-basin during field survey. Of these, 126 were herbs, 88 shrubs, 76 trees and 35 grasses. Of these, 155 species have medicinal values. The important high value medicinal plant of the sub-basin is *Coleus barbatus*, which can be seen around Kirtinagar in Tehri Garhwal, which is also listed as RET species. The dominant species among angiosperms are *Anogeisus latifolia, Adina cordifolia Acacia catechu, Aesculus indica, Bombax ceiba, Celtis australis, Lannea coromandelica, Ficus palmata, Grewia optiva, Lyonia ovalifolia, Mallotus phillippensis, Pinus roxburghii,* and *Quercus leucotrichophora.* Plants with medicinal uses recorded in the valley are *Acacia catechu, Mallotus phillippensis, Syzygium cumini, Diospyros montana, Aegle marmelos, Adhatoda zeylanica, Asparagus adscendens, Cannabis sativa, Colebrookia oppositifolia, Murraya koenigii, Woodfordia fruticosa, Cassia fistula, Sapindus mukorossi, Terminalia bellirica, Terminalia alata, Terminalia chebula, Artemisia roxburghiana* and *Asparagus filicinus.*

Fig. 5.7 View of Balganga sub-basin.

Fig. 5.8 View of Alaknanda sub-basin I.

Mandakini sub-basin

A collection of waters from Sone Ganga, Kali Ganga, Mandani Ganga, and Madh Maheshwar Ganga, the River Mandakini is one of the main tributaries of Alaknanda. The sub-basin extends from middle to the high Himalayan ranges and encompasses subtropical mixed and chir pine forests at the lower elevations (*Rudraprayag*), temperate forests with and scrub in the middle elevations, progressively rising to oak and coniferous mixed sub alpine forests, alpine scrub and meadows, moraines, glaciers and high altitude lakes in the higher elevations.



Fish diversity: A rich fish area, it supports about 38 species of fishes, including 19 restricted range species and several threatened species. The threatened species reported from this sub-basin include golden mahseer (*Tor putitora*), Black mahseer (*Tor chilinoides*), snow trout (*Schizothorax richardsonii*), stone suckers (*Garra gotyla gotyla, Garra lamda, Crossocheilus latius latius*), hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*, *Pseudecheneius sulcatus*). This sub-basin serves as a breeding habitat for mahseers and it is reported that during monsoons mahseers from Alaknanda migrate up to Mandakini river for breeding.

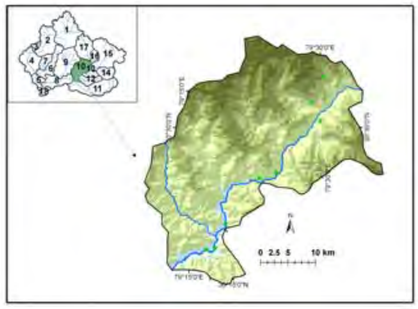
Mammals and Birds: In this sub-basin more than 350 birds species are present, of which 4 species are RET (Indian white-backed vulture, Egyptian vulture, western tragopan and cheer pheasant) and 6 species are mentioned in IWPA Schedule-I list (Indian white-backed vulture, Egyptian vulture, cinereous vulture, western tragopan, cheer pheasant and Himalayan monal). This sub-basin has 32 mammal species which includes 5 RET and also listed IWPA Schedule-I species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard and musk deer) (Green, 1985; Sathyakumar, 1994; Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A total of 400 species of higher plants belonging to 230 genera and 89 families including 126 medicinal plants were found in the sub-basin, with many RET species like *Aconitum hetrophyllum, Aconitum balfourii, Acorus calamus, Allium stacheyi, Allium humile, Cyananthus integer, Dactylorrhiza hatagirea, Dioscorea deltoidea, Nardostachys jatamansi, Podophyllum hexandrum, Picrorhiza kurrooa,* and *Trillidium govanianum* (Semwal *et al.* 2007).

The dominant species found in the sub-basin were *Alnus nepalensis, Quercus leucotrichophora, Carpinus viminea, Ilex dipyrena, Litsea monopetala*, *Neolitsea pallens, Lyonia ovalifolia, Myrica esculenta, Pyrus pashia, Berberis aristata.* were *Aconitum heterophyllum, Aconitum violaceum, Anemone rivularis, Delphinium vestitum, Thalictrum foliolosum, Paeonia emodi, Berberis aristata, Berberis asiatica, Viola bifora, Viola canescens, Malva verticillata, Geranium nepalense, Geranium wallichianum, Geranium polyanthes, Oxalis corniculata, Skimmia anquetilia, Rosa sericea, Bergenia ciliata, Parnassia nubicola, Selinum vaginatum, Galium aparine, Rubia cordifolia, Valeriana hardwickii, Valeriana jatamansi, Morina longifolia, Anaphalis triplinervis, Artemisia nilagirica, Jurinea dolomiaea, Taraxacum officinale, Gaultheria trichophylla, Swertia ciliata, Maharanga emodi, Verbascum thapsus, Ajuga brachystemon, Lamium album, Micromeria biflora, Origanum vulgare, Prunella vulgaris, Salvia hians, Plantago himalaica, Bistorta affinis, Rumex nepalensis, Euphorbia pilosa, Sarcococca saligna, Carpinus viminea, Hedychium spicatum, Dioscorea deltoidea, Paris polyphylla* and *Arisaema jacquemontii*.

Alaknanda Sub-basin II (Karnaprayag to Vishnuprayag):

In this sub-basin, tributaries such as the Urgam, Birahi Ganga, Mandal, Nandakini and Pindar rivers drain into the main Alaknanda River. The sub-basin encompasses subtropical mixed and chir pine forests at the lower elevations, temperate forests and scrub in the middle elevations (near *Vishnuprayag*) and oak and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (*Tungnath, Rudranath* regions). Some high altitude areas of this sub-basin fall within the Kedarnath Musk Deer Sanctuary.



Fish diversity: 26 species of fishes were reported from this sub-basin. It includes 19 restricted range species and 5 threatened species namely, golden mahseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*) hillstream catfish (*Glyptothorax telchitta, Glyptothorax caviai*), and *Pseudecheneius sulcatus*. This basin is the uppermost limit of mahseer distribution in main Ganga river. There are steep water-falls and narrow cascades between *Pipalkoti* and *Vishnuprayag*. These factors could be a major reason for absence of mahseer above Vishnuprayag.

Mammals and Birds: Over 300 birds species including 3 RET species (Indian White-backed vulture, Egyptian vulture and cheer pheasant) and 4 IWPA Schedule-I species (Indian white-backed vulture, Egyptian vulture, cinereous vulture and cheer pheasant). The important mammals including RET and IWPA species that are reported in the sub-basin are snow leopard, common Leopard, brown bear, black bear, musk deer, Himalayan tahr and serow (Green 1985, 1986; Sathyakumar 1994, Sathyakumar et al. 1992; Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005; Bhattacharya & Sathyakumar 2007).

Floristic diversity: A total 177 species (173 Angiosperms and 4 Gymnosperms) have been recorded in the sub-basin. Of these, herbs, shrubs, trees and climbers represent 100, 47, 20 and 10 species respectively (Bhatt, 2009). Some important **RET species** reported from the sub-basin are *Cyananthus integer, Nardostachys jatamansi* and *Picrorhiza kurrooa.*

The dominant species of the basin was *Aesculus indica, Celtis australis, Cinnamomum tamala*, *Cupressus torulosa, Lyonia ovalifolia, Populus ciliata, Pyrus pashia, Quercus semecarpifolia, Pinus roxburghii, Alnus nepalensis, Juglans regia, Mallotus philippensis*, *Rhus wallichii, Toona serrata, Rhododendron arboreum,* and *Myrica esculenta*.

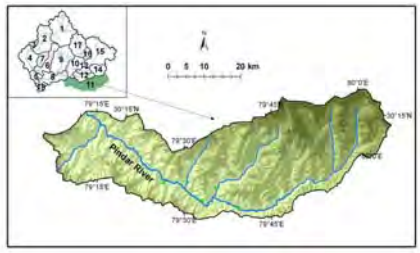
About 82 species of medicinal plants are found in the sub-basin, notable among them were *Alpuda mutica, Anaphalis adnata, Artemisia capillaries, Asparagus adscendens, Barleria cristata, Canabis sativa, Delphinium danudatum, Adhatoda zeylanica, Bergenia ciliata, Hedychium spicatum, Centella asiatica, Verbascum thapus, Berberis asiatica, Rumex hastatus, Swertia chirayita,* and *Zanthoxylum armatum.*

Fig. 5.9 View of Mandakini sub-basin.

Fig. 5.10 View of Alaknanda sub-basin II.

Pindar Sub-basin

The River Pindar originates from the Pindari glacier in Bageshwar District and flows east-west to join the River Alaknanda at Karnaprayag in Chamoli District. The Pindar catchment falls within the middle and greater Himalayan regions and encompasses subtropical mixed and chir pine forests at the lower elevations (*Karnaprayag*), temperate forests and scattered tree and scrub in the middle elevations, and oak and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations (near *Pindari*).This sub-basin is one of the rich riverine habitats with good natural riparian forests. Much of the sub-basin is relatively well protected and attracts trekkers for its scenic beauty and wilderness.



Fish diversity: It supports about 38 species of fishes, comprising 13 restricted range species and several threatened species including golden mahseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*), *Garra gotyla gotyla, Glyptothorax telchitta, Glyptothorax cavia, Puntius sarana* and *Pseudecheneius sulcatus*. This sub-basin is one of the important migratory and breeding habitats for mahseers, which inhabits the lower Alaknanda basin. Invasive brown trout was also found in this sub-basin. The ecological condition of this basin is from oligotrophic at higher altitude to eutrophic at downstream.

Mammals and Birds: More than 350 birds species are present, out of all these 3 species are RET (Indian white-backed vulture, Egyptian vulture and cheer pheasant) and 5 species are mentioned in IWPA Schedule-I list (Indian white-backed vulture, Egyptian vulture, cinereous vulture, cheer pheasant and Himalayan monal). It also has 34 species of mammals including RET and Schedule – I species of IWPA, they are: snow leopard, common Leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow (ZSI 1995, Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005; Bhattacharya *et al*. 2007, 2009, 2011; Bhattacharya & Sathyakumar 2010; Kandpal & Sathyakumar 2010).

Floristic diversity: Over 500 species of vascular plants were recorded in the area, of which herbs, shrubs, climbers, and trees represent 48, 32, 5 and 15% respectively. The common species recorded in the sub-basin were *Pinus roxburghii, Albizia julibrissin*, *Alnus nepalensis, Ficus roxburghii, Dalbergia sericea, Juglans regia, Litsea chinensis, Lyonia ovalifolia, Quercus leuchotricophora, Quercus semecarpifolia, Quercus dilatata, Quercus floribunda, Quercus glauca, Rhus wallichii, Toona ciliata, Pyrus pashia, and Ilex dipyrena.*

Over 50 species of medicinal and aromatic plants were also seen in the area notably, *Asparagus adscendens, Berberis asiatica, Terminalia chebula, T. bellirica, Aconitum heterophyllum, Rubia cordifolia, Prinsepia utilis, Cinnamomum tamala, Rosa macrophylla, Xanthoxylum armatum, Micromeria biflora,* and *Verbascum thapus.*

RET species recorded from this sub-basin are *Berberis osmastonii, Onosma pyramidale, Cypripedium elegans* and *Dactylorhiza hatagirea.*

Nandakini Sub-basin:

Originating near the high peaks of Nandaghunti and Trishul, the river Nandakini, runs east-west to join the Alaknanda at *Nandprayag*. Some high altitude areas of this sub-basin fall within the buffer zone of Nanda Devi Biosphere Reserve. The major vegetation types of the Nandakini sub-basin are temperate chir pine forest, temperate broadleaf forests, moist deodar forest, oak-conifer (mixed) forests, sub-alpine birch-rhododendron forests, alpine scrub and meadows.

Fish diversity: It supports about 38 species of fishes, comprising 13 restricted range species and seven threatened species such as golden mahseers *Tor putitora, snow trout* (*Schizothorax richardsonii*), stone sucker (*Garra gotyla gotyla*), hillstream catfishes (*Glyptothorax telchitta, Glyptothorax cavia*), Olive barbs (*Puntius sarana*) and *Pseudecheneius sulcatus*. This sub-basin is one of the important migratory and breeding habitats for mahseers, which inhabits lower Alaknanda basin. Invasive brown trout was found in this sub-basin. The ecological condition of this basin is from oligotrophic at higher altitude to eutrophic at downstream.

Mammals and Birds: Over 350 birds species are present, out of all these 3 species are listed in RET (Indian white-backed vulture, Egyptian vulture and cheer pheasant) and 5 species are mentioned in IWPA Schedule-I list (Indian white-backed vulture, Egyptian vulture, cinereous vulture, cheer pheasant and Himalayan monal). Pindar sub-basin encompasses 34 mammal species which includes 5 RET species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard and Himalayan musk deer) and 8 IWPA Schedule-I species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard, Himalayan musk deer, Himalayan tahr, blue sheep and serow) (ZSI 1995; Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A total of 116 species were recorded in the proposed HEP sites grouped into herbs (56), shrubs (32) and trees (28). Of these, 36 species have medicinal values.

The common species found in the project area are *Pinus roxburghii, Toona ciliata, Celtis australis, Grewia optiva, Bombax ceiba, Delbergia sissoo, Bauhinia variegata, Sapium insigne,* and *Syzygium cumini.* Important medicinal plant species include *Swertia chirayita, Berginia ciliata, Berberis asiatica, Cinnamomum tamala, Picrorhiza kurrooa, Asparagus adscendens, Woodfordia fruticosa and Zanthoxylum armatum.*

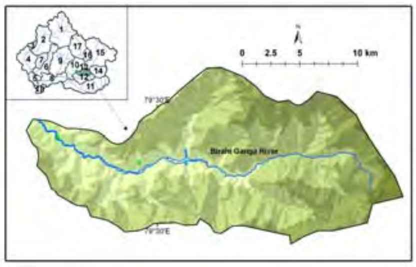
The **RET species** of plants recorded from this sub-basin are: *Acorus calamus, Allium stacheyi, Datisca cannabina, Berberis osmastonii*.

Fig. 5.11 View of Pindar sub-basin.

Fig. 5.12 View of Nandakini sub-basin.

Birahi ganga Sub-basin:

The sub-basin consists of Trishul and Nandaghunti rivers, flowing east-west to form the Birahi Ganga, which finally joins with Alaknanda near *Pipalkoti*. This area encompasses subtropical mixed and chir pine forests at the lower elevations (<2000m), temperate forests and scattered tree and scrub in the middle elevations (2000 – 2500m) and oak and coniferous mixed sub alpine forests, alpine scrub and meadows in the higher elevations.



Fish diversity: This river basin falls in masheer zone and it supports about 22 species of fishes, including 8 restricted range species and 4 threatened species (*Schizothorax richardsonii, Glyptothorax telchitta, Glyptothorax cavia* and *Pseudecheneius sulcatus*).

This sub-basin is very important as several species especially snow trout, *Schizothroax* spp. move into this river to breed. It was observed that snow trouts from main Alaknanda River move up near *Vishnuprayag* but due to steep slope they do not further move upward but return and then move to Birahi Ganga for breeding. However, this movement pattern needs to be studied in detail by tagging some snow trouts and mahseer in this region. Although, the presence of mahseers *Tor tor* and *T. putitora* in this region were not confirmed in this study, the occurrence of other *Tor spp.* were reported in earlier studies.

Mammals and Birds: Over 325 birds species were recorded, out of these 3 species are RET (Indian white-backed vulture, Egyptian vulture and cheer pheasant) and 5 species are mentioned in IWPA Schedule-I list (Indian white-backed vulture, Egyptian vulture, cinereous vulture, cheer pheasant and Himalayan monal). It also has 34 mammal species which includes many RET and scheduled species *viz.* snow leopard, common Leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow, Himalayan monal and raptors (ZSI 1995; Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A total of 118 species were recorded in the survey areas of Birahi sub-basin, many of these have medicinal properties. Of these, 51 species were herbs, 37 shrubs, 20 trees and 10 climbers. Medicinal plants recorded in the area were *Berberis aristata, Colebrokia oppositifolia, Berberis asiatica, Artemisia nilagirica, Woodfordia fruticosa* and *Zanthoxylum armatum.*

The most common and dominant species in the project area are *Aesculus indica, Albizia julibrissin, Celtis australis, Cupressus torulosa, Fraxinus micrantha, Juglans regia, Lyonia ovalifolia, Populus ciliata, Quercus semecarpifolia, Salix alba, Pinus roxburghii, Grewia optiva, Bauhinia variegata, Bimbax ceiba,* and *Alnus nepalensis.* No RET species of plant was reported from this sub-basin.

Rishi ganga Sub-basin:

The River Rishi Ganga originates at the base of Nanda Devi west peak (7817m) and flows northwest to join Dhauli Ganga at Reni village. This area lies within the Nanda Devi NP and its buffer zone, which was inscribed as UNESCO World Heritage Site due to its 'Outstanding Universal Values'. This region encompasses the temperate, subalpine, alpine habitats and many glaciers. This sub-basin is very rich in flora and fauna particularly RET species (Lamba 1987, Tak and Kumar 1987) and many of the RET species occur in high densities in this NP when compared to other PAs in the Western Himalaya (Sathyakumar 1993, Sankaran 1993, Sathyakumar 2004).

Fish diversity: It falls within 'no fish zone', as no fish species were reported from this region. This oligotrophic basin has cooler, clean water with low primary producers. Evidence for the presence of aquatic meiofauna have been recorded in this sub-basin.

Mammals and Birds: Over 250 birds species are present, out of these 2 species are in RET species list (Indian white-backed vulture and cheer pheasant) and 4 species are listed in Schedule-I of IWPA (Indian white-backed vulture, cinereous vulture, cheer pheasant and Himalayan monal). It also has 33 mammal species which includes 4 RET species (Asiatic black bear, snow leopard, common leopard and Himalayan musk deer) and 8 IWPA Schedule-I species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard, Himalayan musk deer, Himalayan tahr, blue sheep and serow) (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A total of 98 species of flowering plants were recorded in Rishi Ganga sub-basin. Of these, 64 species were herbs, 18 shrubs and 16 trees. Also, 28 species were of medicinal value. Common medicinal plants found in the area include *Achyranthes aspera*, *Aconitum balfourii*, *Aconitum heterophyllum*, *Allium humile*, *Angelica glauca*, *Arisaema tortuosum*, *Berberis aristata*, *Berberis lycium*, *Bergenia ciliata*, *Carum carvi*, *Centella asiatica*, *Delphinium denudatum*, *Hippophae salicifolia Picrorhiza kurrooa*, *Rheum australe*, *Podophyllum hexandrum*, and *Zanthoxylum armatum.*

The common and dominant tree species observed in the sub-basin were *Abies pindrow, Quercus semecarpifolica, Aesculus indica, Cedrus deodara, Juglans regia, Pinus wallichiana, Picea smithiana, Cupressus torulosa, Carpinus viminea*.

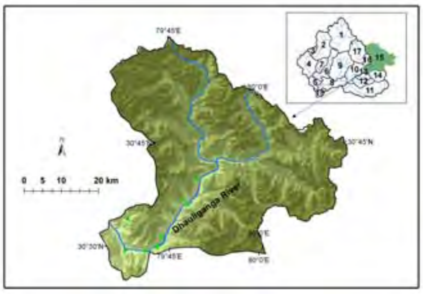
RET species reported from this sub- basin are *Aconitum heterophyllum, Nardostachys grandiflora, Allium humile, Arnebia benthamii, Aconitum falconeri, Angelica glauca, Dactylorhiza hatagirea, Dioscorea deltoidea, Picrorhiza kurrooa, Podophyllum hexandrum, Saussurea obvallata* (Hajra, 1983)

Fig. 5.13 View of Bhirai ganga sub-basin.

Fig. 5.14 View of Rishi ganga sub-basin.

Dhauli ganga Sub-basin:

The River Dhauli Ganga originates from the high peaks along the eastern border of District *Chamoli* (also the international border) and runs south west to join Alaknanda near *Joshimath.* The sub-basin encompasses Greater and Trans-Himalayan regions and has high habitat diversity ranging from temperate forests, scattered tree and scrub in lower elevations to subalpine forests, alpine scrub and meadows, glacier moraines, trans-Himalayan scrub and grasslands in the higher elevations. The uniqueness of this sub-basin is the gradual transition from Greater Himalayan elements (near Joshimath) to Trans-Himalayan elements (at the international border).



Fish diversity: It falls within 'no fish zone', as no fish species were reported from this region. This oligotrophic basin has cool and clean water with low primary producers.

Mammals and Birds: Over 250 species of birds are reported, out of these 2 species are in RET (Indian white-backed vulture and cheer pheasant) and 4 species are listed in IWPA Schedule – I (Indian white-backed vulture, cinereous vulture, cheer pheasant and Himalayan monal). The important mammals and birds that are reported to occur in the sub-basin are snow leopard, common Leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow, Himalayan monal and raptors (ZSI 1995). Typical Trans-Himalayan fauna that occur in this sub-basin include the snow leopard, Tibetan wolf, Tibetan woolly hare and Himalayan marmot. A Snow leopard was photo-captured at Malari during April 2011. The entire sub-basin forms the buffer zone of Nanda Devi BR and contains habitats and corridors for RET and other species that are of high conservation significance (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton,

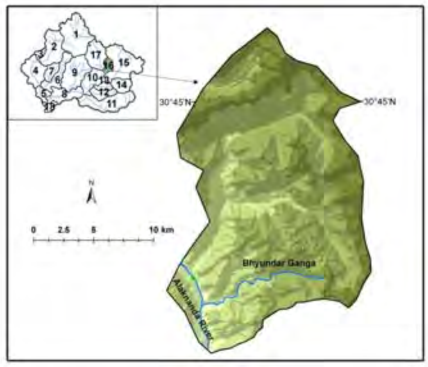
Floristic diversity: A total of 128 species were recorded in the survey localities, many of them are RET species. Of these, 88 species were herbs, 21 shrubs and 19 trees. Phondani (2010) has reported 86 species of medicinal value in this valley.

RET species reported from this sub-basin are *Acer caesium, Aconitum balfourii, Aconitum heterophyllum, Allium stracheyi, Arenaria curvifolia, Saussurea costus, Taxus baccata, Arenaria ferruginea, Berberis petioleris, Calamagrostis garhwalensis, Carex nandadeviensis, Dactylorhiza hatagirea,* and *Picrorhiza kurrooa.*

Important tree species in Dhauli Ganga Valley are *Abies pindrow, Fraxinus zanthoxyloides, Hippophae salicifolia, Pinus wallichiana, Populus ciliata, Cedrus deodara, Rhododendron arboreum* and *Taxus baccata*. Common shrubs include *Berberis petiolaris, Cotoneaster acuminata, Cotoneaster microphyllus, Ephedra gerardiana, Prinsepia utilis, Sorbaria tomentosa, Spiraea arcuata, Lonicera* spp., *Ribes glaciale, Rosa sericea and Rubus niveus*. The predominating herbs and grass species are *Aconitum atrox, Agropyron longearistatum, Arctium lappa, Artemisia gmelinii, Danthonia cachymeriana, Geranium wallichianum, Hieracium umbellatum, Melica persica, Pedicularis hoffmeisterii, Poa* spp., *Potentilla cuneata,* and *Taraxacum officinale.*

Bhyundar Sub-basin

The main river of the Bhyundar sub-basin is the Bhyundar River that is recognized by this name from the point where Paspawati River originating in the Valley of Flowers NP and Lakshman Ganga originating in the Lokpal Lake meet and later flow down through the Bhyundar Valley for about 15 km to join Alaknanda at Govindghat. This sub-basin is a small narrow valley with steep terrain. The World Heritage Site, Valley of Flowers NP and Hemkunad Saheb, a famous Sikh shrine are located in this sub-basin.



Fish diversity: It falls within 'no fish zone', as no fish species was reported from this region. This oligotrophic basin has cooler, clean water with low primary producers.

Mammals and Birds: More than 250 bird species including one RET, (Indian white-backed vulture) was reported and 3 species are listed in schedule-I of IWPA (Indian white-backed vulture, cinereous vulture and Himalayan monal). This sub-basin encompasses 33 mammal species which includes 5 RET species (i.e. Himalayan brown bear, Asiatic black bear, snow leopard, common leopard and Himalayan musk deer) and 8 IWPA Schedule-I species (Himalayan brown bear, Asiatic black bear, snow leopard, common leopard, Himalayan musk deer, Himalayan tahr, blue sheep and serow) (Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: The sub-basin encompasses temperate and sub alpine forests, alpine scrub, meadows and glaciers. 521 species of vascular plants were reported from the Valley of Flowers NP, including 17 RET species.

The sub-basin has several species of threatened medicinal plants as well such as *Aconitum balfourii, Aconitum falconeri, Angelica glauca, Arnebia benthamii, Delphinium brunonianum, Nardostachys grandiflora, Rheum australe, Rheum webbianum, Dactylorhiza hatagirea, Picrorhiza kurrooa, Aconitum violaceum, Meconopsis aculeata, Polygonatum multiflorum, Fritillaria roylei, Podophyllum hexandrum, Saussurea obvallata,* and *Taxus baccata* (Kala et al., 1998; Kala, 2005). Dominant species of plants in the cool temperate belt are *Acer caesium, Abies pindrow, Betula utilis, Rhododendron campanulatum, Taxus wallichiana, Syringa emodi* and *Sorbus lanata*. Some of the common herbs are *Arisaema jacquemontii, Boschniakia himalaica, Corydalis cashmeriana, Polemonium caeruleum, Polygonum polystachyum* (a rampant tall weed), *Impatiens sulcata, Geranium wallichianum, Helinia elliptica, Galium aparine, Morina longifolia, Inula grandiflora, Nomochoris oxypetala, Anemone rivularis, Pedicularis pectinata, P. bicornuta, Primula denticulata* and *Trillidium govanianum*.

The higher alpine zone (>4000m) in Bhyundar sub-basin is an area of pioneer species dispersed among moraines, boulders, and rocky slopes, dominated by scattered and stunted herbs, extensive shrubby patches of *Rhododendron lepidotum, Cassiope fastigiata* and *Juniperus communis*. The sub-basin's dominant species are *Kobresia royleana, Trachydium roylei* and *Danthonia cachemyriana*. There are also several colourful herbs like *Saussurea simpsoniana, Potentilla argyrophylla, Geum elatum, Senecio spp., Bistorta affinis, Bergenia stracheyi* and Himalayan blue poppy (*Mecanopsis aculeata*).

Fig. 5.15 View of Dhauli ganga sub-basin.

Fig. 5.16 View of Bhyundar ganga sub-basin.

Alaknanda Sub-basin III (Vishnuprayag to Badrinath):

The stretch of Alaknanda from its origin up to its confluence with Dhauli Ganga falls in this sub-basin. The River Alaknanda originates from the high peaks near the northern boundary of District *Chamoli* (also international border), flows along *Badrinath* and south towards *Joshimath*. Tributaries such as Khiron Ganga and Bhyundar Ganga drain into Alaknanda. Major proportion of this sub-basin was included into the buffer zone of Nanda Devi Biosphere Reserve and includes habitat for several RET and other species of high conservation significance.

Fish diversity: It falls within 'no fish zone', as no fish species was reported from this region. The basin is oligotrophic with low primary producers.

Mammals and Birds: More than 250 birds species are reported, out of these 1 species is listed in RET (Indian white-backed vulture) and 3 species are listed in Schedule-I of IWPA (Indian white-backed vulture, cinereous vulture and Himalayan monal) and there are 33 mammal species including RET and scheduled species such as snow leopard, common Leopard, brown bear, black bear, Tibetan wolf, musk deer, blue sheep, Himalayan tahr, serow, Himalayan monal and raptors (ZSI 1995, Kala 1998,2004, 2005). This sub-basin connects the Kedarnath WS and Khiron Valley in the west to the Nanda Devi Biosphere Reserve and therefore facilitates the movements of large mammals, particularly snow leopard and brown bear (Grimmet *et al.*, 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

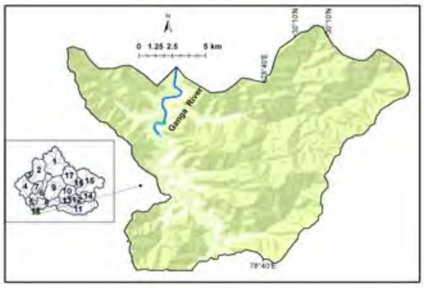
Floristic diversity: Diverse habitats ranging from temperate forests, scattered tree and scrub, subalpine oak-conifer forests, alpine scrub, meadows, moraines and glaciers are present in this sub-basin. Patches of riverine forest and scrub occur along the main river. Major proportion of this sub-basin forms the buffer zone of Nanda Devi BR. The major forest type of the sub-basin are Banj oak forest and Western mixed conifer forest.

243 species were recorded from the Alaknanda III sub-basin. Of these 164 were herbs, 51 shrubs and 28 trees. Among them all species 38 species have medicinal values. The prominent species of plants in the sub-basin include Abies *pindrow, Asculus indica, Alnus nepalensis,* Celtis *australis, Hippophae salicifolia, Lyonia ovalifolia, Populus ciliata, Pinus wallichiana, Pyrus pashia, Pyrus malus, Salix wallichiana, Betula alnoides,* and *Taxus baccata.* Notable, high value medicinal plants in this area include *Arnebia benthamii, Aconitum heterophyllum*, *Ajuga bracteosa, Allium humile, Artemesia vestita, Angelica glauca, Berberis asiatica, Bergenia ciliata,Carum carvi, Dactylorhiza hatagirea, Hippophae salicifolia, Prinsepia utilis, Rheum webbianum*, *Swertia chirayita, Thalictrum foliolosum, Taraxcum officinale* and *Zanthoxylum armatum.*

RET species in the sub-basin are *Allium humile, Allium stracheyi, Aconitum heterophyllum, Carum carvi, Dactylorhiza hatagirea, Hedysarum microcalyx,* and *Picrorhiza kurrooa.*

The Ganga (Devprayag to Rishikesh)

The stretch of Ganga from Devprayag to Rishikesh falls in the lower Himalayan range. A major spring fed perennial river Nayar joins Ganga near Byasi and several small streams also drain between this basin. This area encompasses the subtropical sal and mixed forests, open grassy slopes and scrub, and patches of riverine forests along the river. This sector of river has many deep pools and rapids, which are most preferable habitat for large size fishes like mahseers and barbs. This stretch of the Ganga is heavily used for adventure activities such as river rafting, camping, rock climbing and also for religious/spiritual purposes.



Fish diversity: This is the richest sector of entire Ganga river basin in terms of fish diversity and abundance in the State of Uttarakhand. A total of 56 species of fishes, including 30 restricted range fishes, 16 threatened fishes and 2 endemic fishes namely *Glyptothorax alaknandi* and *Glyptothorax garhwali*. These two species are endemic to the upper reaches of Ganga.

The threatened species of this basin are: *Tor putitora, Tor chelinoides, Schizothorax richardsonii, Bagarius bagarius, Garra gotyla gotyla, Garra lamda, Chagunius chagunio, Nemacheilus multifasciatus, Pseudecheneius sulcatus, Puntius arana, Puntius chola, Botia dario, Amblyceps mangois, Crossocheillus latius latius, Glyptothorax cavia* and *Glyptothorax telchitta*. In the entire Ganges, this is the only sector with viable population of golden mahseer *T. putitora*. This population moves along the Nayar river during monsoon for breeding. Based on the present survey, the Nayar river is recognised as one of the critical habitat for mahseer and its associated species.

Mammals and Birds: More than 225 birds species including 2 RET species (Indian White-backed Vulture and Egyptian vulture) and 4 IWPA Schedule-I species (Indian white-backed vulture, Egyptian vulture, cinereous vulture and Indian peafowl). This sub-basin encompasses 17 species of mammals, of which 2 are RET (Asiatic black bear and common leopard) and 2 species are listed in IWPA Schedule-I list (Asiatic black bear and common leopard). Species such as goral, sambar, barking deer are also present. There were no confirmed reports on the presence of otters, but potential otter habitats are present in some stretches along this basin. The only recent visual encounters of otters recorded by the WII team were near Bhimgoda Barrage, Haridwar on 18 November 2011 and on 3 December 2011 (Grimmet *et al.,* 1998; Menon, 2003 and Rasmussen & Anderton, 2005).

Floristic diversity: A total of 272 species were recorded from the survey area. Of these, 140 species were herbs, 62 shrubs, 69 trees and 2 climbers. About 86 species of medicinal plants were recorded in the area, notably, *Adhatoda zeylanica, Tinospora cordifolia, Aegle marmelos, Premna latifolia, Terminalia chebula, T. bellirica, Emplica officinalis* and *Woodfordia fruticosa.*

Among the RET species, one population of *Catamixis baccharoides*, was recorded close to Saknidhar near Devprayag. Prominent species in the area were *Adina cordifolia, Aegle marmelos, Shorea robusta, Tectona grandis, Holoptelea integrifolia, Lannea coromandelica, Mallotus phillippensis, Pinus roxburghii, Acacia catechu, Rhus parviflora,* Ficus *glomerata, Lantana camara, Syzygium cumini.*

Fig. 5.17 View of Alaknanda sub-basin III.

Fig. 5.18 View of Ganges sub-basin (Devprayag to Rishikesh).

Table 5.1 RET species in different sub-basins of Alaknanda and Bhagirathi basins at a glance.

Sub-basins	No. of terrestrial RET species			No. of aquatic RET species	Total RET species
	Mammals	Birds	Plants	Fish	
Bhagirathi I	5	1	8	0	14
Bhagirathi II	3	4	10	4	21
Asiganga	3	4	6	1	14
Bhagirathi III	2	3	1	5	11
Bhagirathi IV	2	3	0	12	17
Bhilangana	3	4	2	11	20
Balganga	3	4	5	11	23
Alaknanda I	2	4	1	12	19
Mandakini	5	5	10	8	28
Alaknanda II	2	4	6	5	17
Pindar	4	4	8	7	23
Nandakini	4	4	1	5	14
Birahi ganga	3	5	0	4	12
Rishi ganga	4	5	15	0	24
Dhauli ganga	5	5	14	0	24
Bhyundar ganga	5	4	21	0	30
Alaknanda III	5	1	8	0	14
Ganga Basin	2	3	1	16	22

5.2 Biodiversity values based on fish fauna

A total of 76 fish species belonging to 32 genera and 13 families were recorded from the Alaknanda and Bhagirathi basin, of these, 66 species have been reported in the zone of influence of Hydro Electric Projects (Appendix 5.4). Estimates of catches at four points along the Alaknanda in the Garhwal Himalaya showed a range between 1035 to 2475 kg km-1 year-1 with an average of 1650 kg km-1 year-1 while a lower tributary, the Nayar river, an important fish breeding habitat in the region, produced 621 kg km-1 year-1 (Payne and Temple 1996). The cyprinidae was the major dominant family along with presence of other families like, Balitoridae and Sisoridae. Overall, the community structure in the basin was characterized by a few specialized cyprinid types, specifically the snow trouts (*Schizothorax spp*.), the mahseers (*Tor spp.*) and the lesser barils (Barilius spp.), the hillstream loaches (*Nemacheilus spp.)* and the sisorid torrent cat fishes (*Glyptothorax spp*.). There was no record of fish above 2400- 3000 masl elevation. The relative abundance of important fish species in this river stretch was dominated by B. bendelisis (18.64%) followed by *S. richardsonii* (16.21%), *T. putitora* (8.51%), *S. montana* (5.49%), *T. tor* (4.5%), *G. gotyla* (1.49%) and *G. pectinopeterus* (0.77%).

Although much research has focussed on various ecological aspects (Nautiyal and Lal 1984, 1985; Nautiyal et al. 1998; Singh 1988; Sharma 2003) of the species like golden mahseer (*T. putitora, T. tor*) and snow trouts (Schizothorax spp.) from some tributaries in the basin, however, detailed ecological information is still lacking for several cold water species in the region.

As explained in the methodology chapter, the fish biodiversity value was assessed on the basis of 6 criteria which include species richness value, value based on RET species, value based on endemic species, value based on breeding/congregation habitats, value based on migratory habitats and value based on habitat biodiversity value.

As is inferred from the data on fish species from all the sub-basins (Table 5.2), the three sub-basins namely Ganga sub-basin, Alaknanda I sub-basin and Bhagirathi IV sub-basin have "very high" fish biodiversity value (Fig. 5.19). The Ganga sub-basin harbours 56 fish species of the 76 species, including all16 threatened species and both the endemic species, recorded from the Alaknanda and Bhagirathi basins. The fish biodiversity value of this sub-basin is the highest among all the 18 sub-basins in the study area. The Alaknanda I sub-basin harbours 64% of the total fish species in the study area. Out of the 16 threatened species in the study area, 12 species occur in this sub-basin and it is home to both the endemic species found in the study area. The Bhagirathi IV sub-basin harbours 63% of the total fish species in the study area and 12 species out of the 16 threatened species in the two major basins. It is also home for two endemic species such as *Glyptothorax garhwali* and *Glyptothorax alaknandi*. In terms of habitat diversity, the three sub-basins have representative of all the five types of aquatic habitats are present in the area and also contain breeding/congregational sites and migratory pathways for golden mahseers, black mahseers and snow trouts.

The Bhilangana, Balganga, Mandakini, Pindar, Nandakini, Bhagirathi II, Bhagirathi III, Alaknanda II, Birahi ganga and Asiganga sub-basins harbour "high" fish biodiversity value largely due to the presence of breeding/congregational sites and migratory pathways for species such as golden mahseers and snow trouts which have great conservation value.

Fig. 5.19 Relative fish biodiversity values in sub-basins of Alaknanda and Bhagirathi.

Table 5.2. Criteria for assessing aquatic biodiversity values.

S.No.	Name of sub-basin	Criteria for assessing aquatic biodiversity values						Aquatic biodiversity value	Relative ranking of sub-basins	Category
		Species richness value	Value based on RET species	Value based on endemic species	Value based on breeding/ congregation habitats	Value based on migratory habitats	Value based on habitat diversity			
1.	Bhagirathi I	1	1	1	1	1	3	8	27	M
2.	Bhagirathi II	2	2	1	5	5	3	18	60	H
3.	Asiganga	1	1	1	5	5	4	17	57	H
4.	Bhagirathi III	2	2	1	5	5	3	18	60	H
5.	Bhagirathi IV	4	4	3	5	5	5	26	87	VH
6.	Bhilangana	3	4	1	5	5	4	22	73	H
7.	Balganga	3	4	1	5	5	4	22	73	H
8.	Alaknanda I	4	4	5	5	5	5	28	93	VH
9.	Mandakini	2	3	1	5	5	5	21	70	H
10.	Alaknanda II	2	2	1	5	5	3	18	60	H
11.	Pindar	2	3	1	5	5	5	21	70	H
12.	Nandakini	2	2	1	5	5	4	19	63	H
13.	Birahi ganga	1	2	1	5	5	4	18	60	H
14.	Rishi ganga	1	1	1	1	1	3	8	27	M
15.	Dhauli ganga	1	1	1	1	1	3	8	27	M
16.	Bhyundar ganga	1	1	1	1	1	2	7	23	L
17.	Alaknanda III	1	1	1	1	1	3	8	27	M
18.	Ganga Basin	4	5	5	5	5	5	29	97	VH

L: Low; M: Medium; H: High; VH: Very High

Golden mahseer
Tor putitora

Silver mahseer
Tor tor

Alwan snow trout
Schizothorax richardsonii

Snow trout
Schizothoraichthys progastus

Labeo dero

Labeo boga

Glyptothorax alaknandi

Garra gotyla gotyla

Plate 5.2 RET fishes of Alaknanda-Bhagirathi basin, Uttarakhand.

Brachidanio rerio (Zebra fish)
Max. size 4 cm Total length

Danio devario (Devario danio)
Maximum size 10 cm Total length

Puntius conchonius (Rosy barb)
Maximum size 14 cm Total length

Puntius sophore (Pool barb)
Maximum size 18 cm Total length

Tor chilinoides
(Black mahseer)
Maximum size 20 cm Total length

Barilius bendilisis (Baril)
Maximum size 22 cm Total length

Labeo dero (Golaraia)
Maximum size 40 cm Total length

Glyptothorax pectinopterus
(hillstream catfish)
Maximum size 16 cm Total length

Plate 5.3 Some common fishes of Alaknanda-Bhagirathi basin, Uttarakhand.

5.3 Biodiversity value based on terrestrial flora and fauna

The Alaknanda and Bhagirathi basins have high floral and faunal diversities and some valleys have unique biodiversity values and high densities of species particularly, RET species (Table 5.1 and 5.2). Major habitats of Bhagirathi basin includes sub tropical pine mixed forests, temperate broad leaved and coniferous forests, subalpine forests and scrub, alpine scrub and meadows, moraines and perpetual snow areas. The Gangotri National Park is located in the upper catchment of Bhagirathi. About 15 species of mammals and 150 bird species have been documented in this NP. This includes some of the rare and charismatic species such as snow leopard, black bear, brown bear, musk deer, blue sheep or bharal, Himalayan tahr, Himalayan monal, Koklass, and Himalayan snowcock (Paramanand et al. 2000; Uniyal & Ramesh 2004; Chandola et al. 2008; Bhardwaj & Uniyal 2009 and Bhardwaj et al. 2010, Maheshwari & Sharma 2010).

Within the Alaknanada basin, the Nanda Devi NP and Valley of Flowers NP are two areas with rich biodiversity values that have also been designated as UNESCO World Heritage site. These two NPs form the core zone of the Nanda Devi Biosphere Reserve that spreads across most of the upper catchment of Alaknanda and the entire catchment of Dhauliganga. The upper catchments of Alaknanda and Mandakini also form part of the Kedarnath WLS. Over 43 mammals and 250 bird species have been recorded from this basin (Reed 1979; Green 1985, 1986; Lamba 1987; Tak and Kumar 1987; Sathyakumar 1992, 1993, 1994, 2001, 2004, 2006; ZSI 1995; Sathyakumar & Kalsi 2007; Sathyakumar & Kaul 2007; Sathyakumar et al. 1992 1993; Bhattacharya & Sathyakumar, 2007a, 2008, 2010, 2011; Bhattacharya et al. 2007, 2009). There were no confirmed recent reports on the presence of otters in both the basins with the exception of otter signs recorded at a few places downstream of Alaknanda (Table 5.1 and 5.2). However, potential otter habitats occur in some parts of the Alaknanda basin.

These basins have high floral and faunal diversities and some valleys have unique biodiversity values and high densities of species particularly, Rare, Endangered & Threatened (RET) species. The forest types of the Alaknanda basin range from the Himalayan subtropical scrub at lower elevations, temperate broad leaved forests in the middle elevations to subalpine oak and conifer forests at ‘tree line’ at the higher elevations (Champion & Seth, 1968). The forest types of the Bhagirathi basin range from the Himalayan subtropical scrub at lower elevations to subalpine birch-rhododendron forests at ‘tree line’ (Champion & Seth, 1968). Major habitats of Bhagirathi basin includes sub tropical pine mixed forests, temperate broad leaved and coniferous forests, subalpine forests and scrub, alpine scrub and meadows, moraines and perpetual snow areas.

5.3.1 Mammals

The mammalian biodiversity value reflects species richness value, relative richness of RET species and IWPA protected species in different sub-basins. An overview of biodiversity values in the sub-basins is presented in Table 5.3 & Plate 5.4 & 5.5.

According to the Table 5.3, 12 sub-basins have ‘very high’ mammalian biodiversity values which are attributable largely to presence of relatively high proportion of RET species richness. These RET species are represented by Snow leopard, Brown bear and Himalayan musk deer which are also

IWPA species and are restricted to high altitude Himalayan ecosystem. Some of the sub-basins like Bhagirathi-I, Dhauliganga, Rishiganga, Mandakini encompass Protected Areas which are critical habitats for species mentioned above.

Table 5.3 Distribution of birds & mammals in all sub-basins of Alaknanda & Bhagirathi*.

Basins	Sub-basins	Birds Total	Birds RET	Birds IWPA	Mammals Total	Mammals RET	Mammals IWPA
Bhagirathi	Bhagirathi I	219	1	3	29	5	8
	Bhagirathi II	320	4	5	24	3	5
	Asiganga	262	4	5	32	3	5
	Bhagirathi III	238	3	4	17	2	2
	Bhagirathi IV	239	3	4	16	2	2
	Bhilangana	359	4	6	32	3	5
	Balganga	358	4	6	32	3	5
Alaknanda	Alaknanda Sub-basin I	253	4	5	18	2	2
	Mandakini Sub-basin	361	5	6	33	5	7
	Alaknanda Sub-basin 2	318	4	5	23	2	2
	Pindar Sub-basin	357	4	5	34	4	7
	Nandakini Sub-basin	354	4	5	34	4	7
	Birahi ganga	345	5	6	34	3	5
	Rishi ganga	270	5	6	33	4	7
	Dhauli ganga	271	5	6	33	5	8
	Bhyundar ganga	270	4	5	33	5	8
	Alaknanda Sub-basin 3	271	1	2	33	5	8
Ganga	Ganga Basin	227	3	5	17	2	2

Total numbers of Birds in Alaknanda and Bhagirathi basins- 364 (RET = 5; IWPA= 8)
Total numbers of Mammals in Alaknanda and Bhagirathi basins (excluding Chiropterans and small rodents) – 35 (RET = 5; IWPA = 8) * for detailed information refer Appendix 5.5, 5.6 & 5.7.

Plate 5.4: Important mammals in the two basins.
(a) The Snow Leopard Camera trap image taken at Malari, Dhauliganga sub-basin (Photo credit: WII-UNESCO Project)
(b) Asiatic Black bear (Photo credit: WII- Khangchendzonga Project);
(c) Common leopard (Photo credit: WII- Uttarakhand Leopard Project – Dr. S.P. Goyal);
(d) Himalayan musk deer (Photo credit: S.Sathyakumar);
(e) Himalayan Brown bear (Photo credit: Aishwarya Maheshear, WWF-India).

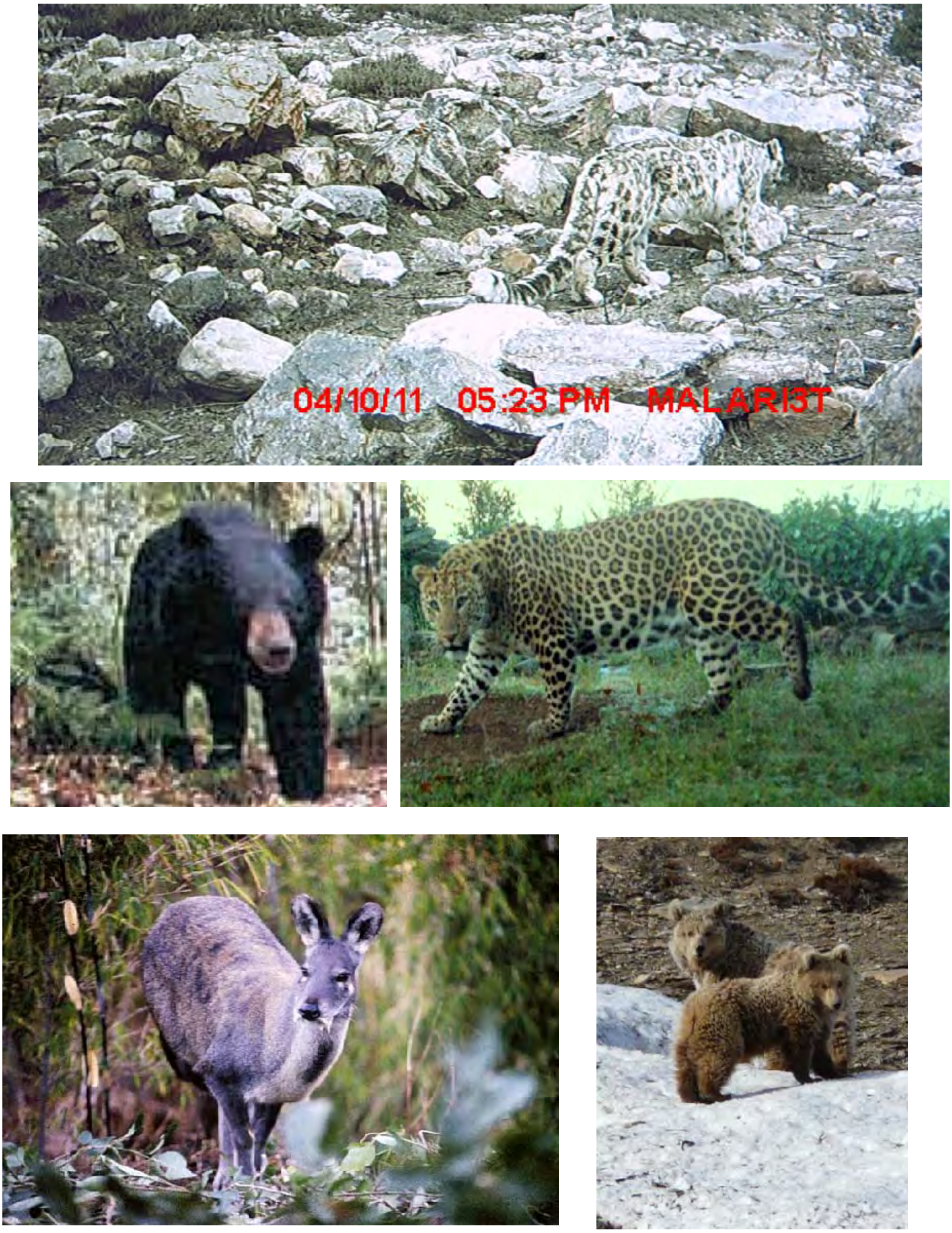


Plate 5.5: Important Galliformes in the two basins.
(a) Western Tragopan (b) Himalayan monal (C) Cheer Pheasant (D) Indian Peafowl
Photos credit: World Pheasant Association (a; b & c) and N K Dimri (d)

Of the 12 sub-basins, Bhagirathi I, Mandakini, Dhauli ganga, Bhyundar ganga, Alaknanda III sub-basins have relatively the highest RET mammalian biodiversity value.

Table 5.4 Criteria for assessing mammal biodiversity values.

S.No.	Sub-basin	Criteria for assessing mammal biodiversity			Mammal biodiversity value	Relative ranking	Category
		Species richness value	Value based on RET species	Value based on species in IWPA			
1.	Bhagirathi I	4	5	5	14	93	VH
2.	Bhagirathi II	4	3	4	11	73	H
3.	Asiganga	5	3	4	12	80	VH
4.	Bhagirathi III	3	2	2	7	47	M
5.	Bhagirathi IV	3	2	2	7	47	M
6.	Bhilangana	5	3	4	12	80	VH
7.	Balganga	5	3	4	12	80	VH
8.	Alaknanda I	3	2	2	7	47	M
9.	Mandakini	5	5	5	15	100	VH
10.	Alaknanda II	4	2	2	8	53	H
11.	Pindar	5	4	5	14	93	VH
12.	Nandakini	5	4	5	14	93	VH
13.	Birahi ganga	5	3	4	12	80	VH
14.	Rishi ganga	5	4	5	14	93	VH
15.	Dhauli ganga	5	5	5	15	100	VH
16.	Bhyundar ganga	5	5	5	15	100	VH
17.	Alaknanda III	5	5	5	15	100	VH
18.	Ganga Basin	3	2	2	7	47	M

M: Medium; H: High; VH: Very High

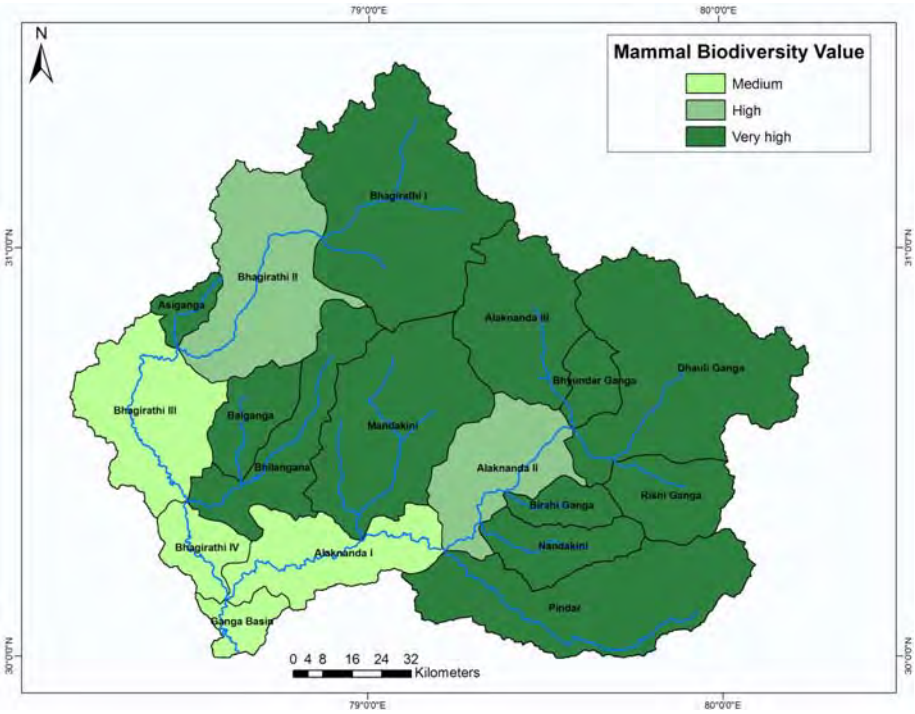


Fig. 5.20 Mammalian biodiversity value.

5.3.2 *Birds*

As with mammalian biodiversity value, the bird biodiversity value reflected in Table 5.5 are based on considerations on species richness, relative richness of RET species and IWPA protected species in different sub-basins. An overview of bird biodiversity values (Fig. 5.21) in the sub-basins highlights that as many as 13 sub-basins out of 18 sub-basins rank "very high" in relative bird biodiversity values. Factors that strongly contribute in the ranking of these basins as areas supporting high bird biodiversity are total species richness, presence of high number of RET and IWPA protected species such as Cheer Pheasant.The sub-basins supporting the highest species richness including those of RET and IWPA species are Mandakini and Birahi ganga sub-basins.

The Cheer pheasant is an endangered pheasant that inhabits subtropical and temperate habitats (1,500-3,000m) of the Greater Himalaya and is reported in Bhyundar Dhauli ganga, Rishi ganga, Birahi, Pindar, Bhilangana Mandakini Bhagirathi II, Asiganga, Nandakini and Balganga sub-basins. Sub-basins with moderate ranking for bird biodiversity such as Bhagirathi I, Alaknanda III are however are important habitats for cheer pheasant.

The western tragopan is a vulnerable pheasant that inhibits forested habitats of the Greater Himalaya and its global distribution is limited to India and Pakistan only. In India, it is distributed in a narrow stretch (2,500-3,500m) from western Uttarakhand to Jammu & Kashmir State. It is a rare bird that occurs singly or pairs in undisturbed upper temperate and sub-alpine habitats. In the Alaknanda and Bhagirathi basins, it is reported to be present in Bhagirathi II, Asiganga, Bhilangana, Balganga and Mandakini sub-basins.

Table 5.5 Criteria for assessing bird biodiversity values.

S.No.	Sub-basin	Criteria for assessing Bird biodiversity			Bird biodiversity value	Relative ranking	Category
		Species richness value	Value based on RET species	Value based on species in IWPA			
1.	Bhagirathi I	4	1	2	7	47	M
2.	Bhagirathi II	5	4	4	13	87	VH
3.	Asiganga	4	4	4	12	80	VH
4.	Bhagirathi III	4	3	3	10	67	H
5.	Bhagirathi IV	4	3	3	10	67	H
6.	Bhilangana	5	4	4	13	87	VH
7.	Balganga	5	4	4	13	87	VH
8.	Alaknanda I	4	4	4	12	80	VH
9.	Mandakini	5	5	4	14	93	VH
10.	Alaknanda II	5	4	4	13	87	VH
11.	Pindar	5	4	4	13	87	VH
12.	Nandakini	5	4	4	13	87	VH
13.	Birahi ganga	5	5	4	14	93	VH
14.	Rishi ganga	4	5	4	13	87	VH
15.	Dhauli ganga	4	5	4	13	87	VH
16.	Bhyundar ganga	4	4	4	12	80	VH
17.	Alaknanda III	4	1	2	7	47	M
18.	Ganga Basin	4	3	4	11	73	H

M: Medium; H: High; VH: Very High

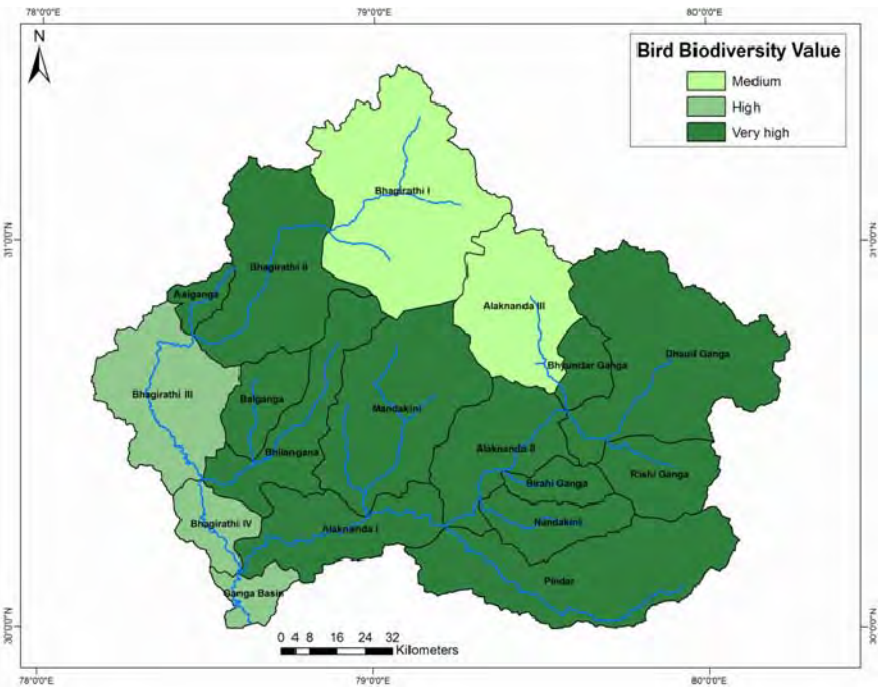


Fig. 5.21 Avifaunal biodiversity value.

5.3.3 Plants

The plant biodiversity value was assessed on the basis of species richness, RET species richness and medicinal value (Table 5.6). The biodiversity value based on the floral components in all the sub-basins is not as high as the value based on the faunal components including both terrestrial and aquatic. Most of the sub-basins have a moderate ranking for floral values with the only exceptions being Alaknanda I and Bhyundar ganga sub-basins (Fig. 5.22).

Table 5.6 Criteria for assessing plant biodiversity value.

S.No.	Sub-basin	Criteria for assessing Plant biodiversity			Plant biodiversity value	Relative ranking of sub-basins	Category
		Species richness value	Value based on RET species	Value based on medicinal species			
1.	Bhagirathi I	2	2	1	5	33	M
2.	Bhagirathi II	2	2	2	6	40	M
3.	Asiganga	3	1	1	5	33	M
4.	Bhagirathi III	2	1	1	4	27	M
5.	Bhagirathi IV	3	1	3	7	47	M
6.	Bhilangana	2	1	1	4	27	M
7.	Balganga	2	1	1	4	27	M
8.	Alaknanda I	4	1	3	8	53	H
9.	Mandakini	2	2	3	7	47	M
10.	Alaknanda II	2	1	2	5	33	M
11.	Pindar	2	1	1	4	27	M
12.	Nandakini	2	1	1	4	27	M
13.	Birahi ganga	2	1	1	4	27	M
14.	Rishi ganga	2	2	1	5	33	M
15.	Dhauli ganga	2	3	2	7	47	M
16.	Bhyundar ganga	5	3	1	9	60	H
17.	Alaknanda III	3	2	1	6	40	M
18.	Ganga Basin	3	1	2	6	40	M

M: Medium; H: High

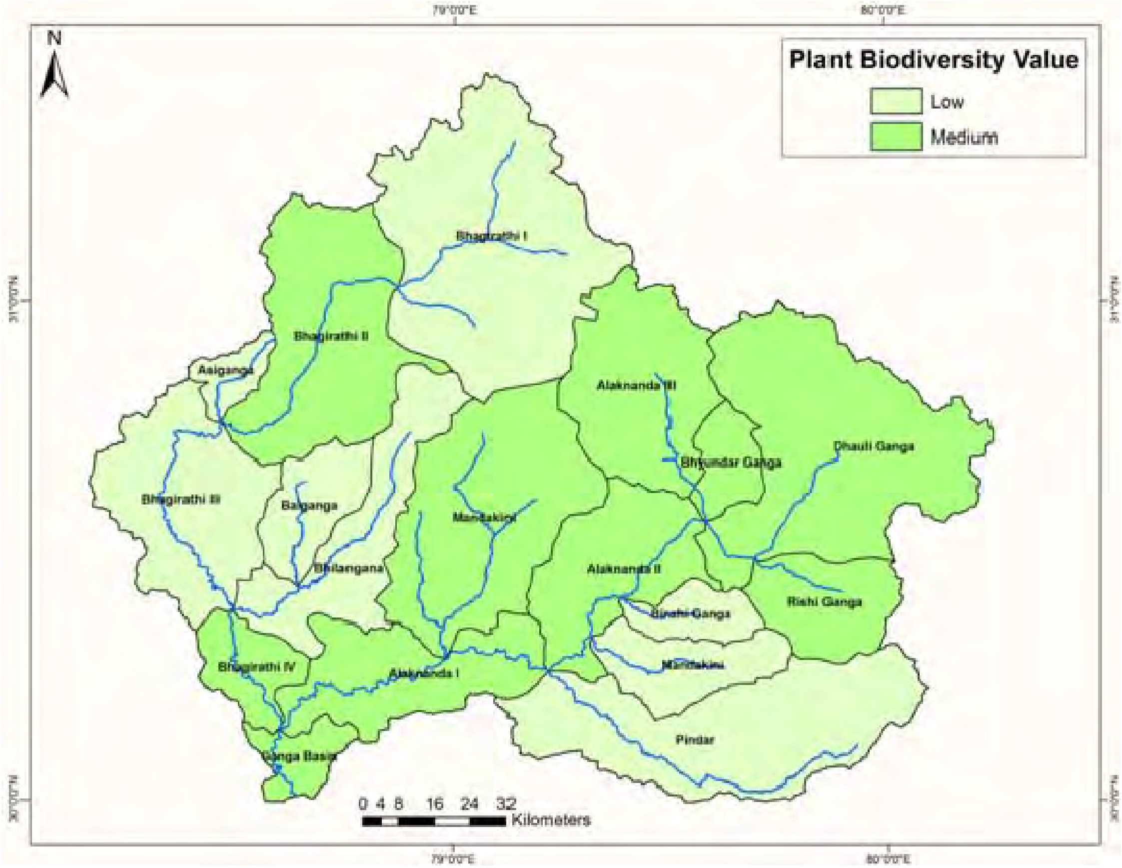


Fig. 5.22 Plant biodiversity value.

Although the overall floral biodiversity values in the two basins are relatively low, it is noteworthy that some of these sub-basins harbour Locally Endemic, near Endemic and Threatened plant species (Table 5.7). Many of these endemic species are restricted to a single sub-basin of Alaknanda or Bhagirathi basins.

Table 5.7 Distribution / location of Endemic and Near Endemic, Threatened plant species in Alaknanda and Bhagirathi basins.

S.No.	Name of the species	Family	Distribution
1.	*Aconitum falconeri* Stapf var. *falconeri*	Ranunculaceae	Rishiganga
2.	*Carex nandadeviensis* Ghildyal, et al.	Cyperaceae	
3.	*Festuca nandadevica* Hajra	Poaceae	
4.	*Listera nandadeviensis* Hajra	Orchidaceae	
5.	*Saussurea sudhanshui* Hajra	Asteraceae	
6.	*Arenaria curvifolia* Majumdar	Caryophyllaceae	Dhauli ganga
7.	*Arenaria ferruginea* Duthie ex F. Williams	Caryophyllaceae	
8.	*Calamogrostis garhwalensis*	Asteraceae	
9.	*Viola kunawarensis* Royle	Violaceae	
10.	*Ranunculus uttaranchalensis* Pusalkar & Singh	Ranunculaceae	Bhagirathi II
11.	*Silene gangotriana* Pusalkar et al.	Caryophyllaceae	
12.	*Microschoenus duthiei* Clarke	Cyperaceae	
13.	*Caragana sukiensis* Nakao	Fabaceae	
14.	*Agrostis tungnathii* Bhattach. & Jain	Poaceae	Mandakini
15.	*Cyananthus integer* Wall. ex Benth.	Campanulaceae	
16.	*Anemone raui* Goel & Bhattach.	Ranunculaceae	Bhilangana
17.	*Trachyspermum falconeri* (Clarke) H. Wolff	Apiaceae	
18.	*Dilophia purii* Rawat, Dangwal & R.D. Gaur	Brassicaceae	Alaknanda II
19.	*Cyathea spinulosa*	Cyatheaceae	
20.	*Euphorbia sharmae* U.C. Bhattach	Euphorbiaceae	Bhyundar ganga
21.	*Gentiana saginoides* Burkill	Gentianaceae	
22.	*Gentiana tetrasepala* Biswas	Gentianaceae	
23.	*Androsace garhwalicum* Balodi & Singh	Primulaceae	
24.	*Berberis osmastonii* Dunn	Berberidaceae	Pindar
25.	*Catamixis baccharoides* Thomson	Asteraceae	Ganga-Basin

Based on the primary and secondary information, floral composition within the ZoI of the different Hydro Electric Projects was also assessed and is presented in Appendix–5.8 & Plate 5.6 & 5.7.

1. *Acer caesium* Wall. ex Brandis.
2. *Aconitum heterophyllum*
3. *Acorus calamus* L.
4. *Allium stracheyi* Baker
5. *Allium humile* kunth
6. *Arnebia benthamii* (Wall. Ex D. Don) Johnston
7. *Berberis osmastonii* Dunn.
8. *Caragana sukiensis* Schn.
9. *Catamixis baccharoides* Thoms.

Plate 5.6 Some RET plant species found in Alaknanda and Bhagirathi basins.

Photocredits: 1.Tabish; 2. C.S Rana; 3. Thingnam Girija; 4. Ishwari Dutt Rai; 5. Guojun Hua; 6. Ajay Maletha; 7. Ishwari Dutt Rai; 8. H.B. Naithani; 9. G.S. Rawat

10. *Coleus barbatus* (Andr.) Benth.

11. *Cyananthus integer* Wall. ex Benth.

12. *Datisca cannabina* L.

13. *Dioscorea deltoidea* Wall. ex Griseb.

14. *Epipogium aphyllum* (Schmm.) Swartz

15. *Lilium polyphyllum* D. Don ex Royle

16. *Nardostachys grandiflora* DC.

17. *Picrorhiza kurrooa* Royle ex Benth.,

18. *Trillidium govanianum* (D. Don) Kunth

Plate 5.7 Some RET plant species found in Alaknanda and Bhagirathi basins.

Photocredits: 10. Ninad Raut; 11. G.S. Rawat; 12. Ninad Raut; 13. Ninad Raut; 14. Skoppelo; 15. G.S. Rawat; 16. Ninad Raut; 17. C.S.Rana; 18. Narayan singh chauhan

Presented below is a composite assessment of terrestrial biodiversity (**Table** 5.8) values in the two basins after combining the biodiversity values based on individual biodiversity components.

Table 5.8 Relative ranking of terrestrial biodiversity value.

S.No.	Sub-basin	Relative ranking of terrestrial biodiversity value	Category
1.	Bhagirathi I	53	H
2.	Bhagirathi II	62	H
3.	Asiganga	60	H
4.	Bhagirathi III	44	M
5.	Bhagirathi IV	51	H
6.	Bhilangana	62	H
7.	Balganga	62	H
8.	Alaknanda I	56	H
9.	Mandakini	76	VH
10.	Alaknanda II	56	H
11.	Pindar	67	H
12.	Nandakini	67	H
13.	Birahi ganga	64	H
14.	Rishi ganga	69	H
15.	Dhauli ganga	73	VH
16.	Bhyundar ganga	73	VH
17.	Alaknanda III	58	H
18.	Ganga Basin	51	H

H: High; M: Medium; VH: Very High

The three sub-basins namely Mandakini, Dhauliganga and Bhyundar ganga have "very high" ranking (**Fig.** 5.23) for terrestrial biodiversity values for the reasons explained below.

The Bhyundar ganga sub-basin has very high (VH) terrestrial biodiversity value especially due to very high richness of mammalian species and plant species. It harbours all the RET mammal species and IWPA mammal species found in the study area. Among avifaunal species, 4 out of 5 RET species and 5 out of 8 IWPA species found in the area occur in this sub-basin. In addition, 53% of RET plant species and 15% of medicinal plants contribute to the overall high biodiversity value of this basin.

The Mandakini sub-basin has very high (VH) terrestrial biodiversity value because of very high mammal and bird species richness. The sub-basin harbours all of the mammal and birds RET species reported from the two basins. In terms of protected species the sub-basin has 7 out of the 8 mammals and 6 out of 8 I bird species listed under IWPA. Additionally, the sub-basin also supports 42% of the medicinal plants reported from the two basins.

The very high terrestrial bioidiversity value of the Dhauli ganga sub-basin can be attributed to the very high species richness of mammals followed by that of bird species richness. The sub-basin is home to all of the (5) RET and (8) IWPA mammal species. Among avifaunal species, all of the RET species and 6 out of 8 IWPA species occur in the sub-basin.

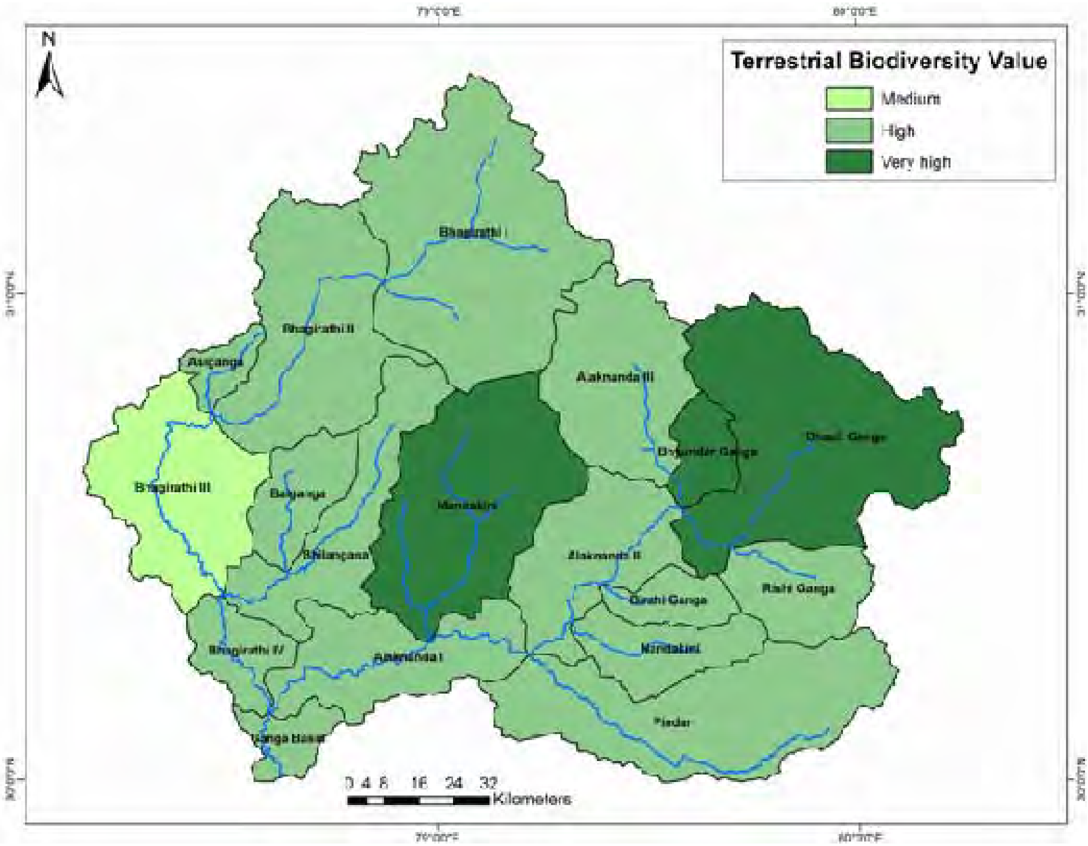


Fig. 5.23 Terrestrial bioidiversity values in Alakananda and Bhagirathi basins.

5.4 Areas representing critically important habitats

Based on the simplest of notions, 'critical natural habitats' are existing and officially proposed protected areas, as well as unprotected areas of known high importance for biodiversity conservation (Ledec and Quintero, 2003). Precise definitions explain “critical habitat' as a specific geographic area(s) that is essential for the conservation of a threatened or endangered species and that may require special management and protection (USFWS, 2002); habitats that are not currently occupied by the species but that will be needed for its recovery; areas within or outside the geographic range of a species (Schreiner 1976, USFWS 1988).

Delineation of critically important habitats in this study has followed the rationale supported by most biologists (U.S. Fish & Wildlife Service, 2002) and has involved identifying all physical and biological habitat features needed for life and successful reproduction of the species. These habitat features essentially included the following:

- Space for individual and population growth and for normal behaviour;
- Cover or shelter;
- Food, water, air, light, minerals, or other nutritional or physiological requirements;
- Migratory routes/corridors
- Sites for breeding and rearing offspring; and
- Habitats protected from disturbances or are representative of historic, geographical and ecological distributions of a species. (modified from U.S. Fish & Wildlife Service, 2002)

Conceptually, these critically important habitats are distinguishable from high-quality habitats which equate to an area's ability to provide resources for population's persistence (Hall *et.al.,* 1997).

Species diversity of fishes in the Alaknanda and Bhagirathi basin was observed to be increasing with increase in flow i.e. more diversity of fishes in the downstream than the upstreams of Alaknanda and Bhagirathi Rivers and their tributaries (R^2 = 0.5002, p<0.001). In general, the quality and use of habitats are much more important parameters than the density of a population or species for selecting the critical habitat of a species (Horne, 1993). Therefore, this study has first looked into the diversity of fishes in all streams of Alaknanda and Bhagirathi basins and then assessed the present condition of the quality of the habitat as well as their use by the fishes. It was found that there are two important rivers which are rain fed and relatively less disturbed such as Balganga (tributary of Bhagirathi) and Nayar (tributary of Ganga) have been observed as the important breeding grounds of mahseer and snow trout. Both these rivers are rain fed and water temperature always relatively warmer than other rivers in the basin. These environments might be conducive for mahseer and snow trout to spawn here. Moreover, species diversity also is relatively higher in these two rivers, therefore, this study has identified these two small rivers as the Important Aquatic Habitats in the basin, which should not be disturbed by any kind of developmental activities including HEP.

5.4.1 Critically important habitats for aquatic species within the Alaknanda and Bhagirathi basins

The following two areas represent the critical habitats for aquatic species:

I. Nayar –Ganges complex

Among all tributaries in the basin, the Nayar River was reported with highest number of 57 fish species. The Nayar River is the spring/rain fed tributary of the main Ganges adjoining the Alaknanda basin. Many cold water fishes including mahseer and snow trouts were observed breeding in this river at least twice in a year especially between March and August. Heterogeneity in the habitats, gradual sloping throughout the river, excellent growth of algae on the substratum provide better food sources for fish and other microbes in the river, eutrophic condition, etc make this river is more conducive for fishes to breed in the region. Therefore, this river has been identified as the critical fish habitat in these basins.

II. Balganga River – Tehri reservoir complex

An important tributary of Bhagirathi River with respect to fishes is Balganga River, which confluence with Bhilangna River and later join with Tehri Reservoir. This eutrophic Balganga River and Tehri Reservoir complex is reported with minimum of 40 species of fishes, highest in the Bhagirathi Basin. Balganga River is the only longest spring/rain fed tributary available in Bhagirathi basin. Many cold water fishes including snow trout and fragmented population of mahseer were observed to be breeding in this river. Heterogeneity in the habitats, gradual sloping throughout the river, excellent growth of algae on the substratum provide better food sources for fish and other microbes in the river. Moreover, relatively warm water and eutrophic condition of the river is more conducive for fishes to breed in this river. Therefore, this river has been identified as the critical fish habitat in these basins.

Fig. 5.24 Nayar River, a critical fish habitat in Uttarkhand.

Fig. 5.25 A view of Balganga River, another important breeding ground of fishes.

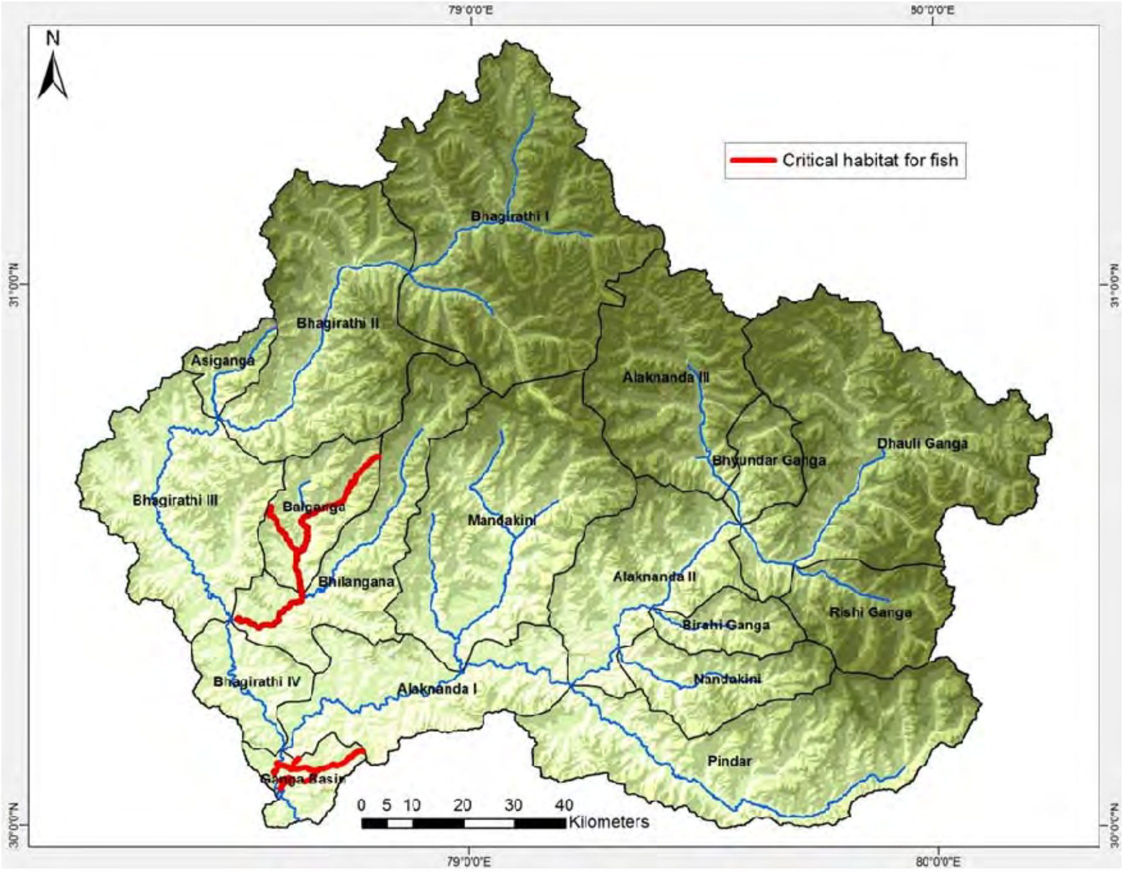


Fig. 5.26. Map showing the location of critically important fish habitats in Nayar River and Balganga and their tributaries.

5.4.2 Terrestrial components of conservation significance

Habitats of snow leopard, Himalayan brown bear, musk deer and cheer pheasant that fall in the altitude above 2500 msl are herewith considered as important biodiversity areas in the basin with respect to terrestrial fauna (Green, 1985; Sathyakumar, 1994, 2006; PSL, 2006; Sathyakumar and Sivakumar, 2007). Of these important biodiversity areas, certain part of landscape that connects existing wildlife protected areas in the basin are important wildlife corridors used by snow leopard and brown bear. Therefore, the potential corridor habitats of long ranging species such as snow leopard and Himalayan brown bear are considered as important biodiversity areas in the basin. Moreover, areas with high concentration of endemic and threatened plants were also taken into consideration while identifying important biodiversity areas in the basin.

Mammals and birds

Highly threatened species that require landscape level conservation plan such as snow leopard and Himalayan brown bear have been taken into consideration while identifying important biodiversity areas. Moreover, habitats of certain other threatened species such as musk deer and cheer pheasant have also been considered while finalizing the important habitats in the basin.

Snow leopard and himalayan brown bear

The Snow leopard and brown bear are distributed in the high altitudes of the Greater and Trans Himalayan regions of Uttarakhand State. Their major habitats fall within the Bhagirathi I, Mandakini, Alaknanda III, Bhyundar, Dhauli ganga, Rishi ganga, Pindar and Nandakini sub-basins of the Alaknanda and Bhagirathi Basins. Most importantly, the distribution of brown bear in India ends in Chamoli district. Both snow leopard and brown bear are solitary, elusive and shy large mammals. The snow leopard preys majorly on blue sheep, musk deer, tahr, serow, galliformes, rodents and domestic livestock whereas the brown bear depends on alpine vegetation, preys on domestic livestock and also occasionally scavenges dead wild animals for its food requirements.

The snow leopards occupy habitat types such as alpine scrub, meadows, moraines and open rocks/cliffs and comes down to valleys in subalpine or upper temperate regions to prey on domestic livestock or for movement between different areas in different seasons. As a large carnivore, the snow leopard requires large contiguous habitats for survival which includes habitats in corridors that connect, larger and more integrated habitats within protected areas such as Nanda Devi and Valley of Flower World Heritage Sites. These corridors outside PAs are also critical habitats to help it move along or across elevation gradients and for long term conservation of the species restricted to specific altitudinal ranges. As the brown bear shares its habitat with the snow leopard, their critical habitats also overlap.

Himalayan musk deer

The Himalayan musk deer is a small, shy, solitary forest ruminant that is distributed in isolated pockets all along the southern side of the Greater Himalaya between 2,500m and 4,500m. Within the Alaknanda and Bhagirathi Basins, it is reported to be present in Bhagirathi I, Mandakini, Alaknanda III, Bhyundar, Dhauli ganga, Rishi ganga, Pindar and Nandakini Sub-basins. It inhabits upper temperate forests, subalpine forests, alpine scrub, and meadows. Habitats such as interspersion of alpine scrub and meadows (*krumholtz*) and the vulnerable tree line are critical habitats for musk deer. It is a selective feeder that feeds on a variety of plants such as leaves of trees and shrubs, grasses, herbs, sedges, moss and lichen. During winter, some musk deer use sub-optimal habitats as low as 2,500m, but not habitats lower than this elevation range. Such sub-optimal habitats are also critical for this species.

Cheer pheasant

The Cheer pheasant is an endangered pheasant that inhabits subtropical and temperate habitats (1,500-3,000m) of the Greater Himalaya. It is a rare bird that inhabits open habitats with low tree cover, moderate scrub cover and high grass and rock cover. Habitats such as scattered tree and scrub with open grassy slopes including those that are along the river stretches are potential cheer habitats. In the Alaknanda and Bhagirathi Basins, cheer pheasant is reported to be present in Bhagirathi I, II, Asiganga, Bhilangana, Balganga, Mandakini, Alaknanda III, Bhyundar, Dhauli ganga, Rishi ganga, Birahi, Nandakini and Pindar Sub-basins. It is a very sensitive species that is highly vulnerable to habitat loss, degradation or disturbances. Most of the cheer habitats are already under threat due to over exploitation of resources by local communities, livestock grazing, and disturbances due to large-scale pilgrimage/tourism and development. They also form important prey for mammalian carnivores and raptors. They are threatened due to poaching for meat and habitat loss or degradation due to developmental projects and anthropogenic pressures. Therefore, the remaining stretches of cheer habitats are of very high significance and are required to be protected for long-term conservation of this species.

5.4.2.1 Critically important habitats for animals

The following areas have been identified as critical habitats for species of mammals and birds described above:

A) Areas of sub-basins overlapping with PAs

The Gangotri NP which is characterized by high ridges, deep gorges and precipitous cliffs, rocky craggy glaciers and narrow valleys falls within the Bhagirathi-I sub-basin (Fig. 5.27). This area is an ideal habitat for snow leopard, brown bear and musk deer. It holds good populations of blue sheep, the main prey of snow leopard. The Bhagirathi I sub-basin supports large alpine grasslands with more than 170 species of flowering plants which provide an excellent habitat for Himalayan brown bear and Himalayan musk deer.

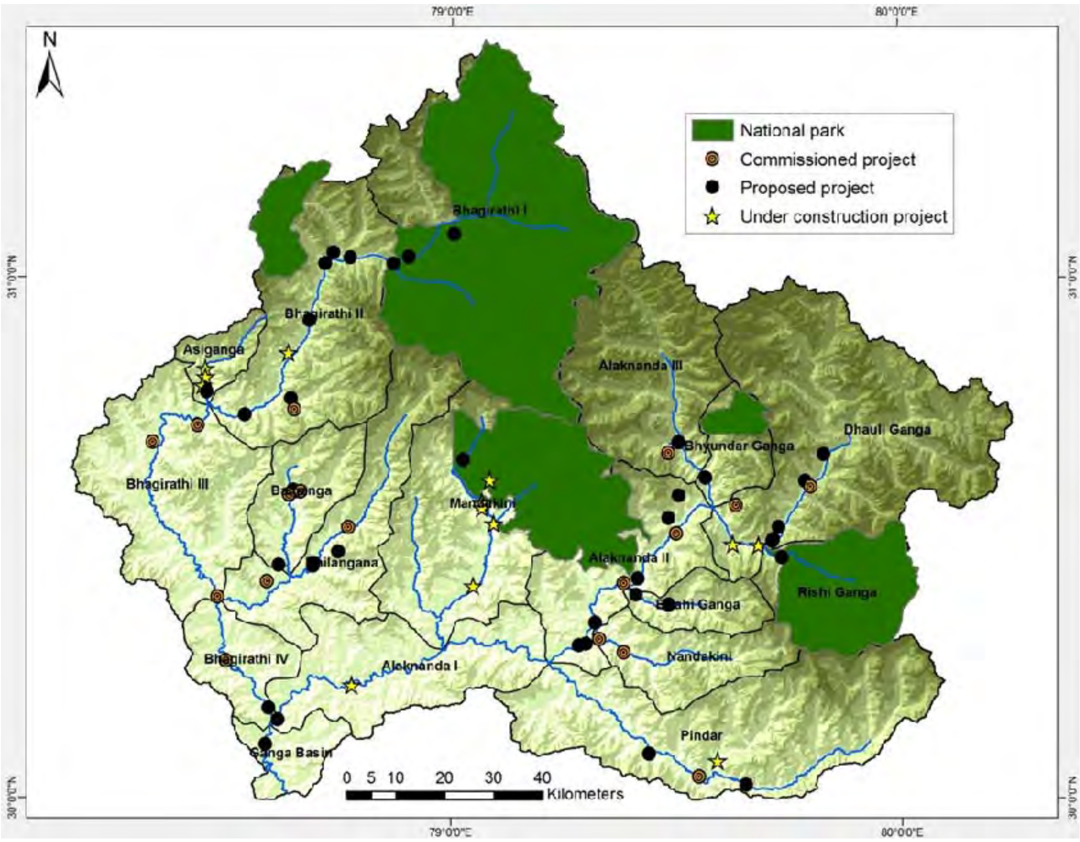


Fig 5.27 Map showing the location of PAs within the Alaknanda and Bhagirathi basins.

The upper reaches of the Kedarnath WLS within the Mandakini sub-basin is also recognised as a high biodiversity area. Area ranging between 2500-5000m within Kedarnath WLS is categorised as critical habitat for snow leopard, Himalayan brown bear and Himalayan musk deer. The Mandakini also constitutes the catchments of Kaliganga and Madhmeshwar rivers which form a major part of the critical habitat of snow leopard, Himalayan brown bear and Himalayan musk deer.

The entire Rishiganga sub-basin falls inside the Nanda Devi NP which is inscribed as UNESCO World Heritage Site for its exceptional beauty and high unique biodiversity. The habitat within the sub-basin is unique as it includes temperate and subalpine forest, alpine scrubs and steep slopes and cliffs, moraine, plateaus and marshes, all of which makes it a critical habitat for species like snow leopard, Himalayan brown bear and Himalayan musk deer. Within Nanda Devi Biosphere, also lies the Western Himalaya Endemic Bird Area, which include habitat of cheer pheasant.

B) Corridors connecting PAs (between 2500-4500 m)

Upper reaches of the Dhauliganga sub-basin mainly Mallari and Tamak form an extremely rugged, wind-swept and frost bitten cold desert habitat presenting a unique ecosystem. Snow leopard[1] and Himalayan brown bear are heavily reliant on such marginal habitats making these as critical habitats. Additionally, the brown bear's eastern most distribution ends in this region (**Fig 5.28**).

Some regions of the Alaknanda-III sub-basin also serve as corridors for snow leopard, brown bear and black bear, and are therefore functionally critical habitats for these species. This sub-basin connects the Kedarnath WS and Khiron Valley in the west to the Nanda Devi Biosphere Reserve. Narrow strips of land within Khiron valley are critical as movement corridors for these large mammals between their isolated habitats. In addition, Khiron valley is also a critical habitat for musk deer.

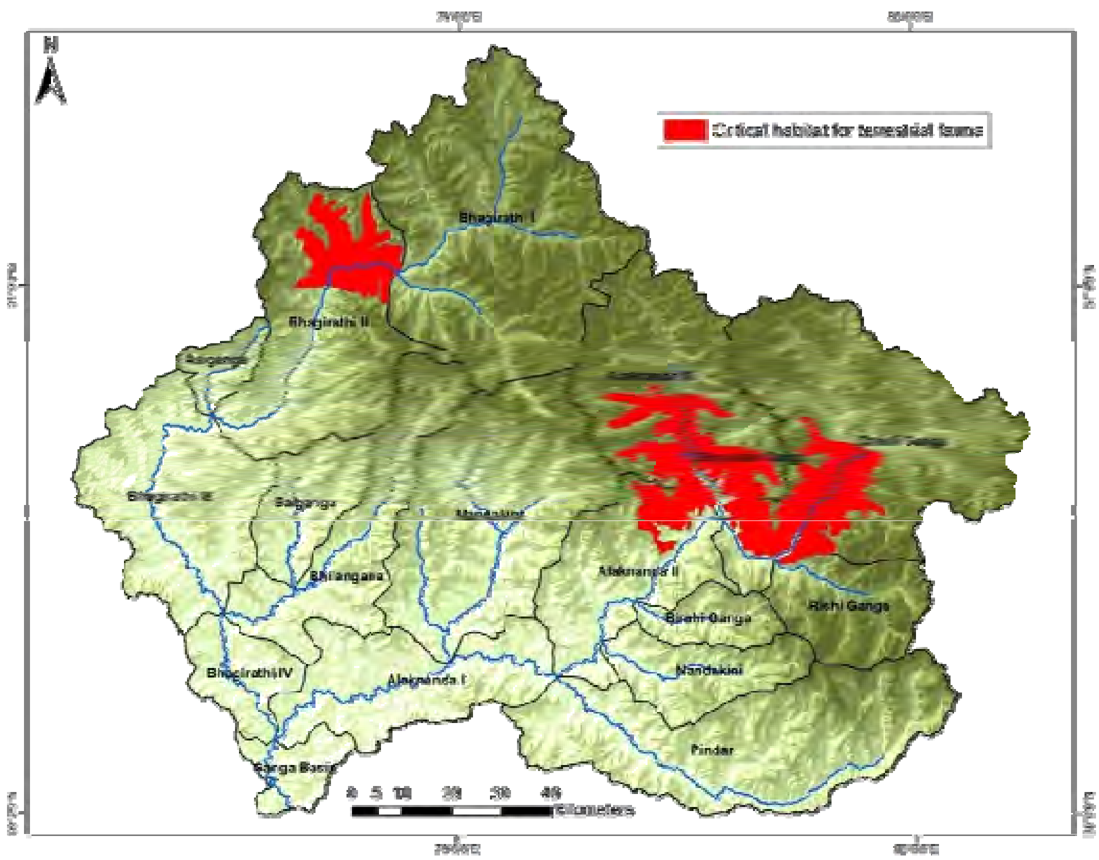


Fig. 5.28 Map showing habitats utilised by snow leopard and brown bear for movement within the altitudinal ranges in Alaknanda and Bhagirathi basins.

5.4.2.2 Critically important habitats of plants

Based on the primary and secondary information, following inferences on critical habitats (**Fig. 5.29**) for floral species can be drawn:

Bhyundarganga, Dhauliganga, Bhagirathi, Rishiganga, and Mandakini sub-basins are the most important areas for conservation of overall floral diversity, endemic and RET species. In some basins, the project zones of influence are important localities of RET and endemic species. As *Catamixis baccharoides* is endemic to Uttarakhand and has a few populations in Shivaliks, and a few individuals close to Kotlibhel II, the ZoI of Kotlibhel II these areas are a critical habitat for this species. Similarly, *Berberis osmastonii* is also endemic to Uttarakhand – having one of the populations in the ZoI of Melkhet Hydro Electric Project. *Caragana sukiensis* is Near Endemic with one population found area between ZoI of Pala maneri and Bharonghati HEPs in Bhagirathi II sub-basin. Thus, the zones of influence of different projects supporting habitats for all the three species are critical for long term conservation of these species in the two basins.

Although, some of the RET species and their critical habitats are protected in the PAs within the two basins, the critical habitats for species such as *Anemone raui* Goel & Bhattach, *Trachyspermum falconeri* (Clarke) H. Wolff *Trachyspermum falconeri* (Clarke) H. Wolff, *Arenaria curvifolia* Majumdar, *Arenaria ferruginea* Duthie ex F. Williams, *Calamogrostis garhwalensis*, *Viola kunawarensis* Royle, *Ranunculus uttaranchalensis* Pusalkar & Singh, *Silene gangotriana* Pusalkar et al., *Microschoenus duthiei* Clarke and *Caragana sukiensis* Nakao need to be protected. These habitats occupy some parts of Dhauliganga, Bhilangana and Bhagirathi I sub-basins.

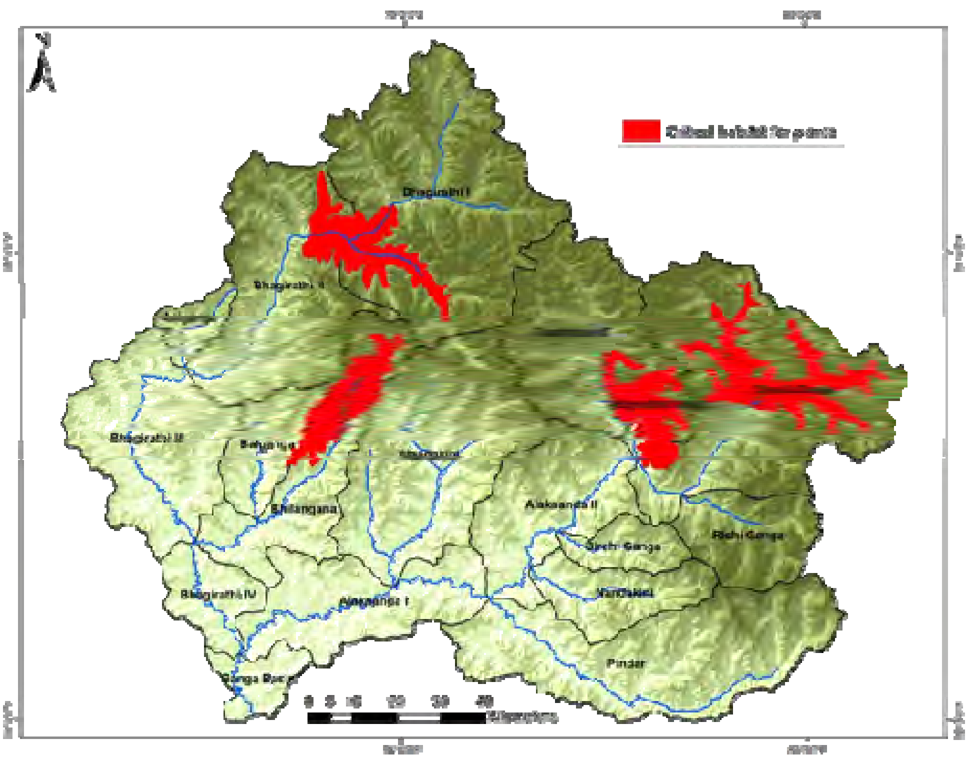


Fig. 5.29 Map showing critically important habitats identified for plants within the Alaknanda and Bhagirathi basins.

It is amply evident (**Fig. 5.30**) that there is a significant overlap in the spatial expanse of the critically important habitats of all valued components of terrestrial and aquatic biodiversity with locations of existing and proposed Hydro Electric Projects in Alaknanda and Bhagirathi Basins

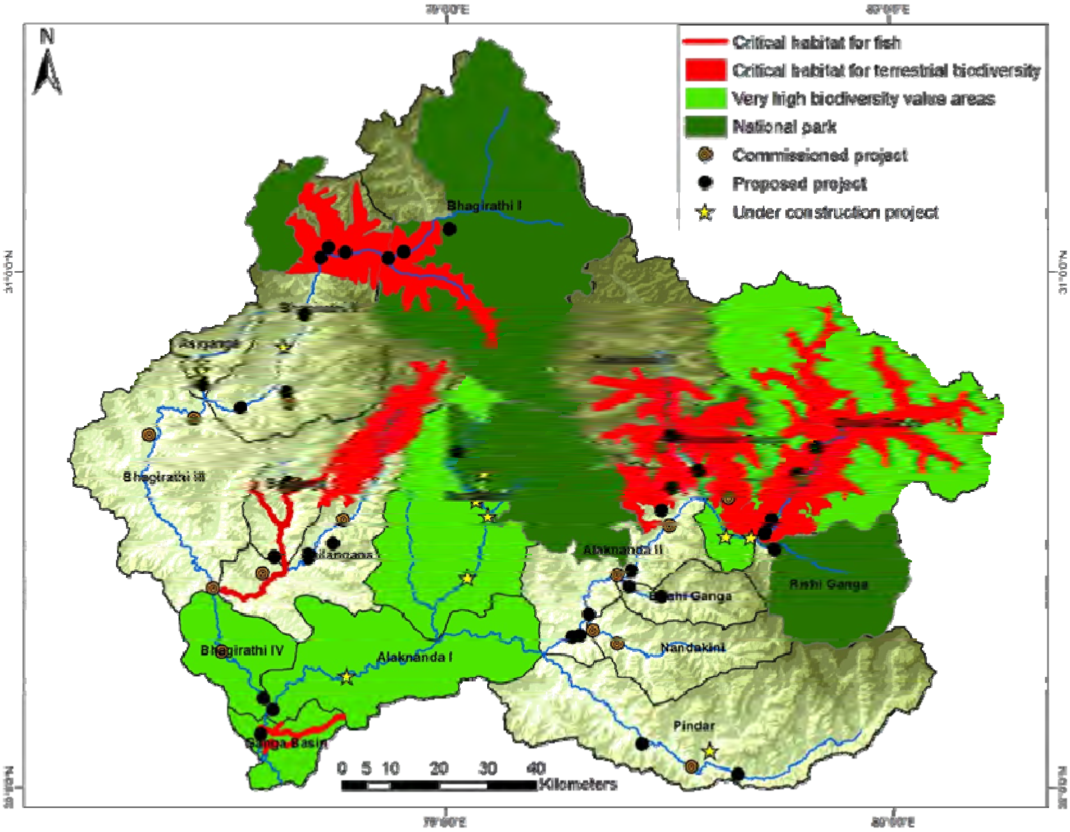


Fig. 5.30 Critically important habitats of valued biodiversity components significantly overlap with locations of Hydro Electric Projects in the Alaknanda and Bhagirathi basins.

Chapter 6 – Impact Prediction and Evaluation

6.1 Introduction

The benefits of energy planning are often more immediate, important and obvious to society to satisfy many of the priority needs and reap economic benefits. The benefits of biodiversity conservation are often less evident and immediate, but are nonetheless important as biodiversity values continue to decline and threats associated with this loss to human well-being become ever-increasing.

This section of the report is aimed at underlining the existing cumulative and potential impacts on biodiversity values of 70 Hydro Electric Projects that are under different stages of implementation in Alaknanda and Bhagirathi basins.

This assessment takes into consideration the existing biodiversity values of the basins/sub-basins, identifies development trends and predicts the cumulative impacts of these developments on the specific ecosystems and their biodiversity values. These impacts would represent the aggregate footprint of all existing and proposed Hydro Electric Projects spatially concentrated within 18 sub-basins in the two major basins. Such an evaluation should not only enable the understanding of incremental and interactive impacts on biodiversity values of the sub-basins but should also aid in the evaluation of the environmental soundness of the energy plan based on all 'commissioned', 'under construction' and 'proposed' projects.

This Cumulative Environmental Impact Assessment (CEIA) is intended to assist in defining the range of impact significance (very high, high, medium and low) associated with Hydro Electric Projects to aid in presenting the 'acceptable trade-offs'. This is needed for selecting the optimum combination of projects and sites for the greater benefit with least impact and for facilitating the preparation of the basin level energy development strategy for the State of Uttarakhand.

As the framework for predicting the cumulative environmental assessment involves the recognition of valued components of environment that are likely to be the receptors of impacts from different sources, this assessment takes into account the baseline information to identify the valued ecological/ biological components considered in this CEIA.

6.1.1 Valued environmental/ecological components of the Alaknanda and Bhagirathi basins

This assessment is premised on evaluation of the significance of the impacts of hydropower development in the two basins. The significance of the impacts has been perceived based on the threats/risks to valued biodiversity components (species and habitats).

Table 6.1 Conservation importance of ecosystems/taxonomic groups included in the study.

Ecosystems/ Taxonomic Group	Conservation importance			Habitats					
Aquatic	RET	Endemic	IWPA	Species specific habitats	Breeding/ congregation sites	Migratory sites	Movement corridors	Critical habitats	Protected areas
Fishes	√	√	X	√	√	√	√	√	X
Aquatic mammal (Otters)	√	X	√	?	?	X	X	?	X
Terrestrial Mammals	√	X	√	√	√	√	√	√	√
Pheasant (Cheer Pheasant)	√	X	√	√	√	√	√	√	√
Plant species	√	√	√	√	√	X	X	√	√

√ - Yes; X – No; ? – *Unknown*

6.2 Perceived environmental dimensions of 'good and bad' projects

All Hydro Electric Projects are not alike from the environmental standpoint (WCD,2000; Ledec and Quintro 2003) . These have been typified as 'good' and 'bad' projects first primarily on the basis of the type of a structure (impoundments, pumped storage and run of the river schemes). The qualifiers for bad dams include (a) a large reservoir surface area; (b) larger areas of natural habitats under flooding and consequent loss of wildlife; (c) a large river with much aquatic biodiversity damaged; (d) a relatively shallow reservoir (sometimes with a fairly short useful life); (e) few or no downriver tributaries; (f) water quality problems due to the decay of submerged forests; (g) location in the lowland tropics or subtropics, conducive to the spread of vector-borne diseases; and (h) serious problems with floating aquatic weeds.

On the contrary, an environmentally benign dam is typified by (a) a relatively small reservoir surface area (often in a narrow gorge with a high head and even a tunnel); (b) little loss of natural habitats and wildlife; (c) a relatively small (often highland) river with little aquatic biodiversity at risk; (d) a deep reservoir which silts up very slowly; (e) many downriver tributaries; (f) little or no flooding of forests; (g) no tropical diseases (often due to high elevations or temperate latitudes); and (h) no aquatic weed problems (i) and low number or no oustees. Generalizing from these findings, a useful rule of thumb is that usually the most environmentally benign hydroelectric dam sites are on upper tributaries, while the most problematic ones are on the large main stems of rivers.

6.3 Ecological consequences of Hydro Electric Projects in Alaknanda and Bhagirathi basins

Given the above backdrop of generic impacts of hydropower generation and the context of developments in the energy sector in Uttarakhand, it is seemingly easy to visualize both from the location of existing and proposed Hydro Electric Projects planned in various sub-basins of Alaknanda and Bhagirathi and from the technical profile of such projects, that they are likely to deliver a mixed bag of consequence for State's economy and prospects of biodiversity conservation.

An attempt is made here to first assess the significance of the potential impacts of the hydropower development projects on aquatic and terrestrial biodiversity at the sub-basin level in the two basins.

The biodiversity values and the ratings for impact potential were combined to give a score reflecting the relative significance/importance of cumulative impacts on each of the sub-basins. These assessments of impacts were separately undertaken for aquatic and terrestrial biodiversity.

6.3.1 Prediction of impacts on aquatic ecology and fish diversity at the sub-basin levels

6.3.1.1 Habitat loss

Changes in flow volume and patterns can adversely impact the structure, distribution and composition of fish communities in the region (Emy et al, 2003). Of the 1121 km long stretch of rivers that flow in the entire Alaknanda and Bhagirathi basins, a minimum of 526.8 km long river stretch is expected to be affected, if all proposed HEP are implemented. This is 47% of total river stretche in the entire basin. Therefore, significant area of the fish habitat would either be modified or lost due to proposed hydro projects in the basin. Out of 76 species of fish reported in the entire basin, a total of 66 species have been reported from the areas which would potentially be affected by the hydro projects. That is about 87% of fish species would be affected, if all proposed hydro projects get implemented in the basin.

Among 18 sub-basins in the region, the most affected sub-basins with respect to fish habitat modification would be Bhagirathi II, III and IV (71%*), Bhirai ganga (74%*), Alaknanda I & II (48%*), Mandakini (44%*), Balganga (40%*) and Nandakini (35%*). Although, fish was not found in Dhauliganga but 94% of stretch of this river would be affected that would have adverse impacts on the downstream fishes in the main Alaknanda River. Alaknanda I and Ganges sub-basins are known to be potential habitats of otter although there was no direct evidence found here during this study. The decline in fish abundance due to HEPs in these basins is likely to affect otters where they exists.

*Data based on report by AHEC IIT Roorkee, 2011

6.3.1.2 Barrier effect

Dam or any construction across rivers is always a barrier for fish which move from one part of stream/ river to another as part of its life cycle processes. These structures are always detrimental to the survival of fishes especially on migrants which use different habitats for different life history requirements. There are a minimum of 17 species of migrant fishes (either long distance or local migrants) found in the Alaknanda and Bhagirathi basins, which include three species of mahseer that are long distance migrants. Mahseer migrate from main river to smaller streams for spawning, or downstream of river to upstream for the same. Any obstacle such as dam/barrage across river will break this normal migratory behaviour which would ultimately affect the breeding cycle. Therefore, there would be decline in population that has already been observed due to Tehri Dam, which has prevented migration of mahseer upstream. Based on literature and observations made in various studies, it has been established that there has been a decline in the populations of mahseer in the upstream of Bhagirathi River due to barrier effect caused by Tehri Dam (Sharma 2003).

Fish passes are often believed to be an engineering mitigation measure for reducing impacts on fish, especially migrants. In general, the efficiency of fish passes is considered low and fish migrations are severely affected (World Commission on Dams, 2000). Even where fish passes have been installed successfully, migrations can be delayed by the absence of better navigational cues, such as strong currents etc. In the salmon (known for anadromous migration) countries the fish passes have been observed to be inefficient, if the dam height is more than 16 m. Compared to salmon, mahseer and snow trouts are poor jumpers/climbers. Based on the study is was observed that snow trout jumping upto 1.5 m height and mahseer upto 2.0 m height above the water surface. If larger volume of water flows down, these fishes may move further upstream using flowing water column as a support. However, the efficiency of fish pass in Himalayan Rivers would be highly doubtful if the dam height is more than 16 m. No comprehensive study has been carried out on the basis of which better fish passes for Himalayan fishes can be prescribed. It is reported that upward movement of *Schizothorax* has been successfully facilitated at Uri HEP (dam height is 43 m) through fish pass. This needs to be however verified by a professional tracking system. Fish lift that may work better in facilitating movements of fish in the Himalayan rivers needs to be designed and monitored.

Any kind of *ex-situ* conservation programme (as an alternate conservation strategy) to artificially restock (through ranching) the fish populations of species that would be threatened due to dams or any other kinds of barrier construction across rivers or streams may not fully compensate the natural breeding phenomenon of migration. Moreover, species that are non-migratory and less significant to fisheries are largely ignored in the *ex-situ* (fish ranching) conservation programme. Migratory fishes in the region would be therefore affected adversely due to HEPs. As per the barrier effect, all sub-basins falling in the fish zone will be impacted. However, HEPs in the downstream sub-basins would be impacted more in respect to migratory fishes.

6.3.1.3 Changes in sedimentation flows

Changes in the sedimentation flows due to dam/barrier construction especially in Himalayan rivers are expected to have an adverse impact on fish habitats. Most of the fishes in the Alaknanda and Bhagirathi Rivers prefer substratum that are pebble, cobble, boulders, gravel, sand and occasionally loamy soil. These substratums are common in most stretches. These substratums were also observed to be ideal grounds for foraging and spawning of snow-trouts and many more Himalayan fishes. However, due to dam construction there would be changes in the sedimentation flow. Sediments would be accumulated in the upstream of dam upto the tail end of submersible zone even though there is a provision of silt channel to remove the silt from the upstream of dam.

Submersible zones of Hydro power projects of existing, under construction or proposed dams vary from project to project. In some cases, the submersible stretch of river is more than 5 km. Even a few centimeters of sediment layer over the natural substrata is enough to effect the foraging and spawning fishes negatively. In this context, it is expected that submersible zones of HEPs would be unsuitable for several fishes especially snow trouts and Himalayan loaches. The HEPs with longer stretch of submersible zone but without proper silt removal plan would be therefore detrimental to populations of several Himalayan fishes such as snow trouts and Himalayan loaches.

Sub-basins such as Bhagirathi III & IV, Bhilanganga, Alaknanda I, Pindar and Mandakini would be affected mostly due to changes in the sedimentation flow. A minimum 162 km long fish habitat would be modified due to precipitation of sediments on their substratum.

6.3.1.4 Changes in environmental flows

It is increasingly recognized that the distribution and abundance of riverine species are limited by the effects of flow regulation (Sivakumar & Choudhury, 2008, Sivakumar, 2008 and Sarkar et al., 2011). A strong correlation exists between stream flow and a river's physico-chemical characteristics such as water temperature and habitat diversity. Research on the distributional ecology of fishes suggests that fish assemblages form in response to the physio-chemical factors of the environment. Change in the assemblage structure of stream fishes or species composition is imposed by temporal variation in stream flow, which ultimately affects the entire biodiversity of the river ecosystem. However, ever increasing human population requires water for drinking, agriculture etc, which affects the river health. Therefore, it becomes necessary to estimate the Minimum Environmental Water Flow and Minimum Environmental Water Level for rivers with reference to their biodiversity and the hydrological regimes.

Three kinds of adverse impacts on the aquatic biodiversity are expected because of changes in the natural flow due to HEPs in the Alaknanda and Bhagirathi Basin: (a) Stagnated water in the submersible zones of HEPs which are not conducive for torrent hill stream/river fishes such as snow trouts and Himalayan loaches, (b) Less or no water flow in the dry zones of HEPs which is also expected to adversely affect the aquatic biodiversity but it may be mitigated by maintaining minimum environment flow and (c) changes in the natural flow may also fail to provide the natural environmental cues to the aquatic biodiversity to breed or maintain annual life histories, but this can again be mitigated by following minimum environmental flows even though it would help partially to maintain the current status of aquatic ecosystem and its biodiversity (see Chapter 7).

Of the 1121 km long stretch of river that flows in the entire Alaknanda-Bhagirathi basin, a minimum of 526.8 km long river stretch is expected to be affected due to changes in the flows, if all HEP projects are implemented. This is 47% of total rivers stretches of the entire basin. Therefore, significant area of the fish habitat would either be modified or lost due to proposed hydro projects in the basin. A total of 364 km long stretch of river in the basin (32% of total river stretch) would get dry, if minimum flows are not recommended.

Among 18 sub-basins in the region, the most affected sub-basins with respect to flow modification would be Dhauliganga, Asiganga, Balganga, Birahi ganga, Mandakini, Alaknanda. As far Otter is concerned, sub-basin Alaknanda I and Ganges are potential habitat of Otter, although their presence was not reported during this study. Changes in the flow may not directly affect the habitat of Otter but it would affect their prey abundance.

6.3.1.5 Changes in nutrient flow

Although majority of proposed HEPs are run-of-river projects 15 HEPs, which would have dam, would stop the nutrient flow either for longer or for a shorter period depending upon presence of dam or barrage. As per the IIT-Roorkee report, minimum 162.6 km long river stretch in the entire basin would be submerged due to various HEPs. These submerged rivers would act as nutrient traps. Changes in the nutrient flow would adversely affect the downstream fishes and other aquatic biodiversity. Moreover, few species may get benefitted due to reservoir water, which would again affect the fish composition in the region. Nutrient availability is the major environment factor that determine the fish species composition in Himalayan rivers (Sivakumar 2008). Therefore, any changes in the nutrient flow would affect the overall composition of the fish community.

Sub-basins such as Bhagirathi III & IV, Bhilanganga, Alaknanda I, Pindar and Mandakini would be affected most due to changes in the nutrient flow. A reservoir like situation would be created in these sub-basins due to HEPs. Although these habitats may be useful for promoting fisheries but they would be detrimental to the native fish diversity in the region.

Dams are environmentally less objectionable if they affect rivers with a naturally low diversity and endemism of native fish species. River segments with threatened fish species and critical habitats found nowhere else in the basin should be protected from dams or other potentially damaging civil works.

6.3.2 Prediction of impacts on terrestrial fauna and flora at the sub-basin levels

6.3.2.1 Habitat loss

Habitat loss to terrestrial wildlife species are largely due to developmental projects where in original habitats are completely replaced with land unlike the original. In case of HEPs, the habitat loss is in the form of forest land take for the project infrastructure and areas submerged under water in the reservoir. Of the 70 HEPs, 17 are commissioned projects which have resulted in the total loss of about 7126.46 ha of land that includes 2705.04 ha as forest land take and 4421.42 ha under submergence. Similarly, the 14 HEPs that are under construction have resulted in the total loss of about 539.59 ha of land that includes 442.36 ha as forest land take and 97.23 ha under submergence. The remaining 39 HEPs that have been proposed would result in an additional loss of about 1828.64 ha of land that includes 467.86 ha as forest land take and 1360.78 ha under submergence.

Of the 39 HEPs that have been proposed, 16 would lead to loss of forest land either for land intake or will be under submergence. Of the 16 HEPs, seven are located in areas that are >2.500m which are wildlife habitats for many RET species and also includes critically important areas for these species. These seven HEPs that have been proposed would result in a loss of about 172.48 ha of land that includes 146.34 ha as forest land take and 26.14 ha under submergence. These habitats are extremely important for RET species such as the snow leopard, common leopard, brown bear, black bear, musk deer, cheer and Himalayan monal. The remaining nine HEPs are located in areas that are <2,500m but would result in habitat loss for RET species such as common leopard, Asiatic black bear, cheer and Indian Peafowl.

6.3.2.2 Habitat degradation and disturbances due to HEPs

Pilang valley and Dayara bhugyal in Bhagirathi II sub-basin have been identified as the key sites for long-term conservation of Galliformes, including a number of RET species. Therefore, proposed development projects (Pilangad II and Siyangad) on the side streams would severely impair the biodiversity values of these areas.

The ZoI of the proposed Rambara and that of projects already under advanced stages of construction (Madmaheswar, Kali ganga I and Kali ganga II) fall in the critically important habitats of snow leopard, brown bear, black bear and musk deer. These HEPs would directly as well as indirectly impact upon the remnant wildlife habitats and consequently the species, particularly the snow leopard, brown bear and musk deer.

The Dhauli ganga sub-basin encompasses critical habitats and corridors for large mammals such as snow leopard, brown bear and Tibetan wolf. ZoI of the proposed HEPs (Tamak-Lata, Malari-Jelam, and Jelam-Tamak) fall in these critically important habitats. Considering that snow leopard and brown bear are very rare with a restricted distribution in Uttarakhand State and the eastern most distribution limits of brown bear ends in this region, hydropower development in these basins will significantly alter the habitats of these species of very high conservation importance.

Bhilangana and Balganga sub-basins form the eastern most distribution limits for western tragopan in India, which is a species with restricted distribution. The ZoI of proposed HEPs (Bhilangana II, A, B & C) in Bhilangana basin and the proposed HEPs (Balganga-II and Jhala koti) in Balganga sub-basin and their associated activities would impact the western tragopan by reducing its distribution range. There are two existing projects in this Bhilangana sub-basin which together with several proposed projects will cumulatively impact upon the western tragopan habitat within the sub-basin. Similarly, Cheer pheasant, which has already become confined to isolated pockets in this region would further become restricted due to likely habitat losses associated with HEPs in this basin.

In the Alaknanda-II sub-basin, the ZoI of the proposed Bowla Nandprayag, and Nandprayag Langasun HEPs and that of Vishnugad-Pipalkoti HEP which is under-construction fall within the distribution range of Cheer pheasant that has restricted distribution in the State and overlaps with the habitats of leopard, black bear and tahr which are species that command high conservation priority globally. The proposed HEP Urgam-II would severely impair the biodiversity values of the Urgam valley, which is one of the key sites for long-term conservation of ungulates species.

Although much of the Pindar sub-basin is relatively well protected and attracts trekkers for its scenic beauty and wilderness areas, the Devsari proposed project may have an important bearing on the distribution range of common leopard and black bear falling within the ZoI of Devasari project.

The two proposed HEPs i.e., Rishi ganga I and Rishi ganga II are both located in the areas with high biodiversity including critically important wildlife habitats for RET species. These areas are also recognised for theirinside '*Outstanding Universal Values*' by UNESCO and hence listed as "World Heritage Site' (Appendix 6.1).

The ZoI of the proposed HEPs (Alaknanda and Khirao ganga) in Alaknanda -III Sub-basin would fall within the critically important habitats of large mammals such as snow leopard, brown bear and black bear. These proposed HEPs and their associated disturbances is likely to impact the movement of snow leopard, brown bear, black bear and also the critically important habitats of musk deer, Himalayan tahr and monal pheasant. This sub-basin connects the Kedarnath Wildlife Sanctuary and Khirao Valley in the west to the Nanda Devi Biosphere Reserve Hydropower developments in this sub-basin would have irreversible impacts on biodiversity values of this basin.

The proposed HEPs (Jadganaga and Karmoli) in Bhagirathi sub-basin and their associated disturbances are likely to cause severe degradation of habitats for snow leopard and Himalayan brown bear and may also adversely impact the movement of snow leopard, brown bear and black bear.

Bhyundar sub-basin contains the most important and significant natural habitats for *in situ* conservation of biological diversity. Any developmental project in this sub-basin would adversely impact the critical habitats, and may also impact the 'Outstanding Universal Value' of this sub-basin (Refer Appendix 6.1)

6.4 Scenario assessment

In view of the various impacts on many of the candidate biodiversity receptors commanding high conservation priority, many Hydro Electric Projects should be reviewed, as developing them would cause unacceptably high environmental damage, whereas in other situations, assessment of thresholds of development are needed for arriving at permissible limits of developments based on exclusion approach applied to proposed projects.

An important tradeoff between conservation benefits and economic objectives in hydropower planning in the two basins can emerge by either choosing to allow (i) projects come in areas with relatively low biodiversity values or (ii) projects that have low impact potential. Selecting both the options would be perfect for achieving a winning ground from biodiversity conservation standpoint but this may be unacceptable from the perspectives of economic progress and societal benefits.

An approach is required to provide the decision maker with choices to consider the option of exclusion or inclusion of specific projects, based on assessment of values that may be jeopardized in the event of proceeding with different scenarios of hydropower generation. The development of scenarios that investigate the impacts of the proposed developments, with and without various combinations of Hydro Electric Projects with different potentials of impacts can be a useful planning approach to arrive at thresholds for sustainable energy development options.

Scenario planning is becoming increasingly useful in studies of environmental change, natural resource management and development to understand dynamic vulnerabilities and explore alternative, long-term, policy responses (Gallopin et al. 1997, Wollenberg et al. 2000, Peterson et al. 2003, Swart et al. 2004, Millennium Ecosystem Assessment 2005). Recent literature (Greig et al., 2004; Duinker and Greig, 2007) suggests that scenario-based approaches are most appropriate in cumulative effects assessments (CEAs) as they are 'futuring' approaches to improve the information and advice they can bring to decision-makers.

Although scenarios may refer to informal imaginative exercise, a visioning game or conjectures about what might happen in the future (Cornish 2004), they provide a variety of approaches to deliver well-grounded options for future by reviewing alternative possibilities and can be an important tool for planning and policy.

In the cumulative effects context of hydropower development in Alaknanda and Bhagirathi basins, the scenario exercise has focused on exploring various trajectories of change that may lead to a broadening range of plausible alternatives for securing and safeguarding priority biodiversity values. The steps included:

I. Evaluating the cumulative impact significance of all projects including those that are commissioned, are under different stages of construction and those are proposed through projected change in the overall biodiversity value of the two basins.

II. Presenting the exclusive impacts of commissioned projects influencing the true baseline biodiversity value of the basins. This provides a starting point for reviewing impacts of projects under different stages. This scenario essentially conveys the message that the decline in biodiversity value has already occurred in some sub-basins on account of the commissioned projects as is reflected in the relatively lower overall biodiversity ranking of those sub-basins.

III. Assessing the combined impacts of all commissioned projects and those under construction on biodiversity values.

IV. Presenting a scenario for projecting the alternatives to lower at the sub-basin levels for aquatic and terrestrial receptors by applying exclusion approach targeting only the proposed projects.

V. Presenting alternative scenario to address the significant impacts on aquatic and terrestrial biodiversity species and their critically important habitats by exclusion approach.

Table 6.2 Interaction matrix for Scenario Ia.

Name of sub-basin	Impact potential based on project profile*	Aquatic biodiversity value	Impacts significance
Bhagirathi I	M	M	M
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	H	VH
Bhagirathi IV	H	VH	VH
Bhilangana	M	H	M
Balganga	M	H	M
Alaknanda I	M	VH	H
Mandakini	M	H	M
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	H	H	H
Rishi ganga	M	M	M
Dhauli ganga	H	M	M
Bhyundar ganga	L	L	L
Alaknanda III	M	M	M
Ganga Basin	H	VH	VH

Refer to Appendix 6.2 for detailed information on impact potential

6.4.1 *Scenario assessment for aquatic biodiversity*

Scenario Ia- Cumulative impacts of all projects

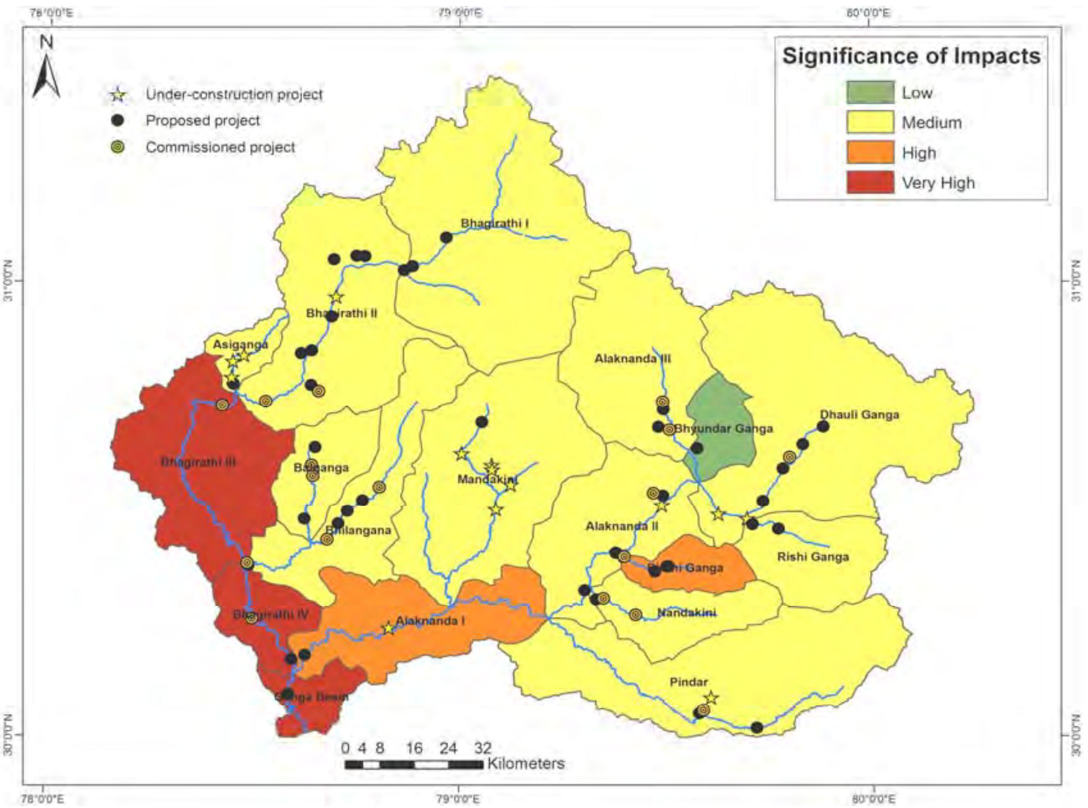


Fig. 6.1 Predicted significance of impacts of all projects on aquatic biodiversity values.

This scenario indicates relative ranking of impact significance on biodiversity in the two basins taking into consideration the biodiversity values of the sub-basins and the impact potential of all projects planned in the basins. The scenario clearly outlines that most of the areas in the sub-basin will be affected with varying levels of impacts if the current hydropower plan is implemented. In the two basins, 5 sub-basins will be adversely impacted by Hydro Electric Projects. Among these sub-basins, Bhagirathi III, Bhagirathi IV and Ganga sub-basin will be the most impacted as represented by the red shade in Fig. 6.2. The aquatic biodiversity values of Bhagirathi III sub-basin have already been compromised due to the construction and operation of two projects namely Tehri HEP and Maneri Bhali II HEP. Tehri HEP, being a reservoir based project which has a huge area under submergence has impacted the biodiversity values both in terms of quality of habitat and the spatial loss.

The aquatic biodiversity values of Bhagirathi IV sub-basin are being negatively influenced by the existing Koteshwar HEP and would be further compounded in the event of the operation of Kotlibhel IA HEP.

The proposed Kotlibhel II HEP in the Ganga sub-basin would cause irreversible damage to the aquatic species and its habitats including Nayar River, which is the only available undisturbed habitat for several threatened fishes, especially mahseer and snow trout in the Garhwal Himalaya

High significance of impact indicated in Alaknanda I sub-basin is predicted considering that the migration of species such as mahaseer and snow trout would be impaired by the Kotlibhel IB proposed project. Similarly, the Birahi ganga sub-basin would receive significant impacts from four projects that includes one commissioned (Birahi ganga) and 3 proposed (Birahi ganga I, Birahi ganga II and Gohana Tal) projects.

Table 6.3 Interaction matrix for Scenario 2a.

Name of sub-basin	Impact potential based on project profile*	Aquatic biodiversity value	Impacts significance
Bhagirathi I	L	M	L
Bhagirathi II	L	H	L
Asiganga	L	H	L
Bhagirathi III	VH	H	VH
Bhagirathi IV	M	VH	H
Bhilangana	L	H	L
Balganga	L	H	L
Alaknanda I	L	VH	L
Mandakini	L	H	L
Alaknanda II	L	H	L
Pindar	L	H	L
Nandakini	M	H	M
Birahi ganga	L	H	L
Rishi ganga	L	M	L
Dhauli ganga	L	M	L
Bhyundar ganga	L	L	L
Alaknanda III	M	M	M
Ganga Basin	L	VH	L

**Refer to Appendix 6.2 for detailed information on impact potential*

Scenario 2a – Exclusive impacts of commissioned projects

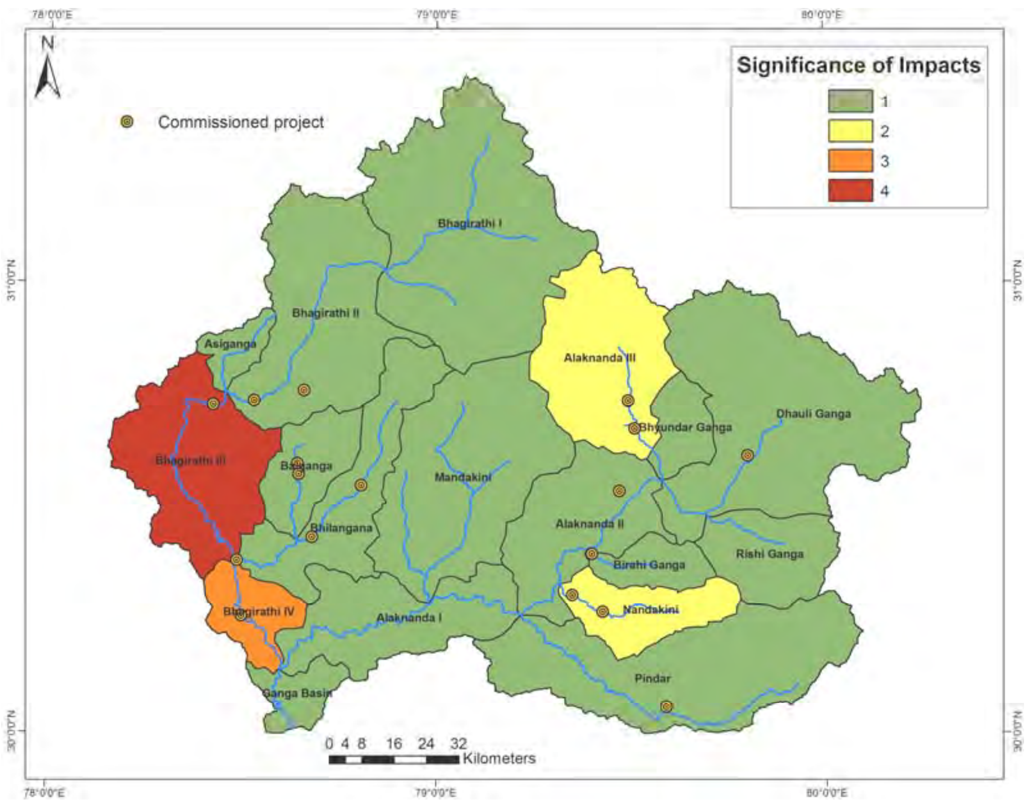


Fig. 6.2 Predicted significance of impacts of commissioned projects on aquatic values.

This scenario portrays the impacts of all the 17 commissioned projects on the aquatic biodiversity values of the two basins. It becomes evident that the impacts of already commissioned projects are spatially concentrated in the two sub-basins as a result of which very high and high significance of impacts (shown in shades of red and orange) are received by Bhagirathi II and Bhagirathi IV sub-basins. These impacts are largely significant owing to large footprints of Tehri HEP and Koteshwar HEP respectively. Careful review of scenarios 1 and 2 clearly demonstrate that all projects under progress and those proposed and widely spread across all sub-basins would have greater impact of reducing biodiversity values as can be seen from the transformation (refer green areas in scenario 2 and yellow areas in scenario 1).

Table 6.4 Interaction matrix for Scenario 3a.

Name of sub-basin	Impact potential based on project profile*	Aquatic biodiversity value	Impacts significance
Bhagirathi I	L	M	L
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	H	VH
Bhagirathi IV	M	VH	H
Bhilangana	L	H	L
Balganga	L	H	L
Alaknanda I	L	VH	L
Mandakini	M	H	M
Alaknanda II	M	H	M
Pindar	L	H	L
Nandakini	M	H	M
Birahi ganga	L	H	L
Rishi ganga	L	M	L
Dhauli ganga	M	M	M
Bhyundar ganga	L	L	L
Alaknanda III	M	M	M
Ganga Basin	L	VH	L

**Refer to Appendix 6.2 for detailed information on impact potential*

Scenario 3a – Combined impacts of all commissioned projects and projects under-construction

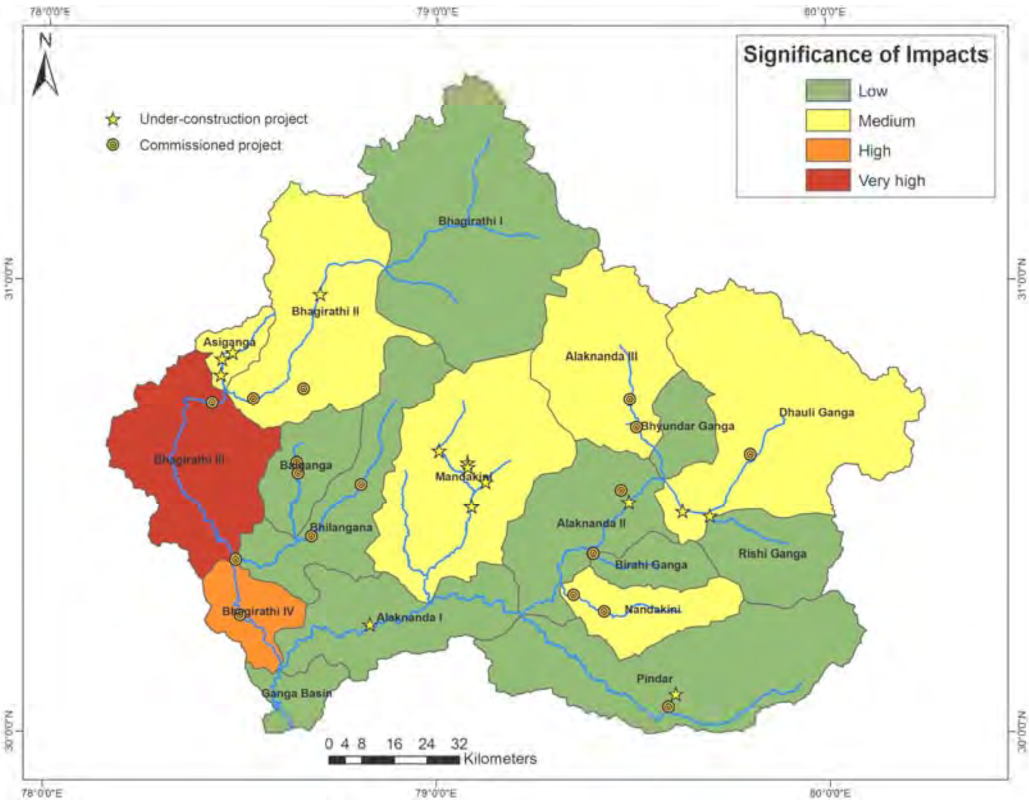


Fig. 6.3 Predicted significance of impacts of commissioned projects and those under construction on aquatic values.

A comparative review of the scenario 1a (which include all projects) with this scenario (which includes only commissioned and projects under-construction) allows visualizing the contribution of all proposed projects in altering the aquatic biodiversity values of the two basins. This scenario provide a useful insight by visioning the future of hydropower development to ensure reduction in impacst by exercising choices of regulated develoments. It allows a starting point for forward thinking on planning actions to promote the projects that are least impacting and to contain the development proposals that are most impacting on aquatic biodiversity values of the sub-basins.

In this present scenario, exclusion of proposed projects in Bhagirathi I, Bal ganga, Bhilangana, Ganga, Alaknanda I, Alaknanda II, Bhyundar ganga, Birahi ganga, Rishi ganga and Pindar sub-basin would be effective in lowering the intensity of impacts on aquatic biodiversity values as compared to the rest of the sub-basins within the two basins.

Table 6.5 Interaction matrix for Scenario 4a.

Name of sub-basin	Impact potential based on project profile*	Aquatic biodiversity value	Impacts significance
Bhagirathi I	M	M	M
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	H	VH
Bhagirathi IV	M	VH	H
Bhilangana	M	H	M
Balganga	M	H	M
Alaknanda I	L	VH	L
Mandakini	M	H	M
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	M	H	M
Rishi ganga	M	M	M
Dhauli ganga	H	M	M
Bhyundar ganga	L	L	L
Alaknanda III	M	M	M
Ganga Basin	L	VH	L

Refer to Appendix 6.2 for detailed information on impact potential

Scenario 4a – Alternatives for lowering the overall impacts on aquatic biodiversity in the sub-basins

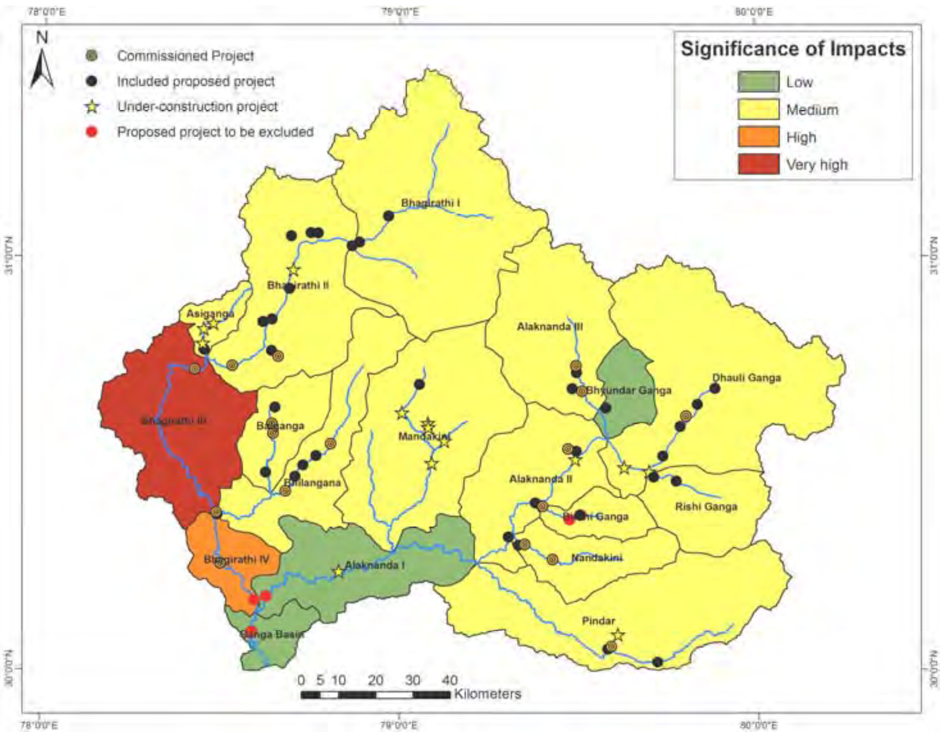


Fig. 6.4 Predicted impact significance on aquatic biodiversity based on inclusion of projects with low impact potential.

In this scenario, an attempt has been made to secure the twin benefits of conservation and economic objectives of harnessing hydropower in the two basins by choosing projects that have low impact potential and excluding those with a higher potential only in sub-basins which could have been a recipient of impacts of very high and high significance.

Table 6.6 List of proposed projects with high impact potential considered for exclusion in Scenario 4a.

S.No.	Sub-basin	Projects excluded
1.	Alaknanda I	Kotlibhel IB
2.	Birahi ganga	Birahi ganga I
		Gohana Tal
3.	Bhagirathi IV	Kotlibhel IA
4.	Ganga	Kotlibhel II
	TOTAL	5

Table 6.7 Interaction matrix for Scenario 5a.

Name of sub-basin	Impact potential based on project profile*	Aquatic biodiversity value	Impacts significance
Bhagirathi I	M	M	M
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	H	VH
Bhagirathi IV	M	VH	H
Bhilangana	M	H	M
Balganga	L	H	L
Alaknanda I	L	VH	L
Mandakini	M	H	M
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	M	H	M
Rishi ganga	M	M	M
Dhauli ganga	H	M	M
Bhyundar ganga	L	L	L
Alaknanda III	M	M	M
Ganga Basin	L	VH	L

Refer to Appendix 6.2 for detailed information on impact potential

Scenario 5a – Alternatives to reduce significant impacts on critically important habitats for aquatic biodiversity

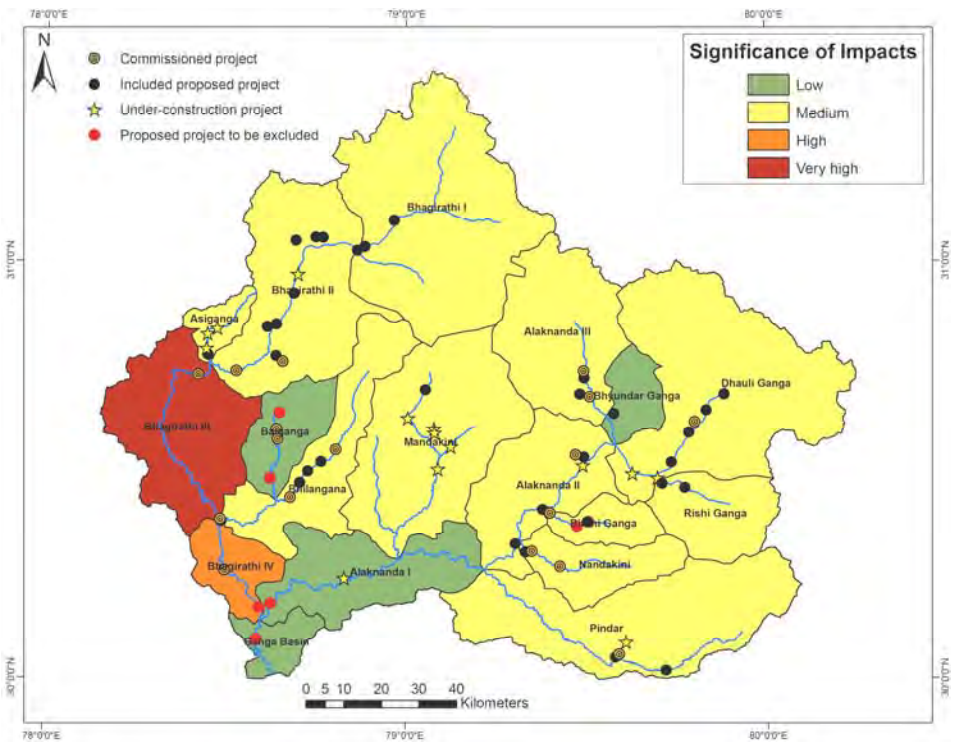


Fig. 6.5 Predicted significance of impacts based on exclusion approach to avoid impacts on critically important aquatic habitats.

This is a resultant scenario based on exclusion of all such projects that have contributed to the decline of biodiversity values of the aquatic species in specific sub-basins and biodiversity value of the habitats (Table 6.8). This is a compounding exercise to exclude some additional projects that remained in the inclusion list in earlier scenario to further reduce impacts.

Table 6.8 List of proposed Hydro Electric Projects to be excluded exclusively for safeguarding aquatic biodiversity.

S.No.	Sub-basin	Projects excluded	Reason for exclusion
1.	Alaknanda I	Kotlibhel IB	High impact potential
2.	Birahi ganga	Birahi ganga I	
		Gohana Tal	
3.	Bhagirathi IV	Kotlibhel IA	
4.	Bal ganga	Bal ganga II	Within critically important habitat
		Jhala koti	
5.	Ganga	Kotlibhel II	High impact potential and within critically important habitat
	TOTAL	7	

Section 5.4.1 in - chapter 5, has highlighted Nayar River in the Ganga sub-basin and River Balganga in the Bal ganga sub-basin as critically important habitats for cold water fishes including mahseer and snow trouts. The Balganga river is additionally an important habitat for fragmented populations of mahseer, which is a IUCN listed RET species.

The proposed projects Bal Ganga II and Jhala koti in the Bal ganga sub-basin have been additionally incorporated in the list of excluded projects for scenario 4a. Kotlibhel II falling within the Ganga sub-basin which would affect the Nayar river was included in the exclusion list even in Scenarion 4a due to its high impact potential.

Table 6.9 Interaction matrix for Scenario 1b.

Name of sub-basin	Impact potential based on project profile*	Terrestrial biodiversity value	Impacts significance
Bhagirathi I	M	H	M
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	M	H
Bhagirathi IV	H	H	H
Bhilangana	M	H	M
Balganga	M	H	M
Alaknanda I	M	H	M
Mandakini	M	VH	H
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	H	H	H
Rishi ganga	M	H	M
Dhauli ganga	H	VH	VH
Bhyundar ganga	L	VH	L
Alaknanda III	M	H	M
Ganga Basin	H	H	H

Refer to Appendix 6.2 for detailed information on impact potential

6.4.2 Scenario assessment for Terrestrial Biodiversity

Scenario Ib – Cumulative impacts of all projects

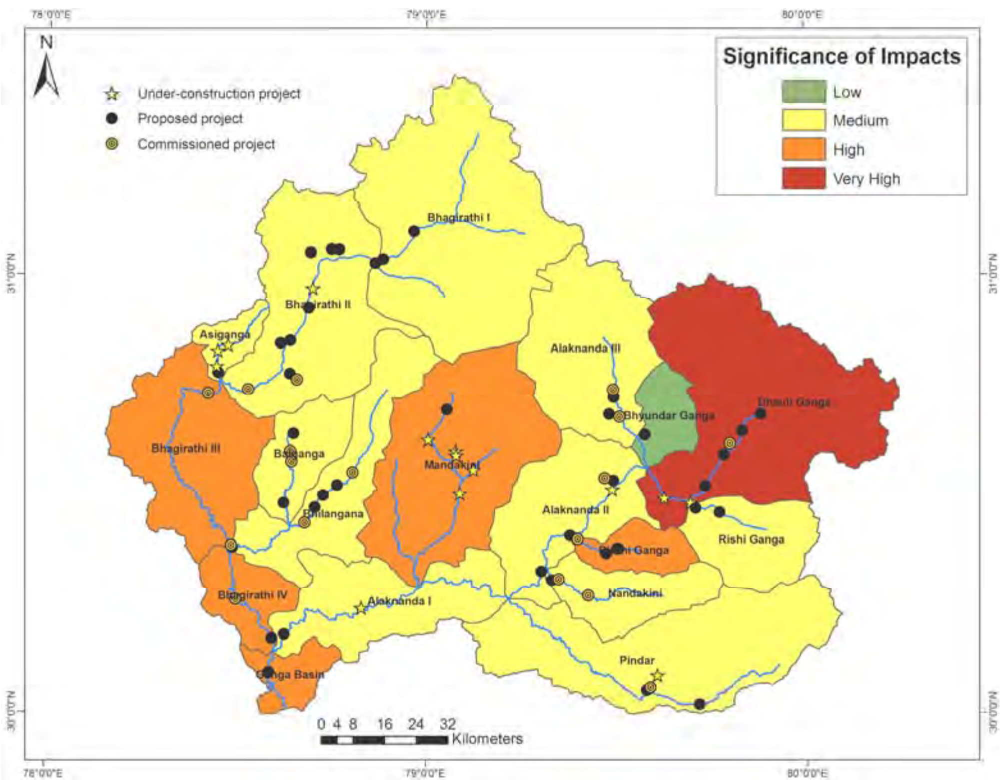


Fig. 6.6 Predicted significance of impacts of all projects on terrestrial biodiversity values.

This scenario indicates relative ranking of impact significance on biodiversity in the two basins taking into consideration the biodiversity values of the sub-basins and the impact potential of all projects planned in the two basins. Most of the terrestrial biodiversity areas in the sub-basins will be affected with varying levels of impacts if the current hydropower plan is implemented with total disregard to the need for ensuring ecological viability of energy projects.

In the two basins, 6 sub-basins will be significantly impacted by Hydro Electric Projects (refer to red and orange areas in Fig. 6.7). Amongst these sub-basins, Dhauliganga sub-basin would be most affected in the event of all six projects becoming operational. Of these the two projects,Tapovan Vishnugad is under advanced stages of construction and Jummagad HEPs is an already commissioned project. Dhauliganga sub-basin has very high richness of RET species and also holds suitable habitats for supporting species such as snow leopard and Himalayan brown bear.

High significance of impact is predicted in Mandakini sub-basin on account of four projects already being in advanced stages of construction. Considering that this sub-basin harbours high proportion of RET species of mammals, birds and plants, impacts of such high significance are likely to jeopardize the habitats of these species and the long term conservation of RET species in this sub-basin.

The impacts of high significance in Bhagirathi IV, Birahi ganga and Ganga sub-basins (Table 6.9) can be attributed to the fact that these areas contain high terrestrial biodiversity values and the projects with high potential to impact these values are also located here.

The terrestrial biodiversity value of Bhagirathi II sub-basin has already been compromised on account of the existing Tehri HEP and in the futuristic scenario this basin would continue to be subjected to incremental impacts on remnant terrestrial biodiversity over a period of time.

Table 6.10 Interaction matrix for Scenario 2b.

Name of sub-basin	Impact potential based on project profile*	Terrestrial biodiversity value	Impacts significance
Bhagirathi I	L	H	L
Bhagirathi II	L	H	L
Asiganga	L	H	L
Bhagirathi III	VH	M	H
Bhagirathi IV	M	H	M
Bhilangana	L	H	L
Balganga	L	H	L
Alaknanda I	L	H	L
Mandakini	L	VH	L
Alaknanda II	L	H	L
Pindar	L	H	L
Nandakini	M	H	M
Birahi ganga	L	H	L
Rishi ganga	L	H	L
Dhauli ganga	L	VH	L
Bhyundar ganga	L	VH	L
Alaknanda III	M	H	M
Ganga Basin	L	H	L

Refer to Appendix 6.2 for detailed information on impact potential

Scenario 2b – Exclusive impacts of commissioned projects

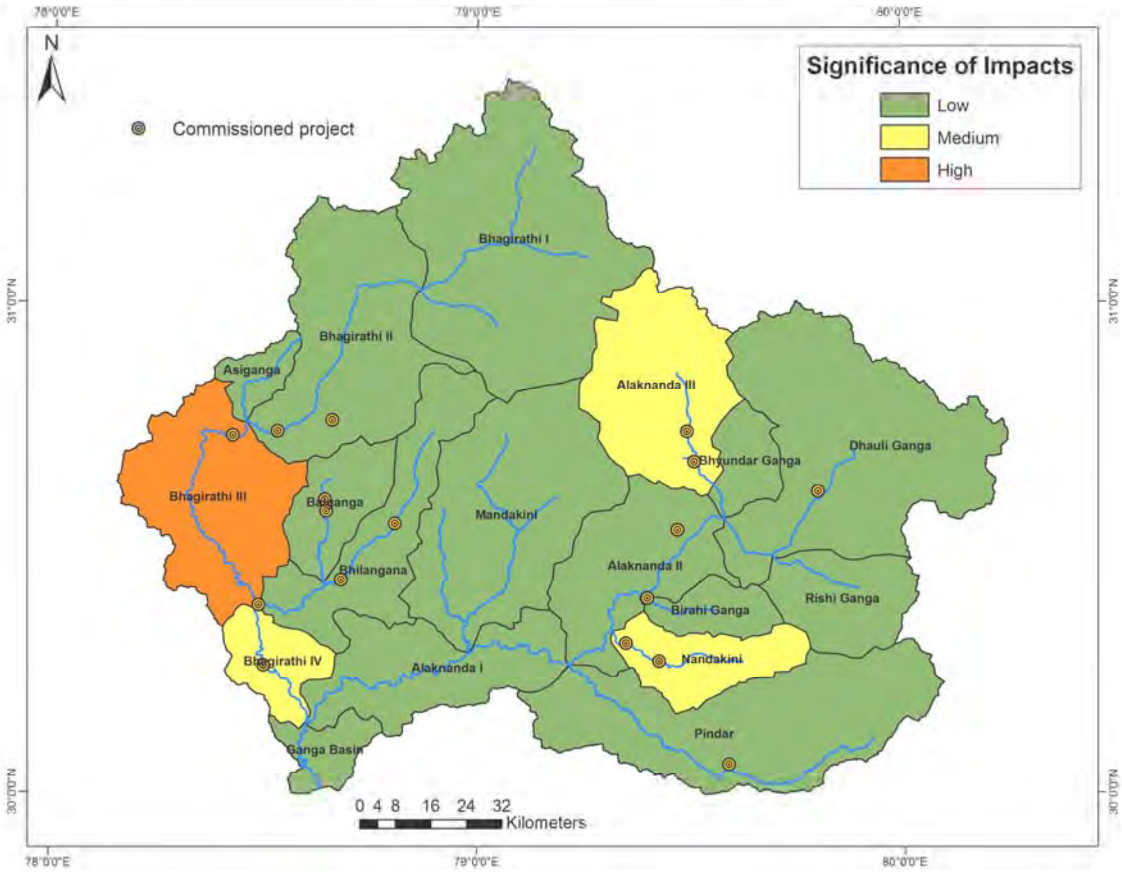


Fig. 6.7 Predicted significance of impacts of commissioned projects on terrestrial biodiversity values.

This scenario portrays the impacts of all the 17 commissioned projects on the terrestrial biodiversity values of the two basins. It becomes evident that the impacts of already commissioned projects are spatially concentrated in only one sub-basin as a result of which high significance of impacts (shown in shades of orange) are received by Bhagirathi III sub-basin (Table 6.10). These impacts are largely significant owing to large footprints of Tehri HEP. Scenarios 1b and 2b clearly demonstrate that all projects under construction and all proposed projects that are widely spread across all sub-basins would have greater impact influence in increasing significance of impacts on biodiversity values. This transformation in impact significance category can be visualized at the sub-basin level where increasing areas under green shade portray the scenario in which incremental impacts on the terrestrial biodiversity would not be significant in the two basins in future.

Table 6.11 Interaction matrix for Scenario 3b.

Name of sub-basin	Impact potential based on project profile*	Terrestrial biodiversity value	Impacts significance
Bhagirathi I	L	H	L
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	M	H
Bhagirathi IV	M	H	M
Bhilangana	L	H	L
Balganga	L	H	L
Alaknanda I	L	H	L
Mandakini	M	VH	H
Alaknanda II	M	H	M
Pindar	L	H	L
Nandakini	M	H	M
Birahi ganga	L	H	L
Rishi ganga	L	H	L
Dhauli ganga	M	VH	H
Bhyundar ganga	L	VH	L
Alaknanda III	M	H	M
Ganga Basin	L	H	L

Refer to Appendix 6.2 for detailed information on impact potential

Scenario 3b – Combined impacts of all commissioned projects and projects under-construction

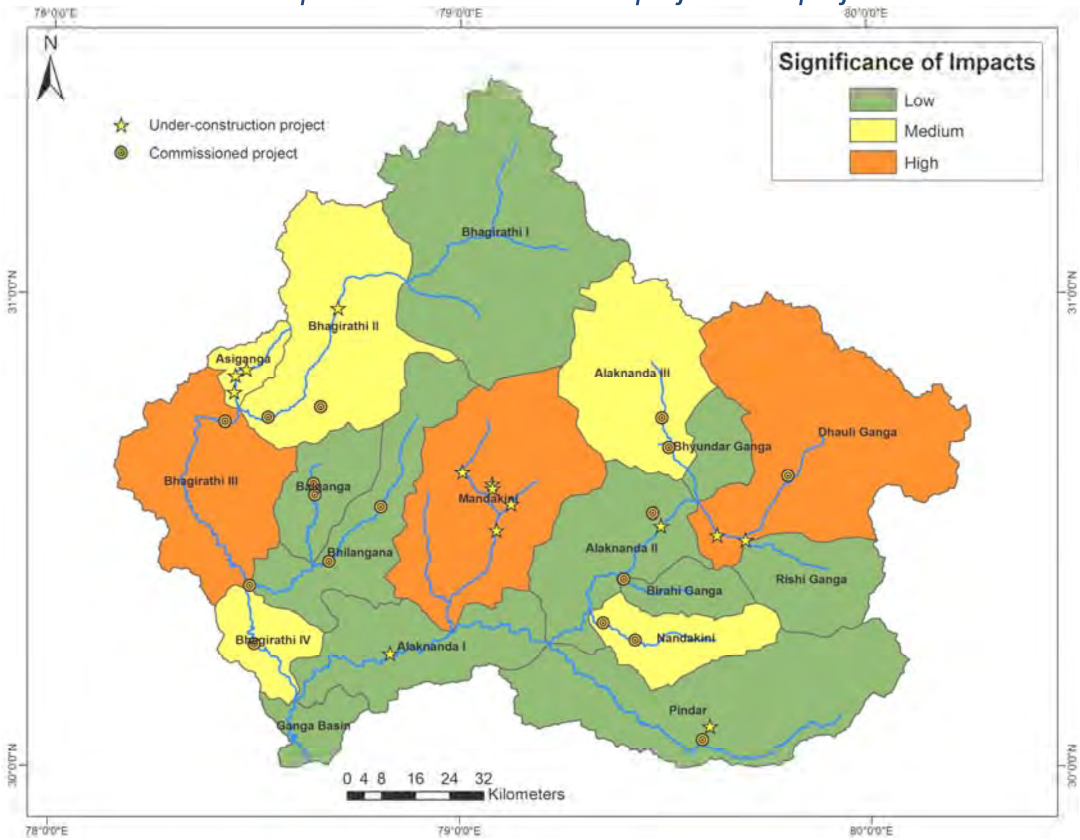


Fig. 6.8 Predicted significance of impacts of commissioned projects and those under different stages of construction on terrestrial biodiversity values.

A comparative review of the scenario 1 (which includes all projects) with this scenario (which includes only commissioned and projects under-construction) allows visualizing the contribution of all proposed projects in altering the terrestrial biodiversity values of the two basins especially in sub-basins seen in green (Fig. 6.8). This scenario provides a reference point to gain a useful insight for futuristic planning of hydropower development which to some extent can integrate the biodiversity conservation concerns specific to sub-basins and larger landscape unit in the two basins.

This scenario however fails to reduce the impacts of developments on Dhauliganga basin to an acceptable level despite this sub-basin being a cradle for many RET species. It only allows moderation of impacts to reduce them to the next lower level (refer to the change from red to orange in this scenario).

Table 6.12 Interaction matrix for Scenario 4b.

Name of sub-basin	Impact potential based on project profile*	Terrestrial biodiversity value	Impacts significance
Bhagirathi I	M	H	M
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	M	H
Bhagirathi IV	M	H	M
Bhilangana	M	H	M
Balganga	M	H	M
Alaknanda I	M	H	M
Mandakini	M	VH	H
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	M	H	M
Rishi ganga	M	H	M
Dhauli ganga	M	VH	H
Bhyundar ganga	L	VH	L
Alaknanda III	M	H	M
Ganga Basin	L	H	L

Refer to Appendix 6.2 for detailed information on impact potential

Scenario 4b – Alternatives for lowering the overall impacts on terrestrial biodiversity in the sub-basins

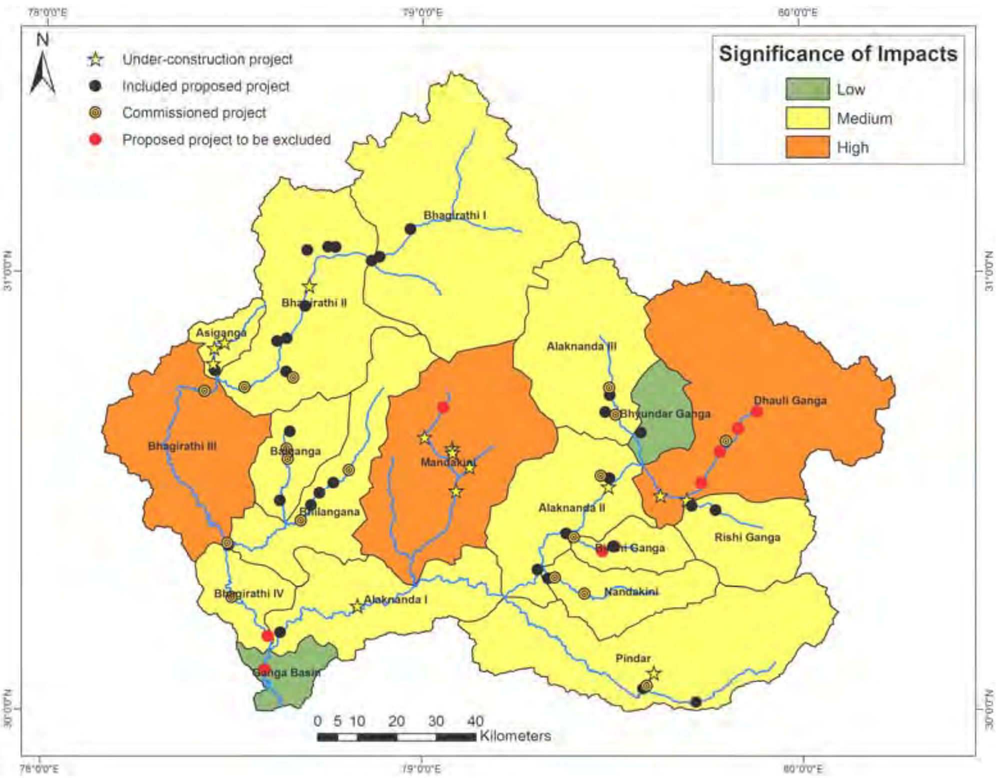


Fig. 6.9 Predicted impact significance on terrestrial biodiversity based on inclusion of projects with low impact potential.

This scenario presents an alternative to secure the twin benefits of conservation and economic objectives of harnessing hydropower in the two basins by choosing 7 projects that have low impact potential and excluding those with a higher potential only in sub-basins which could have been a recipient of impacts of very high and high significance.

Table 6.13 List of proposed projects with high impact potential considered for exclusion in Scenario 4b.

S.No.	Sub-basin	Projects to be excluded
1.	Dhauliganga	Tamak Lata
		Lata Tapovan
		Malari Jhelam
		Jhelam Tamak
2.	Birahi ganga	Birahi ganga I
		Gohana Tal
3.	Mandakini	Rambara
	Bhagirathi IV	Kotlibhel IA
4.	Ganga	Kotlibhel II
	TOTAL	9

Table 6.14 Interaction matrix for Scenario 5b.

Name of sub-basin	Impact potential based on project profile*	Terrestrial biodiversity value	Impacts significance
Bhagirathi I	L	H	L
Bhagirathi II	M	H	M
Asiganga	M	H	M
Bhagirathi III	VH	M	H
Bhagirathi IV	M	H	M
Bhilangana	M	H	M
Balganga	M	H	M
Alaknanda I	M	H	M
Mandakini	M	VH	H
Alaknanda II	M	H	M
Pindar	M	H	M
Nandakini	M	H	M
Birahi ganga	M	H	M
Rishi ganga	L	H	L
Dhauli ganga	M	VH	H
Bhyundar ganga	L	VH	L
Alaknanda III	M	H	M
Ganga Basin	L	H	L

**Refer to Appendix 6.2 for detailed information on impact potential*

Scenario 5b – Alternatives to reduce significant impacts on critically important habitats for terrestrial biodiversity

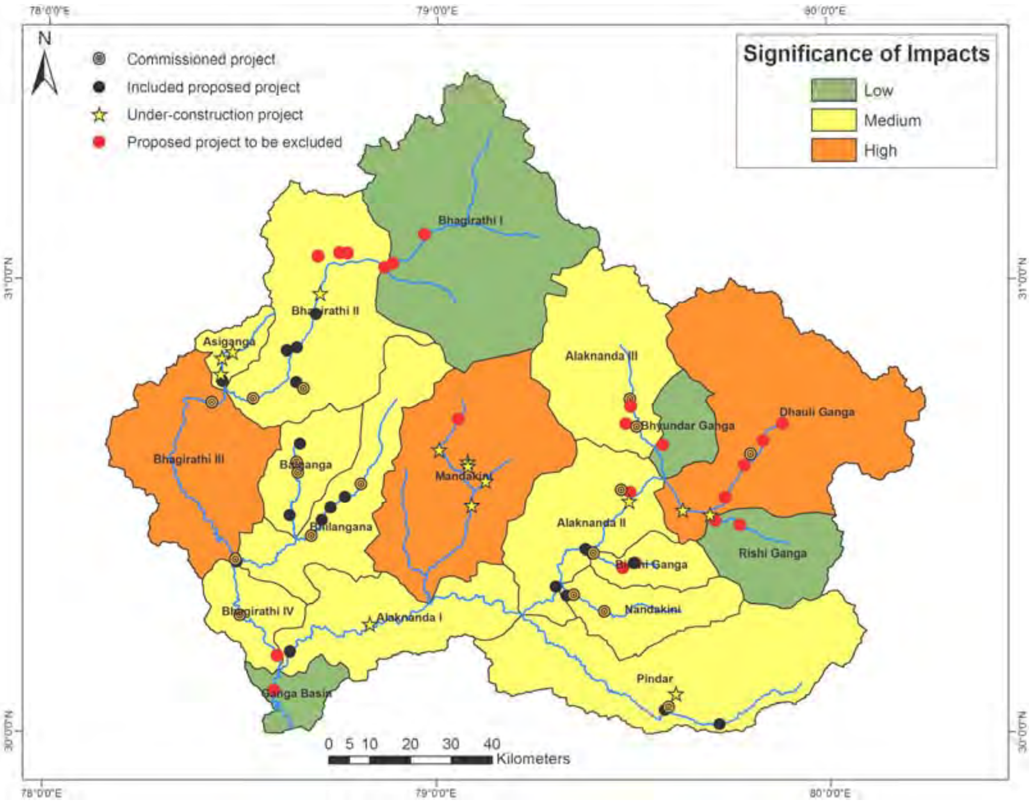


Fig. 6.10 Predicted significance of impacts based on exclusion approach to avoid impacts on critically important habitats for terrestrial biodiversity.

This is a resultant scenario based on exclusion of all such projects that can contribute to the decline of biodiversity values of the terrestrial species in specific sub-basins and biodiversity value of the critically important habitats (Table 6.14). This is a compounding exercise after including additional projects in the exclusion list used in Scenario 4b.

The scenario has been developed to ensure that biodiversity values of critically important habitats both within and outside PAs are not compromised as a consequence of hydropower development. This exclusion exercise is intended to reappraise projects whose zones of influence overlap with critically important habitats for all terrestrial components including mammals, birds and plants.

The benefits of applying this exclusion approach may only yield limited benefits of reducing significant impacts of proposed developments on critically important habitats within PAs and those providing connectivity between PAs (Table 6.15).

Table 6.15 List of proposed Hydro Electric Projects to be excluded exclusively for safeguarding terrestrial biodiversity.

S.No.	Sub-basin	Projects to be excluded	Reason for exclusion
1.	Bhagirathi II	Bharon ghati	ZoI overlapping with the boundary of Gangotri NP
		Jalandrigad	ZoIs falling within important habitats connecting PAs
		Siyangad	
		Kakoragad	
2.	Bhagirathi I	Karmoli	ZoI falling within Gangotri NP
		Jadhganga	
3.	Mandakini	Rambara	ZoI falling within Kedarnath WLS and High impact potential
4.	Alaknanda III	Alaknanda	ZoI is overlapping with the buffer zone of Valley of Flowers NP
		Khirao ganga	
5.	Alaknanda II	Urgam II	ZoI falling within important habitats connecting PAs
6.	Dhauliganga	Lata tapovan	ZoIs falling within important habitats connecting PAs and High impact potential
		Malari jhelam	
		Jhelam tamak	
		Tamak lata	
7.	Bhyundar ganga	Bhyundar ganga	ZoI falling within critically important habitat (buffer zone of Nanda Devi Biosphere Reserve)
8.	Rishi ganga	Rishi ganga I	ZoIs falling within important habitats connecting PAs and High impact potential
9.		Rishi ganga	
10.	Birahi ganga	Birahi ganga I	High impact potential
11.		Gohana Tal	
12.	Bhagirathi IV	Kotlibhel IA	
13.	Ganga	Kotlibhel II	High impact potential and ZoI overalapping with important habitat for plants species (*Catamixis baccharoides)*
	TOTAL	21	

It becomes apparent that with the situation of many projects already in stages of operation and construction, the reversibility of impacts from significant to moderate is not possible in sub-basins (Dhauliganga, Mandakini and Bhagirathi III) that are supporting many species of high conservation values.

It is further highlighted the zone of influence of Melkhet HEP located in Pindar basin overlaps with the area that commands high conservation priority for long term security of the habitat for highly endangered species of plant (refer appendix of plants RET profile).

6.4.3 Final analysis

These five scenarios can be used to improve upfront the process of decision making and forward planning of the hydropower sector. These scenarios distinctly present options to decision makers in respect of approval or relocation of Hydroelectric project(s) based on potential risk to biodiversity values and reflection, if required.

The scenarios also provide adequate basis to make decisions with respect to applying ‘exclusion approach’ across the two basins for securing key biodiversity values in key biodiversity sites, critically important habitats and designated protected areas (Refer Fig 6.11).

For acceptable outcomes from hydropower development for biodiversity conservation and societal well-being, Table 6.17 provides a list of proposed projects that may be reviewed for combined benefits of reducing impacts on both, aquatic and terrestrial biodiversity.

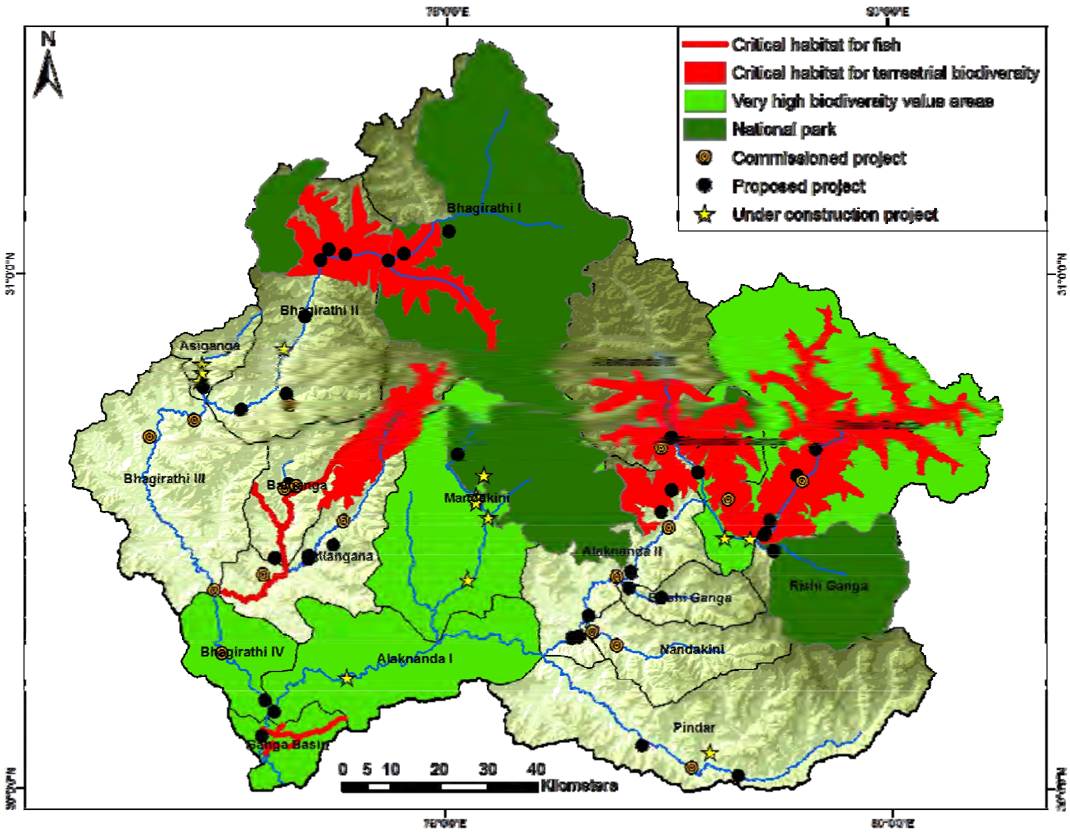


Fig. 6.11 Critically important habitats of valued biodiversity components significantly overlap with locations of hydropower projects in the Alaknanda and Bhagirathi basins.

Table 6.16 List of proposed Hydro Electric Projects to be excluded for safeguarding aquatic and terrestrial biodiversity.

Sub-basin	Projects to be excluded	River	Capacity (MW)	Aquatic	Terrestrial
Bal ganga	Bal ganga II	Bal ganga	7.00	√	
	Jhala koti	Bal ganga	12.50	√	
Bhagirathi II	Bharon ghati	Bhagirathi	381.00		√
	Jalandrigad	Jalandharigad	24.00		√
	Siyangad	Siyangad	11.50		√
	Kakoragad	Kakoragad	12.50		√
Bhagirathi IV	Kotlibhel IA	Bhagirathi	195.00	√	√
Bhagirathi I	Karmoli	Jadhganga	140.00		√
	Jadhganga	Jadhganga	50.00		√
Mandakini	Rambara	Mandakini	24.00		√
Alaknanda I	Kotlibhel IB	Alaknanda	320.00	√	
Alaknanda III	Alaknanda	Alaknanda	30.00		√
	Khirao ganga	Khirao ganga	4.00		√
Alaknanda II	Urgam II	Kalpganga	3.80		√
Dhauliganga	Lata tapovan	Dhauli ganga	170.00		√
	Malari jhelam	Dhauli ganga	114.00		√
	Jhelam tamak	Dhauli ganga	126.00		√
	Tamak lata	Dhauli ganga	250.00		√
Bhyundar ganga	Bhyundar ganga	Bhyundar ganga	24.30		√
Rishi ganga	Rishi ganga I	Rishi ganga	70.00		√
	Rishi ganga II	Rishi ganga	35.00		√
Birahi ganga	Birahi ganga I	Birahi ganga	24.00	√	√
	Gohana Tal	Birahi ganga	50.00	√	√
Ganga	Kotlibhel II	Ganga	530.00	√	√

Chapter 7 – Environmental Flow

7.1 Introduction

Environmental flows are flows that are essential to maintain the normal ecological services of a river. Their purpose could be as general as maintenance of a 'healthy' riverine ecosystem, or as specific as enhancing the survival chances of a threatened species and other associated fauna (Smakhtin, et al, 2007). The flow regime is one of the important components of the river ecosystem, which can reflect its health and geography, and also influence the socio-economic status of the region. Ecosystem components such as channel morphology and patterns; water chemistry and temperature; and the biota of channel, bank and associated wetlands reflect the nature of the flow patterns of the river. In this study, the environmental flow has been defined in the context of maintaining the health of river stretches in the dry zones of the Hydro Electric Projects in the Alaknanda and Bhagirathi basins.

7.2 Methods

A global review of the present status of environmental flow methodologies revealed the existence of more than 200 individual methodologies, recorded from 44 countries covering all realms of the world (Tharme, 1996; Stalnaker and Arnette, 1976; Wesche and Rechard, 1980; Morhardt, 1986; Estes and Orsborn, 1986; Stewardson and Gippel, 1997)). These methods could be categorized into hydrological, hydraulic rating, habitat simulation and holistic methodologies. In an international context, the development and application of methodologies for prescribing Environmental Flow Requirements (EFRs), began as early as the 1950s, in the western U.S.A, with marked progress during the 1970s, primarily as a result of new environmental legislation (Stalnaker, 1982; Trihey and Stalnaker, 1985). Outside the U.S.A., the process by which environmental flow methodologies evolved and became established for use is less apparent, as there is little published information on environmental flow (Tharme, 1996). In Asia, environmental flow assessment appears to be less advanced in the field, with little published literature that deals specifically with environmental flows. This suggests that many countries in Asia have not yet recognized the importance of Environmental Flow Assessments in the long-term maintenance and sustainability of freshwater systems (Tharme, 1996).

There are also a number of hybrid approaches which comprise elements of one or more of these main types of methodology to assess the Environmental Flows. They are: Flow Stressor-Response (FSR) approach, Downstream Response to imposed Flow transformations (DRIFT) approach and Instream Flow Incremental Methodology (IFIM) approach. However, there is no single method for flow assessment that can be used at universal level without any modification(s). This is largely due to variations in the topography, climate and other environmental settings across the globe. Moreover, requirement of flow varies with different needs of the region.

Environmental Flows should also provide the required environmental cues for the various life history traits of a species such as breeding, growth, metamorphosis and migration which are dependent on the seasonal variations in natural flows pattern. Moreover, the flow requirements for the life history stages of many fishes are dependent on the seasonal flow. Taking this into account, the environmental flow required for different sector of the river was calculated from Mean Seasonal Flow (MSF) during this study.

In the recent past, most of the environmental flow estimators have used the hydrological indices for hydrological impact assessment due to water associated developments. However, in the building block and holistic method like DRIFT, habitat rating curve is generally used for the ecological flow estimation since water abstraction from the Bhagirathi/Alakananda rivers for agriculture, drinking, pollution assimilation, etc. is very less as compared to the other rivers of Ganges basin. Ecological flow is a major concern in Alaknanda/Bhagirathi river systems and for these rivers the ecological flow has been considered equivalent to the environmental flow. In the present study, a combination of modified Building Block (King *et al.,* 2000), Habitat Rating (Loar *et al.,* 1986; Dunbar, 1998), and DRIFT (Brown *et al.,* 2000) methods has been used. Moreover, suggested alternate flows based on Environmental Management Class of the Alaknanda and Bhagirathi basins (Smakhtin, et al, 2007) have also been suggested.

7.3.1 Minimum Environmental Flows based on ecological status of River (EMC)

In rivers where natural river flow pattern has been altered by humans, all of ecological components are likely to change compared to their historical conditions. The degree to which this happens reflects the severity of the flow manipulation. As far as fishes are concerned, water flow is one of the important limiting factors for their distribution and abundance. Most of the riverine fishes are attracted towards flow for two important reasons, i) to get more dissolved oxygen and ii) flowing water carries lot of nutrients from upstream, which provides food for many fishes. Natural flow during different seasons stimulates the reproductive system of aquatic organisms and facilitates spawning related activities. A modified flow pattern in stream and river brings about adverse effects on water quality, species diversity, distribution, migration, spawning and survival of many aquatic organisms.

Suitable river flow is necessary for maintaining the health, function and integrity of the river ecosystems. Moreover, seasonal variations in the flow are equally important to maintain the life history cycle of aquatic biodiversity that exists in any river ecosystem. The major aquatic components of Alaknanda-Bhagirathi basin up to Rishikesh are periphyton, phytoplankton, macrophytes, zooplankton, benthic macroinvertebrates, fish, and birds. The only aquatic mammal reported in the basin was the otter but its current distribution needs further validation.

Several studies have been conducted on the water quality and aquatic biodiversity of Bhagirathi (Sharma, 1983; 1984; 1985; 1986), Bhilangana (Sharma *et al.* 1990, Sarkar *et al*. 2011), Alaknanda (Singh and Sharma, 1998), Dahuliganga (Sharma *et al.,* 2004), Tons (Sharma *et al.,* 2008) and Asan (Sharma and Rawat, 2009, Sarkar *et al*. 2011). There is no information available on the precise hydrological requirements of the organisms living in the upper Ganga. It is possible to provide minimum environmental flow required for different fish communities which occur in different fish zones by studying their spatial distributions with supporting data on immediate habitats. Fig. 7.1 shows the flows estimated for the entire Ganga basins and its tributaries.

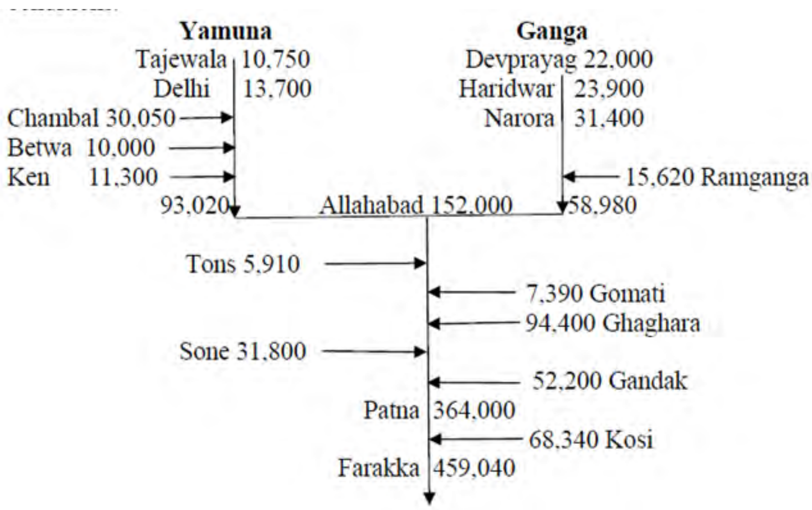


Fig. 7.1. Line diagram of Ganga and its major tributaries (Numbers are average flows in MCM-million cubic meters (Source: IIT-Roorkee, 2011).

Smakhtin and Anputhas (2006) defined six EMCs corresponding to the default levels of environmental flows (Table 7.1). A river which falls into classes C to F would normally be present in densely populated areas with multiple human induced impacts. Poor ecosystem conditions (Class E and F) are sometimes not considered or acceptable from the management perspective and the management intention is always to 'move' such rivers up to the least acceptable class D through rehabilitation measures. It can be noted that the ecosystems in class F are likely to be those which have been modified beyond rehabilitation to anything resembling a natural condition.

Table 7.1 Environnemental Management Classes (EMCs) (modified from Smakhtin, *et al.*, 2007).

EMC	Status	Ecological description	Management perspective	Default FDC shift limit
A	Natural	Pristine condition or minor modification of in-stream and riparian habitat	• Protected river and basins • Reserves and national parks • No new water projects (dam, diversions, etc.) allowed	Lateral shift of reference FDC one percentage point to the left along the time axis from the original FDC position
B	Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications	Water supply schemes or irrigation development present and/or allowed	Lateral shift of reference FDC one percentage point to the left along the time axis from the position of the FDC for A class
C	Moderately	The habitat and dynamics of the biota have been disturbed, but	Multiple disturbances associated with the need	Lateral shift of reference FDC one

EMC	Status	Ecological description	Management perspective	Default FDC shift limit
	modified	basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present.	for socio-economic development, e.g., dams, diversion, habitat modification and reduced water supply	more percentage point to the left along the time axis from the position of the FDC for B class
D	Largely modified	• Large changes in natural habitat, biota and basic ecosystem functions have occurred. • A clearly lower than expected species richness. • Much lowered presence of intolerant species. • Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation	Lateral shift of reference FDC one more percentage point to the left along the time axis from the position of the FDC for C class
E	Seriously modified	• Habitat diversity and availability have declined. • A strikingly lower than expected species richness. • Only tolerant species remain. • Indigenous species can no longer breed. • Alien species.	High human population density and extensive water resources exploitation	Lateral shift of reference FDC one more percentage point to the left along the time axis from the position of the FDC for D class
F	Critically modified	• Modifications have reached a critical level and ecosystem has been completely modified with almost total loss of natural habitat and biota. • In the worst case, the basic ecosystem functions have been destroyed and the changes are irreversible.	This status is not acceptable from the management perspective. Management interventions are necessary to restore flow pattern, river habitats, etc. (if still possible/feasible) – to 'move' a river to a higher management category.	Lateral shift of reference FDC one more percentage point to the left along the time axis from the position of the FDC for E class

7.3.2 Assessment of ecological status of Alaknanda and Bhagirathi basin

Normally, the ecological status of a river is assessed based on the Environmental Management Class of that river. The definition of EMC should be based on existing empirical relationships between flow changes and ecological status/conditions, which are associated with clearly identifiable thresholds (Smakhtin *et al.,* 2007). Limited evidence or knowledge is available of such thresholds (e.g., Beecher, 1990). In this connection, EMC is a management concept that has been developed and used globally because of a need to make decisions regardless of the limited hydro-ecological knowledge available (Smakhtin *et al.,* 2007). In these conditions of uncertainty with regard to which EMC is required for a particular river, the EMCs may be used as default 'scenarios' of environmental protection and associated environmental flows as 'scenarios' of environmental water demand (Smakhtin and Anputhas, 2006). It is possible to estimate environmental demand corresponding to all or any of such default EMCs and then consider which one is the most feasible for a river in question, given the existing and future basin developments. We followed the methodology prescribed by the International Water Management Institute (Smakhtin *et al.*, 2007) to assess the environmental management class of the Alaknanda and Bhagirathi Rivers basins (Table 7.2).

Table 7.2 Ecological status of Alaknanda and Bhagirathi basins using fish as major taxa.

Indicator	Value	Alaknanda	Bhagirathi	Entire Study Area	Remarks
Rare and endangered aquatic biota	Moderate	3	3	3	There are at least 16 threatened fish species in the reach which form about 20% of total fish diversity of the reach. Moreover, this is 13% of total threatened species of fish in the country (NBFGR, 1999). However, among Himalayan species, moderate numbers of threatened species occur in this reach. Presence of otter in the reach was reported earlier but there was no authentic report of their sighting in the recent past.
Unique aquatic biota	High	4	4	4	Although this reach has at least 2 endemic species, but many species are Himalayan element and have adapted to live in torrential river that too in cold water.
Diversity of Aquatic Habitats	Moderate to High	3	3	4	Presence of sandy banks, slow and fast flowing reaches, rafts, lagoons, confluences of different rivers, streams, diversity of substratum, formation of islands during summer and winter offers relatively diverse habitats for fish and other wildlife.
Presence of protected or pristine areas	Moderate	2	2	2	Although small portions of reaches are inside the Protected Areas, majority of reaches are outside and are relatively disturbed due to Hydro Electric Projects such as Tehri Dam, Vishnuprayag project

					etc., Nayar and Balganga rivers are identified as important fish habitats, where several threatened species congregate to breed.
Sensitivity of aquatic ecosystems to flow reduction	High	4	4	4	There are at least 37 species largely restricted to Himalaya that occur in this reach which have evolved to live in fast flowing water. Moreover, at least 17 species that occur here are migrants in nature. Therefore, any change in the flow reduction will be detrimental to the populations of several Himalayan species.
Percentage of watershed remaining under natural vegetation	High	4	4	4	Larger portion of catchment of Alaknanda and Bhagirathi are relatively undisturbed and with natural vegetation
Percentage of floodplains remaining	>75 %	4	4	4	There is not much reduction in the floodplains area within study area, but degradation of floodplains was observed.
Degree of flow regulation	High (reverse value)	2	4	3	Because of presence of Tehri Dam and several other Hydro Electric Projects the reach has already been fragmented and water flow is highly regulated at least in summer and winter.
Percentage of watershed closed to movement of aquatic biota by structures or degree of flow fragmentation	Moderate (reverse value)	2	4	3	Movement of Tor spp.and other migrants have already been blocked by Tehri Dam. There is no provision of successful fish paths in the existing Hydro Electric Projects which has drastically reduced the populations of migrants in upper reaches (e.g. mahseer)
Percentage of aquatic biota that are exotic	Moderate (reverse value)	2	4	3	At least 3 exotic species are present in the reach. One of 100 worst invasive species of world ‘brown trout’ occurs in the upper reaches and seems to be expanding its range at a faster rate. Exotic carps have been introduced in the Tehri Dam which are posing

					threat to several native species.
Aquatic species' relative richness	Very High	4	5	5	Compared to availability of area, 76 species of fish is very high species richness. Of the available species, about 50% are Himalayan species.
Human population density as % of that in the main floodplains	Moderate	2	2	2	Compared to other parts of Ganges, this stretch has moderate population.
Overall water quality	Very High	5	5	5	The quality of water is still very high.
Sum of Indicator Scores		43	48	46	
Maximum Possible Sum of Scores		65	65	65	
Maximum Possible Sum of Scores		63	74	71	
Probable Environment Management Class		C	C	C	The habitats and dynamics of the biota of these rivers have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present. (as per *Smakhtin et al.,* 2007)

7.3.3 Environmental Water Requirement as per EMC

The mountainous lotic aquatic environment of the Alaknanda and Bhagirathi Basins constitute the major river system of the Ganges. Alaknanda and Bhagirathi Basins exhibit many limnological extremes. Tributaries of these basins have low water temperatures, highly turbulent water current and low primary and secondary producers. These tributaries are also exposed to frequent flash floods, heavy soil erosion and sedimentation, high turbidity during heavy precipitation, and many anthropogenic disturbances such as Hydro Electric Projects (Tehri, Vishnuprayag, Srinagar, etc.) and the removal of boulders, stones, pebbles and sand from the river bed. These manifestations of environmental degradation are responsible for the destruction of natural feeding and spawning grounds of the fish inhabiting different rivers of the basin. In general, the habitats and dynamics of the biota of rivers in this basin have been observed as disturbed, but basic ecosystem functions are apparently intact. Some sensitive species are lost and/or reduced in the extent and some alien species are present. Therefore, the Environmental Management Category (EMC) of the Alaknanda and Bhagirathi Basins was assessed as 'C' Class (as per Smakhtin *et al.,* 2007).

Smakhtin and Anputhas (2006) suggested that 28.9% of Mean Annual Runoff (MAR) as Environmental Water Required (EWR) for Ganga River to retain the similar status of the EMC of stretch if it is assessed as 'C' Class. However, Smakhtin and Anputhas (2006) have proposed this EWR for Ganges based on analysis downstream of Ganges that starts from Rishkesh. This downstream stretch of Ganges is considered to have more than 140 species of fishes, of which about 19 species are in threatened categories (Sarkar *et al*. 2011). Moreover, in the same stretch, two species of crocodile *Crocodylus palustris* and the *Gavialis gangeticus* are found. Both are considered endangered (IUCN, 1994). The Common Indian Otter (*Lutra lutra*), and Smooth Indian Otter (*Lutra perspicillata*), have also been sighted in this stretch of the river. In addition, endangered Gangetic dolphin, 12 species of freshwater turtles have also been reported in this stretch apart from hundreds of species of aquatic insects. Several thousands of people are also directly dependent on the fisheries resources on this stretch of Ganges. It is not prudent to recommend the same EWR i.e. 28.9% of MAR as suggested by Smakhtin and Anputhas (2006) to Alaknanda and Bhagirathi Basins. Alaknanda and Bhagirathi basins are observed to be having less than half of the aquatic biodiversity when compared to other parts of Ganges. In the absence of larger animals such as dolphin, crocodiles, etc and with 76 species of fishes (in comparison to 143 species reported in the entire Ganges), it has been estimated that 14.5% to 21.8% of MAR may be the Minimum EWR for the aquatic biodiversity of Alaknanda and Bhagirathi basins as a conservative estimate during the lean season.

Moreover, calculation of Minimum Environmental Flow (MEF) should also recognize that these releases are ensured specifically for environmental purposes especially to meet te requirements of different life history events of the aquatic biota. They should not include flows necessary for downstream commercial activities or for water supply purposes (Acreman and Dunbar, 2004; Petts, 1996).Therefore, this study has calculated that Minimum EWR for a river stretch that falls in the Mahseer zone and Snow-trout zone should be 21.8% of Mean Seasonal Runoff (MSR). The stretch that falls in the 'No fish zone' may be equal to 14.5 % of MSR as this stretch is devoid of fishes but has other aquatic biota.

Table 7.3 Mean Monthly Flows (MMF) for various sites in Alaknanda and Bhagirathi Basins (Monthly flow in Cumec/day) observed during past few decades (Source : IIT-R Report, 2011).

	HEP Site	MAF (cumec/ day)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	Bhagirathi River													
1	Asiganga-III	5.29	0.3	0.3	0.3	0.7	3.3	8.5	17.1	19.1	10	1.9	0.6	0.4
2	Agunda thati	5.48	4.2	4.3	4.2	3.7	4.2	5.4	8.1	10.6	8.1	5.1	3.8	4.3
3	Bhilangana-III	13.74	5.6	5.7	5.7	5.5	9.3	17.8	32.7	38.4	23	8.8	5.5	5.9
4	Bhilangana	52.01	39.6	40.6	40.2	35	39.4	51.3	77	100.8	76.5	48	36.5	41.1
5	Lohari Nagpala	92.27	5.9	4.9	5.9	12.2	57.5	148.5	299	332.9	174.5	33.5	9.8	7
6	Maneri bhali I	114.22	7.3	6.1	7.3	15.1	71.2	183.8	370.1	412.1	216	41.5	12.2	8.7
7	Maneri bhali II	122.87	7.9	6.6	7.9	16.3	76.5	197.7	398.2	443.3	232.4	44.6	13.1	9.3
8	Tehri stage-I	243.41	99.7	100.6	101	97.6	163.8	315.5	579.2	679.3	408.2	156	97.3	104.1
9	Koteshwar	259.73	106.3	107.4	107.7	104.2	174.8	336.6	618	724.8	435.5	166.4	103.8	111.1
10	Kotlibhel I A	266.34	109	110.1	110.5	106.8	179.3	345.2	633.8	743.3	446.6	170.7	106.4	113.9
B	Alaknanda River													
1	Badrinath	39.69	7.6	6.6	8.1	14.2	35.2	70.5	106	95.8	64.8	34.7	21.7	14.8
2	Birahi ganga II	8.18	2.4	2.2	2.5	3	4.1	6.8	16.8	23.6	19.3	8.9	4.7	3.5
3	Bhyunder ganga	9.41	1.8	1.6	1.9	3.4	8.3	16.7	25.1	22.7	15.4	8.2	5.1	3.5
4	Phata Byung	16.82	5.5	6.1	6.6	6.8	9	15.8	39.7	53	31.8	12.8	7.5	8
5	Rajwakti	19.82	5.8	5.4	6	7.2	10	16.4	40.6	57.2	46.8	21.5	11.3	8.5
6	Rishiganga-II	24.51	4.7	4.1	5	8.8	21.7	43.6	65.5	59.1	40	21.5	13.4	9.1
7	Singoli Bhatwari	53.57	13.1	13.9	17.1	22.1	29.9	48	125.2	176.7	108.8	41.7	23	19.2
8	Alaknanda	41.33	8	6.9	8.4	14.8	36.7	73.4	110.4	99.7	67.5	36.2	22.6	15.4
9	Devsari	19.71	5.8	5.5	6	7.2	9.9	17.5	42.2	57.7	45.5	19.7	10.7	7.5
10	Vishnuprayag	46.24	13.2	11.4	14	24.6	60.9	122	183.4	165.7	112.1	60.1	37.5	25.6
11	Tapovan Vishnugad	126.85	24.4	21.1	25.8	45.4	112.5	225.4	338.9	306	207.2	111	69.3	47.3
12	Vishnugad Pipalkoti	191.18	36.8	31.8	38.9	68.4	169.5	339.7	510.7	461.2	312.2	167.3	104.4	71.3
13	Nandaprayag Langrasu	255.06	49.1	42.4	52	91.3	226.2	453.2	681.3	615.4	416.6	223.3	139.3	95.1

Four main seasons occur annually in this region. These are: (a) *Season I:* It is considered as high flow season influenced by monsoon. It covers the months from May to September. (b) *Season II:* This season is considered as average flow period, covers the month of October. (c) *Season III:* This season is considered as low or lean or dry flow season which covers the months from November to March. (d) *Season IV:* This season is considered as average flow period and is same as that of season II, it covers the month of April. Based on this classification of seasons, Mean Seasonal Flow (MSF) was estimated to be 21.8% of MSF for a stretch that falls in the Mahseer and Trout zones. Similarly, 14.5% of MSF is suggested for the stretch that falls in the 'No fish zone'. Final Minimum Environmental Flow based on EMC of stretch and seasonal cues was then calculated and is presented in Tables 7.4 & 7.5.

Table 7.4 Observed Mean Seasonal Flows (MSF) of various sites in Alaknanda and Bhagirathi basins (Seasonal flow in Cumec/day) during past few decades (Data Source IIT-R Report, 2011).

		Season I (High Flow)	Season II (Average Flow)	Season III (Low Flow)	Season IV (Average Flow)
A	Bhagirathi River				
1	Asiganga-III	11.6	1.9	0.38	0.7
2	Agunda thati	7.28	5.1	4.16	3.7
3	Bhilangana-III	24.24	8.8	5.68	5.5
4	Bhilangana	69	48	39.6	35
5	Lohari Nagpala	202.48	33.5	6.7	12.2
6	Maneri bhali I	250.64	41.5	8.32	15.1
7	Maneri bhali II	269.62	44.6	8.96	16.3
8	Tehri stage-I	429.2	156	100.54	97.6
9	Koteshwar	457.94	166.4	107.26	104.2
10	Kotlibhel I A	469.64	170.7	109.98	106.8
B	Alaknanda River				
2	Birahi ganga II	14.12	8.9	3.06	3
3	Bhyunder ganga	17.64	8.2	2.78	3.4
4	Phata Byung	29.86	12.8	6.74	6.8
5	Rajwakti	34.2	21.5	7.4	7.2
7	Singoli Bhatwari	97.72	41.7	17.26	22.1
8	Alaknanda	77.54	36.2	12.26	14.8
9	Devsari	34.56	19.7	7.1	7.2
10	Vishnuprayag	128.82	60.1	20.34	24.6
12	Vishnugad Pipalkoti	358.66	167.3	56.64	68.4
13	Nandaprayag Langrasu	478.54	223.3	75.58	91.3

Table 7.5 Suggested Minimum Environmental Flow (MEF) required based on EMC of River, for various sites in the Mahseer and Trouts zones of the Alaknanda and Bhagirathi Basins (Mean Seasonal Flow in Cumec/Day). MEFs only for the dry zones of the HEPs.

		Season I (High Flow)	Season II (Average Flow)	Season III (Low Flow)	Season IV (Average Flow)
A	Bhagirathi River				
1.	Asiganga-III	2.53	0.41	0.08	0.15
2.	Agunda thati	1.59	1.11	0.91	0.81
3.	Bhilangana-III	5.28	1.92	1.24	1.20
4.	Bhilangana	15.04	10.46	8.63	7.63
5.	Lohari Nagpala	44.14	7.30	1.46	2.66
6.	Maneri bhali I	54.64	9.05	1.81	3.29
7.	Maneri bhali II	58.78	9.72	1.95	3.55
8.	Tehri stage-I	93.57	34.01	21.92	21.28
9.	Koteshwar	99.83	36.28	23.38	22.72
10.	Kotlibhel I A	102.38	37.21	23.98	23.28
B	Alaknanda River				
1	Birahi ganga II	3.08	1.94	0.67	0.65
2	Bhyunder ganga	3.85	1.79	0.61	0.74
3	Phata Byung	6.51	2.79	1.47	1.48
4	Rajwakti	7.46	4.69	1.61	1.57
5	Singoli Bhatwari	21.30	9.09	3.76	4.82
6	Alaknanda	16.90	7.89	2.67	3.23
7	Devsari	7.53	4.29	1.55	1.57
8	Vishnuprayag	28.08	13.10	4.43	5.36
9	Vishnugad Pipalkoti	78.19	36.47	12.35	14.91
10	Nandaprayag Langrasu	104.32	48.68	16.48	19.90

7.4 Environmental Water Requirement as per ecological requirement of fishes

The objective of Environmental Flow Assessment for the Alaknanda and Bhagirathi Basin of this study was to sustain the aquatic biodiversity and provide minimum flow in the dry zones of Hydro Electric Projects. In this connection, we largely used the habitat requirements of certain fishes that have been observed in this study and literature survey (Badola, 2001; Atkore et al 2011; Sivakumar, 2008; Nautiyal and Lal, 1984; Nautiyal and Lal, 1985; Sharma 2003).

The ecological structure of fish communities largely depends on the kind of aquatic habitat and environment in which they move around and survive. In Alaknanda and Bhagirathi Basins, two distinct fish communities occur such as golden mahseer (*Tor putitora*) and its associated species, and snow-trout (*Schizothorax richardsonii)* and its associated species. The *Schizothorax richardsonii* is the most dominant species in the basin and it lives with and without mahseer species. Therefore, we classified the entire basin into three categories such as mahseer zone, snow trout zone and 'no-fish zone'. No-fish zone are in the higher altitudes i.e. 1600 MSL and above. No fish was found during this study in this zone and moreover, there was no report of fish occurring in this zone in literature. Below the 'no-fish zone', is the snow trout zone where water temperature is always low but in the mahseer zone, which falls in the lower altitude rivers and streams, water is relatively warm.

Since fish occur in most of the basin area and occupy all kind of trophic levels, this study considered the fish as flagship fauna to estimate the Minimum Environmental Water Flow required in the different stretches of Alaknanda and Bhagirathi Basins for maintanance of fish diversity in particular and well being of entire ecosystem in general. Studying the habitat requirement of all fish species in a short duration is a difficult task and therefore threatened species of the basins have been studied to assess their habitat requirements, based on primary as well as secondary data. Minimum Environmental Flow required for different stretches of rivers and streams in the basin was then calculated based on the habiat requirement as well as availability of water. There are 16 threatened fish species that occur in the two basins and their habitat requirements are follows;

1. Golden Mahseer (*Tor putitora*) – IUCN status: Endangered.

This species is considered as one of the mighty game fishes in India. It is a migratory species that attains a total length of 2.7 m (Talwar and Jhingran, 1991) and is well known for its utility in angling sports. It inhabits the montane and sub-montane regions, in streams and rivers. This species is native to Himalayan river system and is distributed in mid-hill stretches of Himalayan region. It occurs in rapid streams with rocky bottom and riverine pools. It neither inhabits in the warm '*Terai'* climate nor streams of very cold climate; but in natural conditions it inhabits moderately cold and tropical highlands. The fish is a column feeder in freshwater found in subtropical condition 13°C - 30°C. It is omnivorous in nature during their adult stage it feeds on periphytic algae and on diatoms in juvenile stage (IUCN, 2011). It migrates from the foot hills to upper reaches of the river and tributaries for breeding and needs suitable habitats such as clean, stable, well-oxygenated, gravel habitats to spawn (Sharma, 1984).

The feeding and breeding habitats have been almost lost throughout their distributional range. The population is fast depleting and at present are chiefly localised to certain major river systems and is fast approaching extinction in the streams and lakes of northern India. Large fishes are only found in some of the perennial pools. This species is declining in its natural habitat due to urbanization, illegal encroachment, over fishing and chemical and physical alterations of their natural habitats. Annual productivity of the species has declined from 0.198 gm^2 per year to 0.054 gm^2 per year (about 73% decline/ year) in the Tehri Dam in the Garhwal Himalaya, India (Sharma *et.al.*, 2004). The stress on the population is not only due to its over exploitation, but also due to the rise in developmental activities, especially the growing number of hydroelectric and irrigation projects which have fragmented and deteriorated its natural habitat (IUCN, 2011).

Table 7.6 Summary of the biology and flow-related ecological requirements of Golden Mahseer (*Tor putitora*) in Alaknanda and Bhagirathi river basins.

Observed Requirements	Adults	Juveniles	Spawning	Incubation and larval development
Depth	Deep (>1 m)	Shallow (<0.75 – 1.5 m)	Shallow to high (0.5 - 2.00 m)	Shallow to high (0.3 - 2.00 m)
Velocity	Medium to high (0.5 - 1.5 m/s)	Low to medium (0.1-1.5 m/s)	Low to medium (0.1 -1.0 m/s)	Low to medium (0.1-0.5 m/s)
Habitat	Riffles, pools, glides	Pools, backwater pools closer to the banks and run habitats	Low gradient riffles, backwater pools, secondary channels	Backwater Pools and secondary channels
Substratum	Bed rock, Boulders, Cobbles, gravel to sandy bottom	Cobbles, gravel to sandy bottom	Bed rock undercut Boulder undercut Gravel bed	Cobbles, gravel to sandy bottom Leaf litter
Temperature	12-30 °C	12-20 °C	<12 °C	10-15°C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Omnivorous: small fishes, benthic invertebrates larvae, mollusc, crab, fronts and seeds etc.,	Benthic invertebrates larvae, worms etc.,	Not applicable	Periphytic algae and diatoms
Breeding Period	March – April; October to December			
Passage Requirement	Moves long distance to streams associated with main river, nearby side channels, shallow water and pools to breed			
Migration Timings	March – April; October - December			
Migration cues	Change in flow pattern and water temperature may be a factor which trigger the breeding migration			

2. Silver Mahseer (*Tor tor*) – IUCN status: Endangered.

Tor tor is also an important migratory game fish in India. It inhabits rivers and also rapid streams with rocky bottoms. In India, this species has been recorded from Himalayan river systems, Vindhayas and Satpura ranges in Madhya Pradesh and high reaches of the Mahanadi river basin (Menon, 1999). It migrates toward headwaters at the start of the rainy season and downstream at the end of the rainy season. It is omnivorous, feeds on filamentous algae, chironomid larvae, water beetles, small fishes and crustaceans. Spawning takes place from March to September, over stones and gravel (Shrestha, 1999). It is reported to reach a maximum weight of 68 kg (Talwar and Jhingran, 1991) but these days specimens of more than 30 cm TL are rarely caught (Menon, 1999). This species is heavily utilised for food and sport and declines have been reported from several parts of its range. Sharma (2004) reported that the environmental degradation, brought about by intensified road construction activities at Tehri, and other construction activities along the Bhagirathi and Bhilangana river has adversely obstructed the movement of *Tor tor* from the foot hills to upper reaches of the river and tributaries for breeding purposes.

Table 7.7 Summary of the biology and flow-related ecological requirements of Silver Mahseer (*Tor tor*) in Alaknanda and Bhagirathi river basin.

Observed requirements	Adults	Juveniles	Spawning	Incubation and larval development
Depth	Deep (>1 m)	Shallow (<0.75 – 1.5 m)	Shallow to high (0.5 - 2.00 m)	Shallow to high (0.3 - 2.00 m)
Velocity	Medium to high (0.5 - 1.5 m/s)	Low to medium (0.1-1.5 m/s)	Low to medium (0.1 -1.0 m/s)	Low to medium (0.1-0.5 m/s)
Habitat	Riffles, pools, glides	Pools, backwater pools closer to the banks and run habitats	Low gradient riffles, backwater pools, secondary channels	Backwater Pools and secondary channels
Substratum	Bed rock, boulders, cobbles, gravel to sandy bottom	Cobbles, gravel to sandy bottom	Bed rock undercut boulder undercut gravel bed	Cobbles, gravel to sandy bottom leaf litter
Temperature	16-30 °C	16-30 °C	<20 °C	16 - 20°C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Omnivorous: small fishes, benthic invertebrates larvae, mollusc, crab, fronts and seeds etc.,	Benthic invertebrates larvae, worms etc.,	Not applicable	Periphytic algae and diatoms
Breeding period	March to September			
Passage requirement	Moves long distance to streams associated with main river, nearby side channels, shallow water and pools to breed			
Migration timings	March to September			
Migration cues	Change in flow pattern and water temperature may be a factor which triggers the breeding migration			

3. Snow Trout (*Schizothorax richardsonii*) – IUCN status: Vulnerable

This native species commonly occurs in the western Himalayas and Trans-Himalayan region especially upstream of Indus, Ganges and Bhramaputra rivers (Talwar and Jhingran, 1991) and it is rare in Ladakh (Sivakumar, 2008). *Schizothorax richardsonii* gains weight up to 1 kg and attains a length up to 40 cm in length. The female fishes spawn in natural as well as in artificial environment in two seasons *viz.* April to September. Sexually matured *S. richardsonii* (when they reach 18-24 cm length) spawn naturally in clear water on gravelly / stony ground or on fine pebbles at 10-30 cm depth. Water current of 0.5-1.5 m/sec, pH 7.5, dissolved oxygen concentration of 8-12 mg/L and gravel size of 50-60 mm are the optimum conditions for spawning. Adults feed on periphytic algae, diadems, detritus and rarely feed on aquatic insects. Juveniles feed on peripytons and diatoms. Although *Schizothorax richardsonii* is widely distributed along the Himalayan foothills and previous studies have indicated that it is abundant and commonly found, recent observations over the last 5 to 10 years indicate drastic declines in many areas of its range due to introduction of exotics (especially brown trout), damming and overfishing. In some areas, declines are more than 90% (IUCN, 2011).

Table 7.8 Summary of the biology and flow-related ecological requirements of snow trout (*Schizothorax richardsonii*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	>0.5 m	0.1 - 1 m	0.5 - 1.00 m	0.1 - 1.00 m
Velocity	Low to high (0.5-1.5 m/s)	Low to medium (0.5-1.0 m/s)	Low to medium (0.5 -1.0 m/s)	Low (0.1-0.5 m/s)
Habitat	Riffles, pools, glides,	Riffles, glides, closer to the banks	Low gradient riffle Glides	Back water pools and bank undercuts
Substratum	Boulders, Cobbles, Pebbles, Gravel	Cobbles, boulders, pebbles, gravel	Cobbles, pebbles, gravel	Cobbles, gravel
Temperature	4-20 °C	4-20 °C	<15 °C	4-15°C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of periphytic algae and diatoms. Also feed on benthic invertebrates	Periphytic algae and diatoms.	Not applicable	Diatoms
Breeding Period	April to September			
Passage Requirement	This species is a migrant species, moves from river to upstreams and adjoin streams for spawning.			
Migration Timings	April to September			
Migration cues	Movement is believed to be triggered by the variation in water temperature and flow.			
Other flow-related Needs	Flow may be a crucial factor for the migration of this species.			

3. Chaguni carp (*Chagunius chagunio*) IUCN status: Endangered.

Chagunius chagunio is a minor carb, distributed in the Ganga and Brahmaputra drainages of northern and northeastern India, Nepal and Bangladesh. *C. chagunio* is generally found in large rivers characterised by rocky bottom, clear and fast flowing water, with little or no vegetation and temperature ranges between 22°C and 27°C (Edds, 2007). Adults are found in habitats with swift flowing water and juveniles prefer moderate flow. It is a bottom feeder and attains a total length of 45 cm (Menon, 1999). Omnivorous in feeding habits, its diet largely consists of aquatic insects, crustaceans and detritus. It is a migratory species, migrates upstream for spawning during April to June (Shrestha, 1999). Habitat of this species is being degraded in its native ranges due to deforestation and illegal fishing techniques, dams, sand quarry and mining (IUCN, 2011).

Table 7.9 Summary of the biology and flow-related ecological requirements of chaguni carp (*Chagunius chagunio*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	>1.0 m	0.5 - 1 m	0.4 - 1.00 m	0.4 - 1.00 m
Velocity	Medium (0.1-0.5 m/s)	Low to medium (0.05-0.2 m/s)	Low to medium (0.05-0.2 m/s)	Low (0.05- 0.1 m/s)
Habitat	Pools, riffles	Pools, closer to the banks	Back water pools and bank undercuts	Back water pools and bank undercuts
Substratum	Boulders, cobbles, pebbles, gravel, sand	Cobbles, boulders, pebbles, gravel, sand, leaf litter	Boulders undercut, cobbles, pebbles	Boulders undercut, cobbles, pebbles
Temperature	22 - 27 °C	22 - 27 °C	< 20 °C	< 20 °C
Dissolved O_2	8-10 mg/l	8-10 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of benthic invertebrates, crustaceans, detritus	benthic invertebrates, detritus	Not applicable	Diatoms
Breeding period	April to June			
Passage requirement	This species is a migrant species, moves from river to upstreams and adjoin streams for spawning.			
Migration timings	April to June			
Migration cues	Movement is believed to be triggered by the variation in water temperature and flow.			
Other flow-related needs	Flow may be a crucial factor for the migration of this species.			

4. Indian torrent cat fish (*Amblyceps mangois*) – IUCN status: Endangered.

Amblyceps mangois is a small cat fish belonging to the family Amblyceipitidae. It was described from the Kosi River, a tributary of the Ganges river (Hamilton, 1822). This species was previously thought to be very widespread and variable in form, ranging from the Indus river eastwards to the northern part of the Malayan Peninsula (Hora, 1933). However, Ng and Kottelat (2000) restrict *A. mangois* to the northern part of the Indian subcontinent. *A. mangois* is generally found in fast flowing upland streams with rocky bottom, clear and fast flowing water. It is a bottom dwelling cat fish, feeds largely on aquatic insects and attains a total length of 12.5 cm (Talwar and Jhingran, 1991). The major threats to this species are habitat modification via the removal of river bed materials substrate (for construction) and over fishing as incidental bycatch (Prasad *et al.* 1997; IUCN, 2011).

Table 7.10 Summary of the biology and flow-related ecological requirements of Indian torrent cat fish (*Amblyceps mangois*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 - 1.5 m	0.2 – 1.0 m	>0.5 m	0.2 – 0.10 m
Velocity	Medium (0.1-1.0 m/s)	Low (0.05 - 0.1 m/s)	Medium (0.1-1.0 m/s)	Low (0.05 - 0.1 m/s)
Habitat	Run, Pools, backwater pools	Pools, backwater pools	Run, backwater pools	Run, backwater pools
Substratum	Cobbles, pebbles, gravels	Cobbles, pebbles, gravels, sand	Cobbles, pebbles, gravels	Cobbles, pebbles, gravels, sand
Temperature	20-25 °C	20-25 °C	<20 °C	18-20°C
Dissolved O_2	6 - 8 mg/l	6 - 8 mg/l	8-10 mg/l	8-10 mg/l
Food	Benthic invertebrates	Benthic invertebrates, worms	Not applicable	Worms
Breeding period	May to July.			
Passage requirement	This species is not a migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	-			

5. Sucker throat cat fish (*Pseudecheneis sulcatus*) - IUCN status: Vulnerable.

Pseudecheneis sulcatus is distributed in the Himalayan foothills of the Ganges and Brahmaputra River drainage in India. This species is found in swift hillstream, typically with torrential areas and riffles and a substrate of coarse gravel and fine sand. It is a carnivore and predates mostly on benthic aquatic insects. This species attains a total length of 20 cm (Menon, 1999). Construction of dams, shifting cultivation and destructive fishing are the major threats to this species.

Table 7.11 Summary of the biology and flow-related ecological requirements of Sucker throat cat fish (*Pseudecheneis sulcatus*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 – 1.5 m	0.5 – 1.0 m	0.5 – 1.0 m	0.5 – 1.0 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1.0 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (>0.1 m/s)
Habitat	Riffles, cascades, glides	Riffles, cascades, glides	Riffles, run	Run
Substratum	Cobbles, pebbles, gravely beds	Cobbles, pebbles, gravely beds	Pebbles and gravels	Pebbles and gravels
Temperature	4-18 °C	4-18 °C	<15 °C	10-16°C
Dissolved O2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic invertebrates	Benthic invertebrates	Not applicable	Worms
Breeding period	Probably May to July. Gravid females were found during July			
Passage requirement	This species is locally migrates for breeding			
Migration timings	After the monsoon			
Migration cues	Fresh oxygenated water			
Other flow-related needs	Survival of this species needs continuous flow of water.			

6. Goonch (*Bagarius bagarius*) – IUCN status: Vulnerable.

Goonch, a giant catfish grows well over 200 kg and is the biggest fish in the Gangetic system. It is one of the popular game fishes of India. It inhabits rapid and rocky pools of large and medium-sized rivers on the bottom, even with swift currents and enters small streams. It is carnivorous and primarily feeds on insects, fishes, frogs and shrimps. *Bagarius bagarius* is a migratory fish. The main upstream migration begins close to the peak of flood, when the current is very strong and the water is turbid. It breeds in rivers prior to the beginning of the annual flood season. *Bagarius bagarius* are harvested heavily in different parts of its range as food fish and for ornamental trade and as sport fish. Recent survey report indicates that this species is suffering declines in parts of its range. A considerable decline in the population in southern West Bengal of 29.2% over four decades from 1960 to 2000 has been reported (Mishra *et al*. 2009).

Table 7.12 Summary of the biology and flow-related ecological requirements of Goonch (*Bagarius bagarius*) in Alaknanda and Bhagirathi river basin.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	> 1.0 m	1.0 – 1.5 m	0.25 – 0.5 m	0.25 – 0.5 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (0.1-1 m/s)
Habitat	Riffles, pools	Riffles, pools, glides	pools, riffle	Pools and bank undercuts
Substratum	Cobbles, boulders, pebbles, also stony to gravely beds	Cobbles, boulders, pebbles, also stony to gravely beds	Fine gravel	Cobbles, boulders, pebbles, also stony to gravely beds fine gravel
Temperature	18°C - 25°C	18°C - 25°C	18 - 20 °C	18 - 20 °C
Dissolved O_2	6-10 mg/l	6-10 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic insects, fishes, frog, crustaceans	Benthic invertebrate larvae, worms, fish fry	Not applicable	Not known
Breeding period	July to August			
Passage requirement	Migratory fish, requires very strong current and turbid water.			
Migration timings	Upstream migration begins close to the peak of flood			
Migration cues	Monsoon flow			
Other flow-related needs	They are specialized in torrential flow; it may be a crucial factor for spawning of this species.			

7. Hillstream cat fish (*Glyptothorax cavia*) – IUCN status: Endangered.

This catfish inhabits montane regions under stones and rocks. It is distributed in the headwaters of Himalaya. It is a specialized hillstream cat fish and prefers riffles and cascade habitats with torrential flows. It is carnivorous and predates mostly on benthic aquatic insects. It attains a total length of 16.5 cm (Menon, 1999). Main threats to this species are siltation, boulders and gravel extraction, sand mining etc.

Table 7.13 Summary of the biology and flow-related ecological requirements of hillstream cat fish (*Glyptothorax cavia*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.2 - 0.5 m	0.2 – 0.5 m	0.2 – 0.5 m	0.1 – 0.20 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1.0 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (>0.1 m/s)
Habitat	Riffles, cascades, glides	Riffles, cascades, glides	Riffles, Run	Run
Substratum	Cobbles, pebbles, gravely beds	Cobbles, pebbles, gravely beds	Pebbles and gravels	Pebbles and gravels
Temperature	4-18 °C	4-18 °C	<15 °C	10-16°C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic Invertebrates	Benthic Invertebrates	Not applicable	Worms
Breeding period	Probably May to July. Gravid females were found during July			
Passage requirement	This species is locally migrates for breeding			
Migration timings	After the monsoon			
Migration cues	Fresh oxygenated water			
Other flow-related needs	Survival of this species needs continuous flow of water.			

8. Hillstream cat fish (*Glyptothorax telchitta*) – IUCN status: Endangered.

Glyptothorax telchitta is known from the Ganges and Bhramaputra drainages in India. It is a specialized hillstream cat fish and prefers riffles and cascade habitats with torrential flows. It is carnivorous and predates mostly on benthic aquatic insects. It attains a total length of 10 cm (Menon, 1999). Since there is little information on the biology of this species and therefore the impact of potential threats (especially those of an anthropogenic nature) remains unknown. The human made activities such as siltation, boulders and gravel extraction, sand mining adversely affect the feeding and breeding habitats of this species.

Table 7.14 Summary of the biology and flow-related ecological requirements of hillstream cat fish (*Glyptothorax telchitta*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.2 - 0.5 m	0.2 – 0.5 m	0.2 – 0.5 m	0.1 – 0.20 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1.0 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (>0.1 m/s)
Habitat	Riffles, cascades, glides	Riffles, cascades, glides	Riffles, Run	Run
Substratum	Cobbles, pebbles, gravely beds	Cobbles, pebbles, gravely beds	Pebbles and gravels	Pebbles and gravels
Temperature	4-18 °C	4-18 °C	<15 °C	10-16°C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic Invertebrates	Benthic Invertebrates	Not applicable	Worms
Breeding period	Probably May to July. Gravid females were found during July			
Passage requirement	This species is locally migrates for breeding			
Migration timings	After the monsoon			
Migration cues	Fresh oxygenated water			
Other flow-related needs	Survival of this species needs continuous flow of water.			

9. Chola barb (*Puntius chola*) – IUCN status: Vulnerable.

Puntius chola is a small barb distributed throughout India, Nepal, Bangladesh, Sri Lanka, Myanmar and Pakistan. It Inhabits streams, rivers, canals, beels and ponds and inundated fields. *P. chola* is a column feeder found in subtropical condition 20°C - 25°C and attains maximum length of 12 cm (Talwar and Jhingran, 1991). Omnivorous in feeding habits, its diet largely consists of aquatic insects, worms, crustaceans and plant.

Table 7.15 Summary of the biology and flow-related ecological requirements of Chola barb (*Puntius chola*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 - 1.0 m	0.5 – 1.0 m	0.5 - 1.0 m	>0.5 m
Velocity	Low to medium (0.05-0.2 m/s)	Low to medium (0.05-0.2 m/s)	Low to medium	Low >0.05 m/s)
Habitat	pools, Runs,	Pools, closer to the banks	Back water pools and bank undercuts	Back water pools and bank undercuts
Substratum	Cobbles, Pebbles, Gravel, Sand	Cobbles, boulders, pebbles, gravel, sand, leaf litter	Boulders undercut, Cobbles, pebbles	Boulders undercut, Cobbles, pebbles
Temperature	22 - 28 °C	22 - 28 °C	< 20 °C	< 20 °C
Dissolved O_2	6-8 mg/l	6-8 mg/l	8 mg/l	8 mg/l
Food	Large portion of benthic invertebrates and detritus	benthic invertebrates, detritus	Not applicable	Diatoms
Breeding period	Not known			
Passage requirement	Non migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	-			

10. Olive barb (*Puntius sarana*) – IUCN status: Vulnerable.

This barb is distributed in all northern and northeast Indian rivers and tanks. It attains a length of 31 cm. It breeds during monsoon in running waters amongst submerged boulders and vegetation (Talwar and Jhingran, 1991). Spawning occurs in two stages once between May to mid September but prominent in June and the second spawning time is the months of August and September (Chakraborty *et al.*, 2007). It forms schools in groups of four or five to several dozens (Pethiyagoda, 1991). *P. sarana* feeds on aquatic insects, fish, algae and shrimps. It spawns in running waters among submerged boulders and vegetation and spawns in running waters among submerged boulders and vegetation (Talwar and Jhingran, 1991).

Table 7.16 Summary of the biology and flow-related ecological requirements of Olive barb (*Puntius sarana*) in Alaknanda and Bhagirathi river basin.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	>1.0 m	0.5 - 1 m	0.4 - 1.00 m	0.4 - 1.00 m
Velocity	Medium (0.1-0.5 m/s)	Low to medium (0.05-0.2 m/s)	Low to medium (0.05-0.2 m/s)	Low (0.05- 0.1 m/s)
Habitat	pools, Riffles,	Pools, closer to the banks	Back water pools and bank undercuts	Back water pools and bank undercuts
Substratum	Boulders, Cobbles, Pebbles, Gravel, Sand	Cobbles, boulders, pebbles, gravel, sand, leaf litter	Boulders undercut, Cobbles, pebbles	Boulders undercut, Cobbles, pebbles
Temperature	22 - 27 °C	22 - 27 °C	< 20 °C	< 20 °C
Dissolved O_2	8-10 mg/l	8-10 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of benthic invertebrates, crustaceans, detritus, plant matters	benthic invertebrates, detritus	Not applicable	Diatoms
Breeding period	May to June; August - September			
Passage requirement	Non migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	-			

11. Gotyla garra (*Garra gotyla gotyla*) – IUCN status: Vulnerable.

Garra gotyla gotyla is a small sucker fish and it has a wide distribution all along the Himalaya, Chota-Nagpur plateau and the Vindhaya-Satpura mountains of the Indian Peninsula, Uttarakhand (Dehra Dun, Tehri, Pauri, Uttarkashi, Chamoli, Nainital, Almora, Pithoragarh), Arunachal Pradesh, Assam, Bihar, Chattisgarh and Jharkand (Talwar and Jhingran, 1991). This species attains a length of 14 cm. This species inhabits swift flowing streams with bedrock and boulders and they are substrate specialist. It is herbivorous, bottom feeder and feeds largely on algae and detritus (Sharma, 1990). Though it is wildly distributed, removal of boulders, sand mining, siltation and damming are the major threat to this species.

Table 7.17 Summary of the biology and flow-related ecological requirements of Gotyla garra (*Garra gotyla gotyla*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 - 1.0 m	0.5 - 1 m	0.4 - 1.00 m	0.4 - 1.00 m
Velocity	Low to high (0.5-1.5 m/s)	Low to medium (0.5-1.0 m/s)	Low to medium (0.5 -1.0 m/s)	Low (0.1-0.5 m/s)
Habitat	Riffles, pools, glides,	Riffles, glides, closer to the banks	Low gradient riffle Glides	Back water pools and bank undercuts
Substratum	Boulders, Cobbles, Pebbles, Gravel	Cobbles, boulders, pebbles, gravel	Cobbles, pebbles, gravel	Cobbles, gravel
Temperature	18 - 24 °C	18 - 24 °C	18- 20 °C	18- 20 °Cs
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of periphytic algae and diatoms.	Periphytic algae and diatoms.	Not applicable	Diatoms
Breeding period	April to September			
Passage requirement	Non migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	They require torrential flows; it may be a crucial factor for survival of this species.			

11. Lamta Garra (*Garra lamta*) – IUCN status: Vulnerable.

Garra lamta is a small sucker fish and it has a restricted distribution in northern and north eastern Himalaya and is reported from Assam, Bihar, Darjeeling, Kumaon Himalaya (IUCN, 2011). This species attains a total length of 13.4 cm. Like Gotyla stone sucker, this species is also a habitat specialist and inhabits swift flowing streams with bedrock and boulders. It is found in tropical temperature (24°C - 27°C). It is herbivorous and feeds largely on algae and detritus. Removal of boulders, sand mining, siltation and damming are the major threats to this species.

Table 7.18 Summary of the biology and flow-related ecological requirements of Lamta garra (*Garra lamta*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 - 1.0 m	0.5 - 1 m	0.4 - 1.00 m	0.4 - 1.00 m
Velocity	Low to high (0.5-1.5 m/s)	Low to medium (0.5-1.0 m/s)	Low to medium (0.5 -1.0 m/s)	Low (0.1-0.5 m/s)
Habitat	Riffles, pools, glides,	Riffles, glides, closer to the banks	Low gradient riffle Glides	Back water pools and bank undercuts
Substratum	Boulders, Cobbles, Pebbles, Gravel	Cobbles, boulders, pebbles, gravel	Cobbles, pebbles, gravel	Cobbles, gravel
Temperature	24 - 27 °C	24 - 27 °C	20 - 24 °C	20 - 24 °C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of periphytic algae and diatoms.	Periphytic algae and diatoms.	Not applicable	Diatoms
Breeding period	April to September			
Passage requirement	Non migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	They require torrential flows; it may be a crucial factor for survival of this species.			

12. Gangetic latia (*Crossocheilus latius*) – IUCN status: Vulnerable.

In India, Crossochilus latius is reported from drainages of the Ganga and Brahmaputra in northern India; Mahanadi River drainage, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Tripura, India. It is a bottom dowelling small cyprinids, mostly found in flowing streams with gravel bed. They are herbivorous and largely feed on periphytic algae and diatoms. This species attains a total length of 12.5 cm and it is highly sought after aquarium trade. They are found in tropical temperature (22°C - 27°C). Removal of boulders, sand mining, siltation and damming are the major threats to this species.

Table 7.19 Summary of the biology and flow-related ecological requirements of Gangetic latia (*Crossocheilus latius*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 - 1.0 m	0.5 - 1 m	0.4 - 1.00 m	0.4 - 1.00 m
Velocity	Low to high (0.5-1.5 m/s)	Low to medium (0.5-1.0 m/s)	Low to medium (0.5 -1.0 m/s)	Low (0.1-0.5 m/s)
Habitat	Riffles, pools, glides,	Riffles, glides, closer to the banks	Low gradient riffle Glides	Back water pools and bank undercuts
Substratum	Boulders, Cobbles, Pebbles, Gravel	Cobbles, boulders, pebbles, gravel	Cobbles, pebbles, gravel	Cobbles, gravel
Temperature	22 - 27 °C	22 - 27 °C	18- 22 °C	18- 22 °Cs
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Large portion of periphytic algae and diatoms.	Periphytic algae and diatoms.	Not applicable	Diatoms
Breeding period	April to September			
Passage requirement	Non migrant			
Migration timings	-			
Migration cues	-			
Other flow-related needs	They are specialized in torrential flow; it may be a crucial factor for survival of this species.			

13. Necktie loach (*Botia dario*) – IUCN status: Vulnerable.

Botia dario is a popular aquarium in the ornamental trade. The body is marked with seven to eight attractive oblique vertical bands, descending from back to abdomen. It is distributed in the Ganga and Brahmaputra drainages in India. It is a bottom dowelling species, mostly found in clear mountain streams with gravel bed. It is omnivorous in feeding habits and it feeds on aquatic insects larvae, worms, detritus etc. This species attains a total length of 9 cm and prefer temperature 23°C - 26°C. Major threats to this species are overexploitation for international ornamental fish trade, habitat modifications due to sand mining and gravel extractions.

Table 7.20 Summary of the biology and flow-related ecological requirements of Necktie loach (*Botia dario*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 – 1.0 m	0.25 – 0.5 m	0.25 – 0.5 m	0.25 – 0.5 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (0.1-1 m/s)
Habitat	Riffles, pools, glides	Riffles, pools, glides	pools, glides	Pools and bank undercuts
Substratum	Cobbles, boulders, pebbles, also stony to gravely beds	Cobbles, boulders, pebbles, also stony to gravely beds	Fine gravel	Cobbles, boulders, pebbles, also stony to gravely beds fine gravel
Temperature	23- 26 °C	23- 26 °C	18 - 20 °C	18 - 20 °C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic invertebrate larvea, worms, algae etc.	Benthic invertebrate larvae, worms	Not applicable	Not known
Breeding period	Probably May to September. Gravid females were found during July and August			
Passage requirement	Non migrant species.			
Migration timings	-			
Migration cues	-			
Other flow-related needs	They require torrential flows; it may be a crucial factor for survival of this species.			

14. Multi-banded loach (*Schistura multifasciatus*) – IUCN status: Vulnerable.

Schistura multifasciata is disturbed in the Himalayan foothills of the Ganges River drainage in India and Nepal. Found in shallow, gently flowing clear streams/creeks and riffles, over gravel or pebbles. It is a bottom dweller and feeds mostly on worms and detritus. It is threatened by ornamental fish trade and from declining habitat quality. This species attains a total length of 12 cm and prefers temperature 18°C - 25°C. Major threats to this species are overexploitation for international ornamental fish trade, habitat modification due to sand mining and gravel extractions.

Table 7.21 Summary of the biology and flow-related ecological requirements of multibanded loach (*Schistura multifasciata*) in Alaknanda and Bhagirathi river basins.

	Adults	Juveniles	Spawning	Incubation and larval development
Depth	0.5 – 1.0 m	0.25 – 0.5 m	0.25 – 0.5 m	0.25 – 0.5 m
Velocity	low to high (0.1-1.5 m/s)	Low to medium (0.1-1 m/s)	Low to medium (0.1 -1 m/s)	Low to medium (0.1-1 m/s)
Habitat	Riffles, pools, glides	Riffles, pools, glides	Pools, glides	Pools and bank undercuts
Substratum	Cobbles, boulders, pebbles, also stony to gravely beds	Cobbles, boulders, pebbles, also stony to gravely beds	Fine gravel	Cobbles, boulders, pebbles, also stony to gravely beds fine gravel
Temperature	18°C - 25°C	18°C - 25°C	18 - 20 °C	18 - 20 °C
Dissolved O_2	8-12 mg/l	8-12 mg/l	8-12 mg/l	8-12 mg/l
Food	Benthic invertebrate larvea, worms, algae etc.	Benthic invertebrate larvae, worms	Not applicable	Not known
Breeding period	Gravid females were found during July and August			
Passage requirement	Non migrant species.			
Migration timings	-			
Migration cues	-			
Other flow-related needs	They require torrential flows; it may be a crucial factor for survival of this species.			

7.4.1. Estimation of Minimum Environment Flow based on requirements of aquatic biodiversity especially fishes

A total of 66 species have been reported from the habitat of golden mahseer (*Tor putitora)* in the Alaknanda and Bhagirathi Basins. Environmental water requirement of golden mahseer was observed to be greater than any other fish species that occurs in the mahseer zone. Moreover, maximum 11 species were found at a sampling point in the mahseer zone with an average of seven species per sampling station.

There are 28 Hydro Electric Projects that either exist or are under construction or proposed in the exclusive mahseer zone of the Alaknanda and Bhagirathi basins. The mahseer zone is already fragmented and is likely to fragment further due to proposed or under construction HEPs.

Table 7.22 Details of Hydro Electric Projects existing/under construction/proposed in the exclusive Mahseer Zone.

S.No.	Projects site Name	River/Stream/Tributary Name
1.	Bhilangana	Bhilangana
2.	Dewal	Kail ganga
3.	Maneri bhali I	Bhagirathi
4.	Maneri bhali II	Bhagirathi
5.	Rajwakti	Nandakini
6.	Tehri stage-I	Bhagirathi
7.	Vanala	Nandakini
8.	Bhilangana-III	Bhilangana
9.	Kail ganga	Kail ganga
10.	Koteshwar	Alaknanda
11.	Lohari Nagpala	Bhagirathi
12.	Singoli Bhatwari	Mandakini
13.	Srinagar	Alaknanda
14.	Balganga-II	Balganga
15.	Bhilangana-IIA	Bhilangana
16.	Bhilangana-IIB	Bhilangana
17.	Bhilangana-IIC	Bhilangana
18.	Bowla Nandprayag	Alaknanda
19.	Devsari	Pinder
20.	Devali	Nandakini
21.	Kotbudhakedar	Balganga
22.	Kotlibhel IA(Bhagirathi)	Bhagirathi
23.	Kotlibhel IB (Alaknanda)	Alaknanda
24.	Kotlibhel II	Ganga
25.	Melkhet	Pinder
26.	Nandprayag Langasu	Alaknanda
27.	Tehri stage-II	Bhagirathi
28.	Vishnugad Pipalkoti	Alaknanda

A total of 27 species have been reported from the exclusive habitat of snow trout (*Schizothorax richardsonii)* in the Alaknanda and Bhagirathi basins. Environmental water requirement of snow trout was observed to be either equal or greater than any other fish species that occurs in the exclusive snow trout zone. Moreover, maximum 6 species were found at a sampling point in the exclusive snow trout zone with an average of four species per sampling station. There are 18 Hydro Electric Projects that either exist or under construction or proposed in the exclusive snow trout zone of the Alaknanda and Bhagirathi basins. Some of the snow trout habitats in the basin have already been fragmented by HEPs. Invasive brown trout was also found to be expanding its range in the exclusive snow trout zone, possibly due to climate change or changes in the environmental flow or barrier effect caused by existing HEPs.

Table 7.23 Details of Hydro Electric Projects existing / under construction / proposed in the exclusive snow trout zone.

Sl.No	Projects site Name	River/Stream/Tributary Name
1	Agunda thati	Dharam ganga
2	Pilangad	Pilangad
3	Birahi ganga	Birahi ganga
4	Asiganga-I	Asiganga
5	Asiganga-II	Asiganga
6	Asiganga-III	Asiganga
7	Bharon Ghati(I,II) including Harsil	Bhagirathi
8	Birahi ganga-I	Birahi ganga
9	Birahi ganga-II	Birahi ganga
10	Gohana Tal	Birahi ganga
11	Jalandharigad	Jalandhari
12	Jhala koti	Balganga
13	Pala Maneri	Bhagirathi
14	Pilangad-II	Pilangad
15	Suwarigad	Suwarigad
16	Urgam-II	Kalpganga
17	Kaliganga-II	Kaliganga
18	Madhmesheshwar	Madhmesheshwar

Minimum environmental flow required in the dry zones of the various Hydro Electric Projects of the Alaknanda and Bhagirathi Basin was calculated after fulfilling the observed habitat requirements of certain fishes mentioned above in this report. The habitat rating method has been combined with

Building Block Method for estimating the minimum ecological flow for the river. In habitat rating method, the final outputs, usually in the form of habitat-discharge curves for the target biota, have been used to predict optimum discharges as environmental flow recommendations. The suggested minimum environmental flow have been given Table 7.24 & 7.25. As expected, there is a strong correlation between the flow and species richness (Fig. 7.2, R^2=0.5007, $p<0.001$)). More number of species occurred in the downstream where the water flows were also high. During this study, maximum number of species i.e. 11 (with Mean=7, SD=2.3) were found in a single sampling station (N=7 sampling stations) in the mahseer zone where the average flow recorded was 8.1± SD 6.2 cumec/day (during the lean season). Of these, two sampling sites were in the downstream of Nandprayag, where the flows were 17 cumec/day. The observed flow of 8.1 cumec/day in the mahseer zone (where maximum number of species found) was approximately 20% of average flow of lean seasonal flow.

Similarly, maximum number of species i.e. six (Mean=4, SD 2.1) were found in a single sampling station in the trout zone when the average flow was 0.05 cumec/day. The observed flow of 0.05 cumec/day in the trout zone (where maximum number of species found) was approximately 20% of average flow of lean seasonal flow. Therefore, baseline for minimum required flow of 20% was set during the lean season while applying modified Building Block Method, while fixing the Minimum Environmental Flow. The estimated 20% flow of lean season is also expected to fulfill the habitat requirements of 16 threatened species mentioned above.

Fig. 7.2 Relationship between the river flow and species richness in the Alaknanda and Bhagirathi basins.

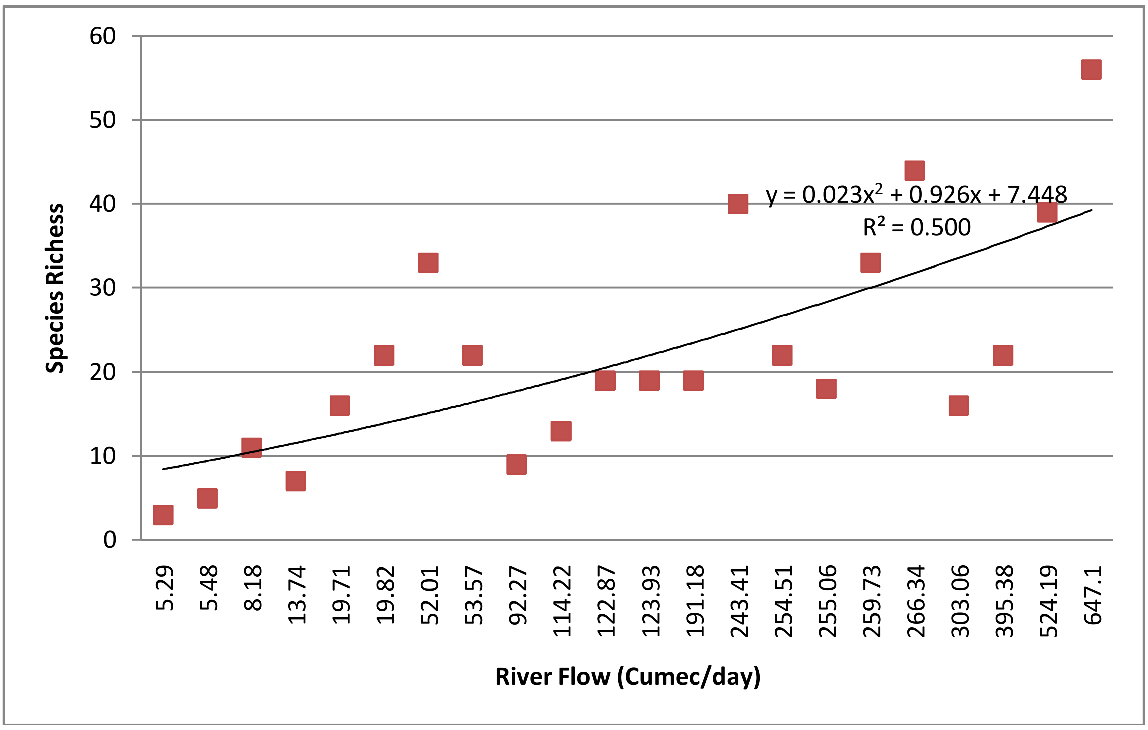


Table 7.24 Minimum flow required to sustain riverine ecology with special reference to fishes in the dry zones of HEPs in the Alaknanda and Bhagirathi basins.

Month	Percentage of Mean Seasonal Flow suggested (%) (Cumec/day)
June	30
July	30
August	30
September	30
October	25
November	20
December	20
January	20
February	20
March	20
April	25
May	30

Daily requirements of minimum environmental flow (MEF) has been calculated using Mean Annual Flow (**Fig.** 7.3) and also using mean monthly flows (**Fig.** 7.4) at Kotli Bhel IA. Both these flows were checked to determine whether the calculated flows provided the similar environmental and seasonal cues (**Fig.** 7.5) to fishes to maintain their normal breeding and migratory behavior or not. Similar analysis were also carried out for all sites of HEPs in the basin. It was found that calculated flows with respect to Mean Monthly Flows are better than flows calculated using Mean Annual Flows. Therefore, flows calculated with reference to Mean Monthly Flow have been suggested as the Minimum Environmental Flows required to fulfill the ecological requirements of dry zones.

Fig. 7.3 Calculated Minimum Environmental Flow (MEF) with reference to Mean Annual Flow (i.e. 20% of MAF) at Kotlibhel IA.

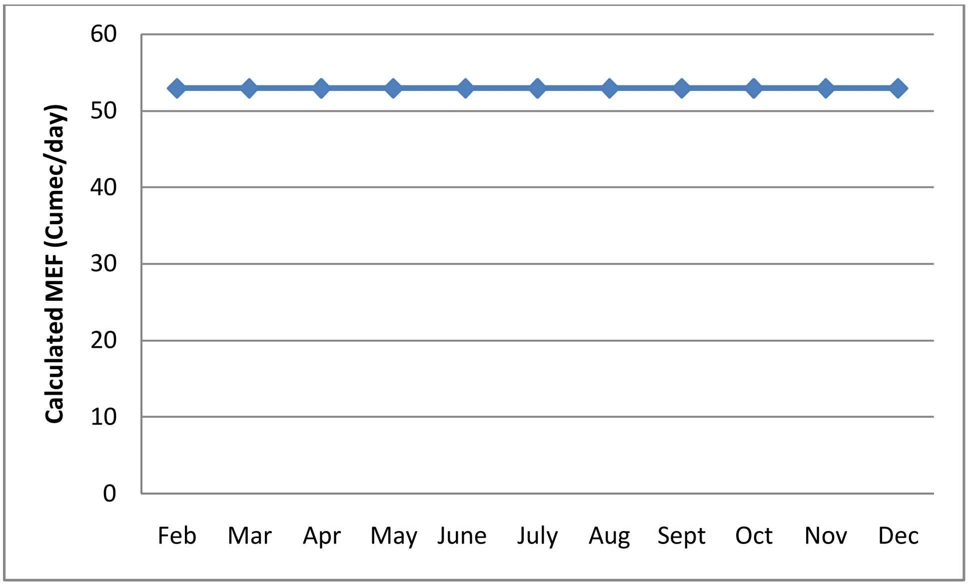


Fig. 7.4 Calculated Minimum Environmental Flow (MEF) with reference to Mean Monthly Flow (i.e. 20%, 25% and 30% of MMF depending upon season) at Kotlibhel IA.

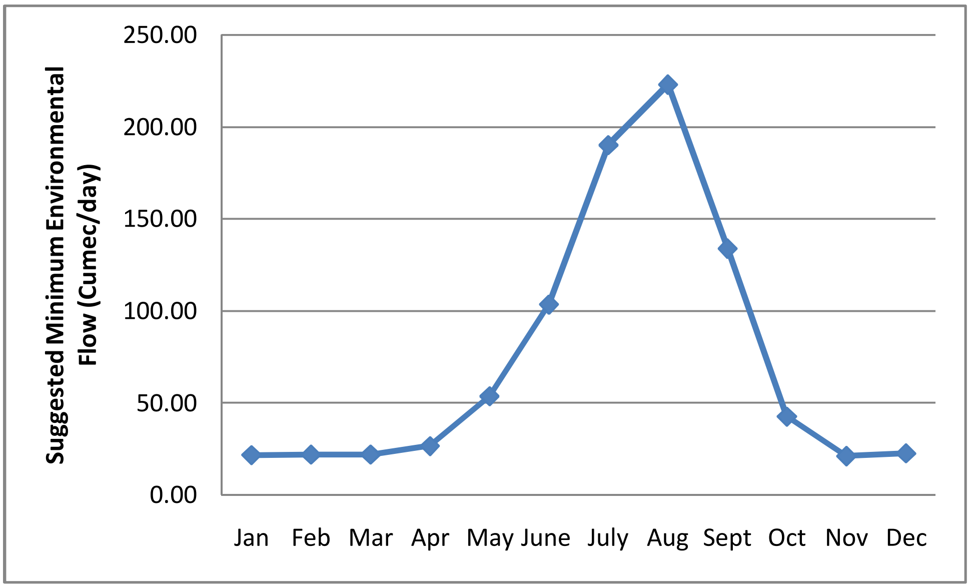


Fig. 7.5 Observed Mean Monthly Flows during past few years at Kotibhel IA (IIT-R Report, 2011).

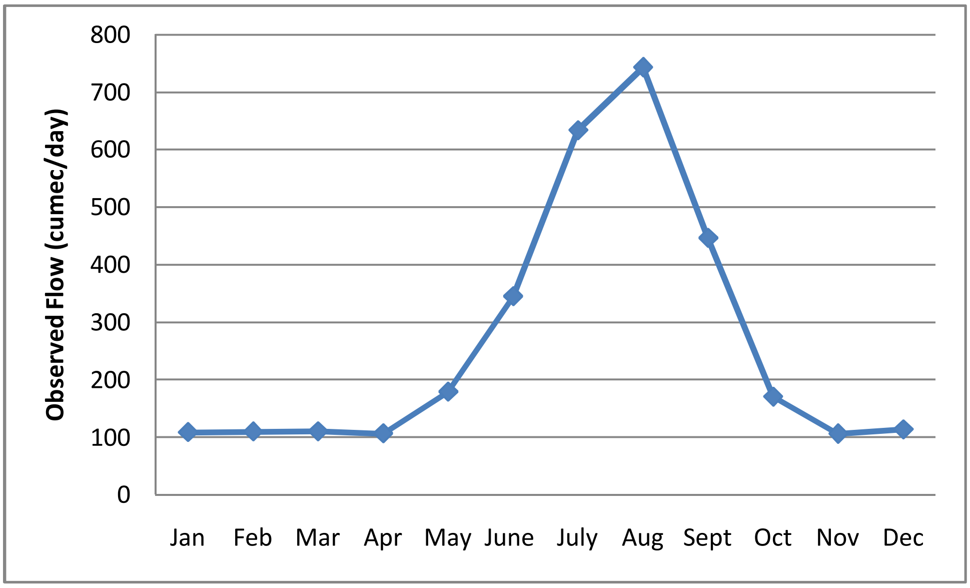


Table 7.25 Suggested Environmental Minimum Flow required to sustain riverine ecology with special reference to fishes in the dry zones of HEPs in the Alaknanda and Bhagirathi Basin (cumec/day, Data source: IIT-R Report, 2011).

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	Bhagirathi River												
1	Asiganga-III	0.06	0.06	0.06	0.18	0.99	2.55	5.13	5.73	3.00	0.48	0.12	0.08
2	Agunda thati	0.84	0.86	0.84	0.93	1.26	1.62	2.43	3.18	2.43	1.28	0.76	0.86
3	Bhilangana-III	1.12	1.14	1.14	1.38	2.79	5.34	9.81	11.52	6.90	2.20	1.10	1.18
4	Bhilangana	7.92	8.12	8.04	8.75	11.82	15.39	23.10	30.24	22.95	12.00	7.30	8.22
5	Lohari Nagpala	1.18	0.98	1.18	3.05	17.25	44.55	89.70	99.87	52.35	8.38	1.96	1.40
6	Maneri bhali I	1.46	1.22	1.46	3.78	21.36	55.14	111.03	123.63	64.80	10.38	2.44	1.74
7	Maneri bhali II	1.58	1.32	1.58	4.08	22.95	59.31	119.46	132.99	69.72	11.15	2.62	1.86
8	Tehri stage-I	19.94	20.12	20.20	24.40	49.14	94.65	173.76	203.79	122.46	39.00	19.46	20.82
9	Koteshwar	21.26	21.48	21.54	26.05	52.44	100.98	185.40	217.44	130.65	41.60	20.76	22.22
10	Kotlibhel I A	21.80	22.02	22.10	26.70	53.79	103.56	190.14	222.99	133.98	42.68	21.28	22.78
B	Alaknanda River												
2	Birahi ganga II	0.48	0.44	0.50	0.75	1.23	2.04	5.04	7.08	5.79	2.23	0.94	0.70
3	Bhyunder ganga	0.36	0.32	0.38	0.85	2.49	5.01	7.53	6.81	4.62	2.05	1.02	0.70
4	Phata Byung	1.10	1.22	1.32	1.70	2.70	4.74	11.91	15.90	9.54	3.20	1.50	1.60
5	Rajwakti	1.16	1.08	1.20	1.80	3.00	4.92	12.18	17.16	14.04	5.38	2.26	1.70
7	Singoli Bhatwari	2.62	2.78	3.42	5.53	8.97	14.40	37.56	53.01	32.64	10.43	4.60	3.84
8	Alaknanda	1.60	1.38	1.68	3.70	11.01	22.02	33.12	29.91	20.25	9.05	4.52	3.08
9	Devsari	1.16	1.10	1.20	1.80	2.97	5.25	12.66	17.31	13.65	4.93	2.14	1.50
10	Vishnuprayag	2.64	2.28	2.80	6.15	18.27	36.60	55.02	49.71	33.63	15.03	7.50	5.12
12	Vishnugad Pipalkoti	7.36	6.36	7.78	17.10	50.85	101.91	153.21	138.36	93.66	41.83	20.88	14.26
13	Nandaprayag Langrasu	9.82	8.48	10.40	22.83	67.86	135.96	204.39	184.62	124.98	55.83	27.86	19.02

7.5 Major findings

1. Minimum Environmental Flow Required (cumec/day) based on EMC of Rivers, for various sites in the Mahseer and Snow Trout zones of the Alaknanda and Bhagirathi Basins based on Environmental Management Class of the basins is given below.

		Season I (High Flow)	Season II (Average Flow)	Season III (Low Flow)	Season IV (Average Flow)
A	Bhagirathi River				
1	Asiganga-III	2.53	0.41	0.08	0.15
2	Agunda thati	1.59	1.11	0.91	0.81
3	Bhilangana-III	5.28	1.92	1.24	1.20
4	Bhilangana	15.04	10.46	8.63	7.63
5	Lohari Nagpala	44.14	7.30	1.46	2.66
6	Maneri bhali I	54.64	9.05	1.81	3.29
7	Maneri bhali II	58.78	9.72	1.95	3.55
8	Tehri stage-I	93.57	34.01	21.92	21.28
9	Koteshwar	99.83	36.28	23.38	22.72
10	Kotlibhel I A	102.38	37.21	23.98	23.28
B	Alaknanda River				
2	Birahi ganga II	3.08	1.94	0.67	0.65
3	Bhyunder ganga	3.85	1.79	0.61	0.74
4	Phata Byung	6.51	2.79	1.47	1.48
5	Rajwakti	7.46	4.69	1.61	1.57
7	Singoli Bhatwari	21.30	9.09	3.76	4.82
8	Alaknanda	16.90	7.89	2.67	3.23
9	Devsari	7.53	4.29	1.55	1.57
10	Vishnuprayag	28.08	13.10	4.43	5.36
12	Vishnugad Pipalkoti	78.19	36.47	12.35	14.91
13	Nandaprayag Langrasu	104.32	48.68	16.48	19.90

2. Minimum Environmental Flow Required (MEFR) to sustain riverine ecology with special reference to fishes in the dry zones of HEPs in the Alaknanda and Bhagirathi Basin (cumec/day) based on ecological requirements of fishes.

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	Bhagirathi River												
1	Asiganga-III	0.06	0.06	0.06	0.18	0.99	2.55	5.13	5.73	3.00	0.48	0.12	0.08
2	Agunda thati	0.84	0.86	0.84	0.93	1.26	1.62	2.43	3.18	2.43	1.28	0.76	0.86
3	Bhilangana-III	1.12	1.14	1.14	1.38	2.79	5.34	9.81	11.52	6.90	2.20	1.10	1.18
4	Bhilangana	7.92	8.12	8.04	8.75	11.82	15.39	23.10	30.24	22.95	12.00	7.30	8.22
5	Lohari Nagpala	1.18	0.98	1.18	3.05	17.25	44.55	89.70	99.87	52.35	8.38	1.96	1.40
6	Maneri bhali I	1.46	1.22	1.46	3.78	21.36	55.14	111.03	123.63	64.80	10.38	2.44	1.74
7	Maneri bhali II	1.58	1.32	1.58	4.08	22.95	59.31	119.46	132.99	69.72	11.15	2.62	1.86
8	Tehri stage-I	19.94	20.12	20.20	24.40	49.14	94.65	173.76	203.79	122.46	39.00	19.46	20.82
9	Koteshwar	21.26	21.48	21.54	26.05	52.44	100.98	185.40	217.44	130.65	41.60	20.76	22.22
10	Kotlibhel I A	21.80	22.02	22.10	26.70	53.79	103.56	190.14	222.99	133.98	42.68	21.28	22.78
B	Alaknanda River												
2	Birahi ganga II	0.48	0.44	0.50	0.75	1.23	2.04	5.04	7.08	5.79	2.23	0.94	0.70
3	Bhyunder ganga	0.36	0.32	0.38	0.85	2.49	5.01	7.53	6.81	4.62	2.05	1.02	0.70
4	Phata Byung	1.10	1.22	1.32	1.70	2.70	4.74	11.91	15.90	9.54	3.20	1.50	1.60
5	Rajwakti	1.16	1.08	1.20	1.80	3.00	4.92	12.18	17.16	14.04	5.38	2.26	1.70
7	Singoli Bhatwari	2.62	2.78	3.42	5.53	8.97	14.40	37.56	53.01	32.64	10.43	4.60	3.84
8	Alaknanda	1.60	1.38	1.68	3.70	11.01	22.02	33.12	29.91	20.25	9.05	4.52	3.08
9	Devsari	1.16	1.10	1.20	1.80	2.97	5.25	12.66	17.31	13.65	4.93	2.14	1.50
10	Vishnuprayag	2.64	2.28	2.80	6.15	18.27	36.60	55.02	49.71	33.63	15.03	7.50	5.12
12	Vishnugad Pipalkoti	7.36	6.36	7.78	17.10	50.85	101.91	153.21	138.36	93.66	41.83	20.88	14.26
13	Nandaprayag Langrasu	9.82	8.48	10.40	22.83	67.86	135.96	204.39	184.62	124.98	55.83	27.86	19.02

3. It is suggested to use the flows, whichever is maximum from the above suggested flows (Point No. 1 & 2).
4. Minimum Environmental Flow Required (MEFR) at the dry zones of HEPs were calculated only for those river stretches where flow data was available. However, the same flow is suggested for all other river stretches which are having similar flow/biodiversity values or else follow the methodological approach similar to Point No.1. In that case, MEFR should be 21.5% of Mean Seasonal Flow of river if it falls in the mahseer or trout zones. MEFR should be 14.5% of Mean Seasonal Flow if the river stretch falls in the 'no fish zone'.
5. The suggested minimum environmental flows in the Point No.1 & 2, would provide the necessary environmental cues to trigger the breeding and migration behavior of Himalayan fishes. Most importantly, the suggested Minimum Environmental Flows are only for the dry zones of the HEPs and not for the entire stretch of the rivers.
6. Minimum environmental flows suggested above need to be reviewed periodically in relation to changes in the population status of fishes that occur in the stretch. Periodic review may be carried out once in every five years with inputs from professional institutions such as National Institute of Hydrology, IIT-Roorkee, National Bureau of Fish Genetic Resources, Directorate of Cold Water Fisheries Research, Local Universities etc.

Chapter 8 – Conclusions and Recommendations

This report is an outcome of the study conducted in response to the directives of the Ministry of Environment and Forests (MoEF) vide letter no. F 8/9/2008-FC dated 23rd July 2010 (Annexure---) on cumulative impacts of Hydro Electric Projects in Alaknanda and Bhagirathi river basins in Uttarakhand.

Aims and methodology

- The focus of the study included assessment of the baseline status of rare, endangered and threatened (RET) species of flora and fauna; identification of the critically important habitats for RET species in the two basins; delineation of river stretches critical for conservation of RET aquatic species; and assessment of the minimum flows for ecological sustainability of the two rivers.
- The study adapted the globally applied cumulative environmental impact assessment (CEIA) approach for assessing impacts of existing and proposed Hydro Electric Projects within Alaknanda and Bhagirathi basins on aquatic and terrestrial biodiversity values. This assessment has led to the evaluation of the cumulative impacts of Hydro Electric Projects at the landscape level using the sub-basin as a smallest landscape unit.
- The entire Alaknanda and Bhagirathi basins have been categorised into 18 sub-basins based on drainage profile of rivers. There are 10 sub-basins within the Alaknanda basin, seven within Bhagirathi basin and one in Ganga basin.
- This assessment takes into account the cumulative impact of 70 Hydro Electric Projects of which 17 are existing, 14 are under-construction and 39 are proposed.

8.1 Aquatic component

8.1.1 Aquatic biodiversity profile

a) Of the 76 fish species found in the Alaknanda-Bhagirathi basins, a total of 66 species of fishes have been reported from the study area based on the data collected from the zones of influence of 70 Hydro Electric Projects. Sixteen species are globally threatened and 17 species are either long distance or local migrants.

b) The Cyprinidae is the major dominant family along with presence of other families like, Balitoridae and Sisoridae. Overall, the community structure in the basin is characterized by a few specialized cyprinid types, specifically the snow trouts (*Schizothorax spp*.), the mahseers (*Tor spp*.) the lesser barils (*Barilius spp*.), the hillstream loaches (*Nemacheilus spp.)* and the sisorid torrent cat fishes (*Glyptothorax spp*.).

c) The three sub-basins viz. Ganga, Alaknanda I and Bhagirathi IV sub-basin have "very high" fish biodiversity values (Fig. 5.1). The Ganga sub-basin harbours 56 fish species of the 76 species, including all16 threatened species and the two endemic species, recorded from the Alaknanda and Bhagirathi basins. The fish biodiversity value of this sub-basin is the highest among all the 18 sub-basins in the study area.

d) The Alaknanda I sub-basin harbours 64% of the total fish species in the study area. Out of the 16 threatened species in the study area, 12 species occur in this sub-basin and it is home to both the endemic species found in the study area. The Bhagirathi IV sub-basin harbours 63% of the total fish species in the study area and 12 species out of the 16 threatened species in the two major basins.

e) The Bhilangana, Balganga, Mandakini, Pindar, Nandakini, Bhagirathi II, Bhagirathi III, Alaknanda II, Birahi ganga and Asiganga sub-basins harbour "high" fish biodiversity values largely due to the presence of breeding/congregational sites and migratory pathways for species such as golden mahseers and snow trouts.

f) At least four exotic fish species have been found in the two basins. There is no record of fish presence above 2400 masl elevation.

g) Diverse habitats conducive for breeding and nursery grounds of mahseer, snow trouts etc were observed within the Balganga and the Ganga (Nayar) sub-basins.

h) High diversity of fishes was reported in the Mahseer zone. Sixty-six species were recorded in this zone including exotic carps (common, silver and mirror carps), mahseer (golden and silver mahseers) snow trouts (*Schizothorax* sp), Indian barils (*Barilius* spp.) and hill stream loaches (*Nemacheilus* spp.).

i) Twenty-seven species were reported from the exclusive trout zone including an exotic invasive species, the brown trout.

j) No fishes were reported from the zone of influence of 24 HEPs located within the high altitude ranges.

k) There was no observation on the presence of otters in the Alaknanda and Bhagirathi basins during this study. However, potential otter habitats occur in sub-basin Alaknanda I and Ganges.

8.1.2 Critically important fish habitats

a. Species diversity of fishes in the Alaknanda and Bhagirathi basin was observed to be increasing with increase in flow. It was found that there are two important rivers which are rain fed and relatively less disturbed such as Balganga (tributary of Bhagirathi) and Nayar (tributary of Ganga). These are important breeding grounds of mahseer and snow trout. Both these rivers are rain fed. As the temperature of their water is always relatively warmer than of other rivers in the basin, this may be conducive for mahseer and snow trout to spawn and rear. Based on this study these two small rivers are recognised as Important Aquatic Habitats in the basin, that should not be disturbed by any kinds of developmental activity including HEP. These identified critical fish habitats may be considered for declaring as 'Conservation Reserve'. The conservation value of the two critically important habitats is reiterated here.

b. Nayar – Ganges complex: Among all tributaries in the basin, the Nayar River was reported to have the highest number of 57 species. The Nayar river is the spring/rain fed tributary of the main Ganges adjoining the Alaknanda basin. Many cold water fishes including mahseer and snow trout were observed breeding in this river at least twice in a year especially during March and August. Heterogeneity in the habitats, gradual sloping throughout the river, excellent growth of algae on the substratum provide better food sources for fish and other microbes in the river, eutrophic condition, etc make this river more conducive for fishes to breed in the region. Therefore, this river has been identified as the critical fish habitat in these basins.

c. **Balganga river – Tehri reservoir complex:** An important tributary of Bhagirathi River with respect to fishes is Balganga River, which confluence with Bhilangna River and later join Tehri Reservoir. This eutrophic Balganga River and Tehri Reservoir complex is reported with minimum of 40 species of fishes, highest in the Bhagirathi Basin. Balganga River is the only longest spring/rain fed tributary available in Bhagirathi basin. Many cold water fishes including snow trout and fragmented population of mahseer were observed to be breeding in this river. Heterogeneity in the habitats, relatively warm water and eutrophic condition of this river is more conducive for fishes to breed in this river. Therefore, this river has also been identified as the critical fish habitat in these basins.

8.1.3 Impacts on aquatic biodiversity and their habitats

8.1.3.1 Habitat modification/loss:

a) Of the 1121 km long stretch of rivers that flow in the entire Alaknanda-Bhagirathi basins, a minimum of 526.8 km long river stretch is expected to be affected, if all proposed HEP are implemented. This is 47% of total rivers stretch in the entire basin. Therefore, significant area of the fish habitat would either be modified or lost due to proposed Hydro Electric Projects in the basin. Out of 76 species of fish reported in the entire basin, a total of 66 species have been reported in the influence zones of HEP. This means that about 87% of fish species would be affected, if all proposed Hydro Electric Projects get implemented in the basin.

b) Among 18 sub-basins in the region, the most affected sub-basins with respect to fish habitat modification/loss would be Bhagirathi III and IV (71%), Birahi ganga (74%), Alaknanda I & II (48%), Mandakini (44%), Balganga (40%) and Nandakini (35%). Although, fish was not found in Dhauliganga, nearly 94% of stretch of this river would be affected which in turn would adversely impact the downstream fishes in the main Alaknanda River.

8.1.3.2 Barrier effect

a) Dam or any construction across rivers is always detrimental to the survival of fishes especially of migrants, which use different habitats for completing life history requirements. There are a minimum of 17 species of migrant fishes found in the Alaknanda and Bhagirathi basins, which include three species of mahseer that are long distance migrants. Any obstacle such as dam/barrage across river will hamper normal migratory behaviour of these fishes and consequently affect their breeding cycle. Their migration has already been obstructed by Tehri dam. Based on literature and observations made in various studies it is confirmed that there has been a general decline in the populations of mahseer in the upstream of Bhagirathi River due to barrier effect caused by Tehri Dam.

b) Fish passes are often believed to be an appropriate mitigation measure for reducing impacts on fish (WCD, 2000), especially migrants. In general, the efficiency of fish passes is considered low and fish migrations are severely affected (WCD, 2000). Even when fish passes have been installed successfully, migrations can be delayed by the absence of better navigational cues, such as strong currents etc. Moreover, the efficiency of fish pass in Himalayan Rivers would be highly doubtful if the dam height is more than 16 m.

8.1.3.3 Changes in sedimentation flows

a) Changes in the sedimentation flows due to dam/barrier construction especially in Himalayan rivers are expected to have an adverse impact on fish habitats.

b) Most of the fishes in the Alaknanda and Bhagirathi Rivers prefer substratum that are pebble, cobble, boulders, gravel, sand and occasionally loamy soil. These substrata are common in most stretches. These substrata were also observed to be ideal grounds for foraging and spawning of snow trout and many more Himalayan fishes. However, due to dam construction there would be changes in the sedimentation flow. Sediments would be accumulated in the upstream of dam up to the tail end of submersible zone even though there is a provision of silt channel to remove the silt from the upstream of dam.

c) Submersible zones of Hydro Electric Projects of existing, under construction or proposed dams vary from project to project. In some cases, the submersible stretch of river is more than 5 km. Just few centimetres of sediment over the natural substratum is more than enough to negatively influence the foraging and spawning fishes. It is expected that submersible zones of HEPs would be unsuitable for several fishes especially snow trout and Himalayan loaches. Therefore, the HEPs with longer stretch of submersible zone but without proper silt removal plan would be detrimental to populations of several Himalayan fishes such as snow trout and Himalayan loaches.

d) Sub-basins such as Bhagirathi III & IV, Bhilanganga, Alaknanda I, Pindar and Mandakini would be affected mostly due to changes in the sedimentation flow. A minimum 162 km long river stretch of fish habitat would be modified due to precipitation of sediments on their substratum.

8.1.3.4 Changes in environmental flows

a) It is increasingly recognized that the distribution and abundance of riverine species are limited by the effects of flow regulation. Three kinds of adverse impacts on the aquatic biodiversity are expected because of changes in the natural flow due to HEPs in the Alaknanda and Bhagirathi Basin: (i) Stagnated water in the submersible zones of HEPs which are not conducive for torrent hill stream/river fishes such as snow trout and Himalayan loaches, (ii) Less or no water flow in the dry zones of HEPs which is also expected to adversely affect the aquatic biodiversity although it may be mitigated by maintaining minimum environment flow and (iii) Changes in the natural flow may also fail to provide the natural environmental cues to the aquatic biodiversity to breed or maintain annual life histories, but this can again be mitigated by following minimum environmental flows even though it would help partially to maintain the current status of aquatic ecosystem and its biodiversity.

b) Of the 1121 km long stretch of rivers that flows in the entire Alaknanda-Bhagirathi basin, a minimum of 526.8 km long river stretch is expected to be affected due to changes in the flows, if all HEP projects are implemented. This is 47% of total river stretches of the entire basin. A total of 364 km long stretch of river in the basin (32% of total river stretch) would get dry, if minimum flows are not implemented.

c) Among 18 sub-basins in the region, the most affected sub-basins with respect to flow modification would be Dhauliganga, Asiganga, Alaknanda, Balganga, Birahi ganga and Mandakini. As far as the otter is concerned, sub-basin Alaknanda I and Ganges are potential habitats of otter, although their presence was not reported during this study. Changes in the flow may not directly affect the habitat of otter but it would affect their prey abundance.

8.1.3.5 Changes in nutrient flow

a) Although majority of proposed HEPs are run-of-river projects but 15 HEPs, which would have dam, would stop the nutrient flow either for longer period or for a shorter depending upon presence of dam or barrage. As per the IIT-Roorkee report (2011), minimum 162.6 km long stretch of river in the entire basin would be submerged due to various HEPs. These submerged rivers would act as nutrient traps.

b) Nutrient availability is the major environment factor that determines the fish species composition in Himalayan rivers. Changes in the nutrient flow would adversely affect the downstream fishes and other aquatic biodiversity. Although few species may get benefitted due to reservoir water but overall the fish composition in the region would be affected. Therefore, changes in the nutrient flow due to HEP would affect the overall composition of the fish community in the Alaknanda and Bhagirathi basins.

8.2 Terrestrial component

8.2.1 Biodiversity profile and critical habitats

a) Over 35 mammals, 350 birds and 1000 plants have been reported in these sub-basins. Of these, five each of mammals and birds, and 55 plant species are rare, endangered or threatened.

b) Bhagirathi-I, Mandakini, Alaknanda-III, Dhauli ganga, Rishi and Bhyundar ganga sub-basins have very high terrestrial biodiversity values, particularly due to the presence of RET species. Substantial portions of these sub-basins are critically important habitats and most of these are encompassed by Protected Areas. RET species such as snow leopard, brown bear, musk deer, cheer pheasant and three species of vultures occur in these sub-basins.

c) Snow leopard is extremely rare and occurs only in Bhagirathi-I, Mandakini, Alaknanda –III, Bhyundar, Dhauliganga, Rishi ganga, Pindar,and Nandakini sub-basins . Similarly, the brown bear also occurs in these sub-basins and the eastern most distribution range of brown bear in India ends in Alaknanda basin.

d) The forest types of the Alaknanda basin range from the Himalayan subtropical scrub at lower elevations, temperate broad leaved forests in the middle elevations to Subalpine oak and conifer forests at 'tree line' at the higher elevations whereas that of Bhagirathi basin ranges from the Himalayan subtropical scrub at lower elevations to subalpine birch-rhododendron forests at 'tree line'.

e) Bhyundar ganga, Dhauliganga and Rishi ganga sub-basins have the maximum number of plant RET species as compared to the rest of sub-basins.

f) The two basins support over 300 medicinal plants within which highest number (over 150) occur in Alaknanda I sub-basin.

g) Protected Areas such as Gangotri NP, Nanda Devi NP, Valley of Flowers NP, Kedarnath WLS and buffer zones of Nanda Devi BR are located in one or more sub-basins and serve as critically important habitats for floral and faunal RET species. Sub-basins such as Rishi ganga and Bhyundar encompass the Nanda Devi NP and Valley of Flowers NP respectively that are globally recognized for their Outstanding Universal Values and hence listed as UNESCO World Heritage Sites. These two NPs are well recognised for their exceptional natural beauty and for encompassing critically important habitats that maintain ecological processes (Appendix 8). Nanda Devi NP is the only PA in India to hold the single wild population of Saussurea costus – a Red listed plant species.

h) Habitats found within the elevation range of 2500-4500 m which connect these PAs are also identified as critically important habitats for species such as snow leopard, brown bear, musk deer, Asiatic black bear, Himalayan tahr, serow, common leopard, blue sheep, as they serve as movement corridors between two important habitats.

i) The Alaknanda and Bhagirathi sub-basins also harbour certain plant species which are endemic to Uttarakhand. Out of the two populations of Catamixis baccharoides found in Uttarakhand, one is found within the zone of influence of Kotlibhel II. One of the populations of *Berberis osmastonii,* another endemic species, is found in the ZoI of Melkhet Hydro Electric Projects. *Caragana sukiensis* is Near Endemic with one population found area between ZoI of Pala maneri and Bharonghati HEPs in Bhagirathi II sub-basin. These areas are critical for the long term conservation of the species mentioned above in the two basins.

8.2.2 Impacts on terrestrial biodiversity and habitats

a) Of the 70 HEPs, 17 are commissioned projects which have resulted in the total loss of about 7126.46 ha of land that includes 2705.04 ha as forest land take and 4421.42 ha under submergence. Similarly, the 14 HEPs that are under construction have resulted in the total loss of about 539.59 ha of land that includes 442.36 ha as forest land take and 97.23 ha under submergence. The remaining 39 HEPs that have been proposed would result in an additional loss of about 1828.64 ha of land that includes 467.86 ha as forest land take and 1360.78 ha under submergence.

b) Of the 39 HEPs that have been proposed, 16 would lead to loss of forest land either for land intake or will be under submergence. Of the 16 HEPs, seven are located in areas that are >2.500m which are wildlife habitats for many RET species and also includes critically important areas for these species. These seven HEPs that have been proposed would result in a loss of about 172.48 ha of land that includes 146.34 ha as forest land take and 26.14 ha under submergence.

c) Pilang valley and Dayara bhugyal in Bhagirathi II sub-basin have been identified as the key sites for long-term conservation of Galliformes, including a number of RET species. Therefore, proposed development projects (Pilangad II and Siyangad) on the side streams would severely impair the biodiversity values of these areas.

d) The ZoI of the proposed Rambara and that of projects already under advanced stages of construction (Madmaheswar, Kali ganga I and Kali ganga II) fall in the critically important habitats of snow leopard, brown bear, black bear and musk deer and would impact the remnant wildlife habitats of these species.

e) The Dhauli ganga sub-basin encompasses critical habitats and corridors for large mammals such as snow leopard, brown bear and Tibetan wolf. ZoI of the proposed HEPs (Tamak-Lata, Malari-Jelam, and Jelam-Tamak) fall in these critically important habitats. Considering that snow leopard and brown bear are very rare with a restricted distribution in Uttarakhand State and the eastern most distribution limits of brown bear ends in this region, hydropower development in these basins will significantly alter the habitats of these species of very high conservation importance.

f) Bhilangana and Balganga sub-basins form the eastern most distribution limits for western tragopan in India, which is a species with restricted distribution. The ZoI of proposed HEPs (Bhilangana II, A, B & C) in Bhilangana basin and the proposed HEPs (Balganga-II and Jhala koti) in Balganga sub-basin and their associated activities would impact the western tragopan by reducing its distribution range. There are two existing projects in this Bhilangana sub-basin which together with several proposed projects will cumulatively impact upon the western tragopan habitat within the sub-basin.

g) Cheer pheasant, which has already become confined to isolated pockets in this region would further become restricted due to likely habitat losses associated with HEPs in this basin.

h) In the Alaknanda-II sub-basin, the ZoI of the proposed Bowla Nandprayag, and Nandprayag Langasun HEPs and that of Vishnugad-Pipalkoti HEP which is under-construction fall within the distribution range of Cheer pheasant that has restricted distribution in the State and overlaps with the habitats of leopard, black bear and tahr, which are species that command high conservation priority globally. The proposed HEP Urgam-II would severely impair the biodiversity values of the Urgam valley, which is one of the key sites for long-term conservation of ungulates species.

i) The two proposed HEPs i.e., Rishi ganga I and Rishi ganga II are both located inside the Nanda Devi NP. HEP developmental project in this sub-basin would adversely impact the 'Outstanding Universal Values' of the Nanda Devi World Heritage Site.

j) The ZoI of the proposed HEPs (Alaknanda and Khirao ganga) in Alaknanda -III Sub-basin would fall within the critically important habitats of large mammals such as snow leopard, brown bear and black bear. These proposed HEPs and their associated disturbances is likely to impact the movement of snow leopard, brown bear, black bear and also the critically important habitats of musk deer, Himalayan tahr and monal pheasant. This sub-basin connects the Kedarnath Wildlife Sanctuary and Khirao Valley in the west to the Nanda Devi Biosphere Reserve. Hydropower developments in this sub-basin would have adverse impacts on biodiversity values of this basin.

k) The ZoI of the proposed HEPs (Jadganaga and Karmoli) in Bhagirathi sub-basin fall within the Gangotri NP and therefore these projects are likely to adversely impact the habitats of snow leopard and Himalayan brown bear.

l) Bhyundar sub-basin contains the most important and significant natural habitats for in situ conservation of biological diversity. Any developmental project in this sub-basin would adversely impact the critical habitats, and may also impact the 'Outstanding Universal Value' of this sub-basin.

8.3 Recommendations

8.3.1 Environmental flows

a) Minimum Environmental Flows required in the Alaknanda and Bhagirathi basins only for the dry zone of HEP has been estimated based on (i) Environmental Management Class of the rivers and (ii) Ecological requirement of fishes.

b) Environmental Management Class (EMC) of the Alaknanda and Bhagirathi basins was assessed as 'C' Class. Minimum Environmental Water Requirement for a river stretch that falls in the Mahseer and Snow trout zones of study area should be 21.8% of Mean Seasonal Runoff (MSR) and for river stretches that falls in the 'No fish zone' should be 14.5 % of MSR (Table 7.5).

c) Minimum Environmental Flow Required (MEFR) (cumec/day) to sustain riverine ecology with special reference to fishes in the dry zones of HEPs in the Alaknanda and Bhagirathi basins based on ecological requirements of fishes was calculated as 20% of monthly average of flow during dry season (November to March), 25% of monthly average of flow from October and April, and 30% of monthly average of high flow season from May to September (Table 7.5).

d) Minimum Environmental Flow Required (MEFR) in the dry zones of HEPs was calculated only for those river stretches where flow data was available (section 7.4).

e) The suggested minimum environmental flows would provide the necessary environmental cues to trigger the breeding and migration behavior of Himalayan fishes.

f) Minimum environmental flows that have been suggested need to be reviewed periodically in relation with changes in the population status of fishes. This review may be carried out once in every five years with inputs from professional institutions such as National Institute of Hydrology, IIT-Roorkee, National Bureau of Fish Genetic Resources, Directorate of Cold Water Fisheries Research, Local Universities etc.

8.3.2 Present and future scenario

The scenario building for assessing impacts on biodiversity values portrays very distinctively the present and futuristic trends of the impact significance of hydropower developments in all the sub-basins in the larger landscape represented by the Alaknanda and Bhagirathi basins.

It becomes apparent that because of the fact that many of the projects are already in stages of operation and construction, the reversibility in significance of impacts on terrestrial biodiversity is not possible in sub-basins - Dhauliganga, Mandakini and Bhagirathi III which harbour many species of high conservation values.

The implementation of the current hydropower power plan which envisages the operation of 70 Hydro Electric Projects is likely to significantly impact the aquatic biodiversity of Bhagirathi IV and Ganga sub-basins. Decline in biodiversity values of Bhagirathi III sub-basin have significantly been compounded by Tehri dam.

The scenarios provide adequate understanding to make decisions with respect to applying exclusion approach across the two basins for securing key biodiversity sites (such as critically important habitats) and prevent adverse impacts on designated protected areas.

Based on five different scenarios that have been presented the most acceptable option suggests that the decision with respect to 24 proposed Hydro Electric Projects may be reviewed.

8.3.3 Conservation reserve

It is proposed that (a) Nayar River and the Ganges stretch between Devprayag and Rishikesh, and (b) Balganga – Tehri Reservoir complex may be declared as Fish Conservation Reserve as these two stretches are comparatively less disturbed and have critically important habitats for long term survival of Himalayan fishes (Refer Appendix 8.1) basin.

8.3.4 Strategic options for regulating impacts of Hydro Electric Projects

At the global level there is an increasing consensus on the need to manage water, water-related processes and biodiversity in a sustainable manner. However, at the local level, water related developments are still taken for granted often without due regards to biodiversity conservation. A key challenge for decision makers is how to balance energy and human demands with conservation imperatives. Broad guidelines on reducing the impact of development projects (e.g. dams) on wetlands (Box 8.1) can guide the regulatory principles in the context of water resource planning in Uttarakhand State, depending on the stages in which the development of hydropower project has progressed.

Box 8.1 Ramsar convention: Guidelines for contracting parties relating to reducing the impact of water development projects on wetlands.

I. Ensure that proposals for water development projects are carefully reviewed at their initial stages to determine whether non-structural alternatives may be feasible

II. Take all necessary actions in order to minimise the impact of water development projects on biodiversity and socio-economic benefits during the construction phase and longer term operation

III. Ensure that project design/planning processes includes a step by step process to integrate environmental issues, especially initial biodiversity/resource surveys, and post project evaluation and monitoring.

IV. Incorporate long-term social benefit and cost considerations into the process from the very initial stages of project preparation.

Source: IUCN 2001

The Energy Plan of Uttarakhand State encompasses projects in three stages of development (i) that are in operation, (ii) under construction and (iii) proposed. A range of corrective, restorative or preventive actions can be taken to regulate hydropower developments. A suite of options that are specific to each category of projects based on the stages of their development are given below:

Category I Projects: Already commissioned – As a consequence of commissioned projects in Alaknanda and Bhagirathi basins, biodiversity values have been greatly compromised both on account of direct and indirect impacts induced by these projects on size and quality of terrestrial wildlife habitats. The altered land use regimes and disturbance factors have further compounded the impacts. The changes in stream quality and ecological flows subsequent to the development of hydropower project(s) that together alter the river ecology cause significant impacts on the aquatic biodiversity values.

Regulating options

- Options to compensate or mitigate direct impacts and indirect impacts discussed above become almost impossible or greatly limited when development projects have progressed past the stage of construction and have become fully operational and are delivering the economic benefits from power generation. The aggregated footprint of the project associated infrastructure in a basin could be a function of many projects with relatively similar impact potentials or could be a result of a single project that is a major contributor to the degradation of biodiversity values of the specific landscape. In this category, the cumulative impact assessment of 17 projects (9 in Bhagirathi basin and 8 in Alaknanda basin) has highlighted varying levels of detrimental changes in biodiversity values in the different sub-basins. The specifics step that can be taken for regulating the impacts are:

  i. Ensure revised environmental flows are implemented as indicated in section 8.3.1;

  ii. Monitoring for compliance of clearance conditions and conducting environmental audits to identify areas of negligence in environmental management so that regulatory frameworks can be better tailored for ensuring the reduction in the combined footprint of all projects operating in the sub-basins;

iii. Identifying biodiversity offsets and compensatory opportunities for areas of high biodiversity values. The nearest parallel of such an offset scheme is the proposal to set up two Conservation Reserves (refer section 8.3.3);

iv. Review the sustainability of livelihoods that are dependent on bio-resources and promote alternatives to protect remnant biodiversity in areas of use;

v. Treatment of released water (to ensure a natural range of salinity, turbidity, temperature, oxygenation, etc) and restoration of river bed substratum for making them suitable habitats of fishes;

vi. Controls on access, and low impact siting of resettlement areas, workforce camps, sites and stockyards.

Category-II: Projects under-construction- In this category, 14 projects that are in various stages of construction have to be regulated.

Regulating options

- In case of projects where the work on site has advanced to a stage of accepting the project as 'nearly complete', all of the measures proposed for Category I projects must apply. In addition, conditions for site specific measures must be additionally stipulated at all project sites to ensure that the zone of project influence is substantially reduced. Measures that must be essentially incorporated in regulatory framework for individual projects are:

  i. Ensure revised environmental flows are implemented as indicated in section 8.3.1

  ii. Material and waste management to reduce impacts on natural habitats of animals and plants in the sub-basins(s).

  iii. Location of temporary and permanent structures (muck disposal sites, resettlement areas, workforce camps, workshops and stockyards) to reduce the zone of project influence to avoid their impacts on wildlife areas.

  iv. Prevention of physical disturbances along river courses, to maintain unhindered flow and stream quality during construction.

  v. Appropriately plan operation of the dam/barrage to maintain continuous natural flow in post construction and inundation stages;

  vi. Rescheduling construction activities where necessary to avoid prolonging the duration of impacts linked to construction phase. This would specially apply to activities causing physical disturbance at sites that can affect habitat utilisation, impair movement of animals and destruction of sites that harbour important plant species.

- In case of projects where preparatory work on site and construction has been initiated, all of the strategic and project specific regulatory measures indicated above must apply. Assuming that there is still time for modifications, design specification(s) must be reviewed to ensure (i) continuous natural flow during construction and inundation stages; (ii) reduce impacts on riverine habitats for aquatic species, reduce flooding of riparian habitats and (iii) prevent requirements of land take from forest areas.

Category-III: Proposed projects

Regulating options

Out of the total of 39 proposed projects considered in the CEIA, 24 projects have been found to be significantly impacting the biodiversity values in the two sub-basins. The relevant details of these 24 projects is given in Table 8.1.

Table 8.1. List of Hydro Electric Projects to be re-appraised.

Sub-basin	Name of the project	River	River length Affected (m)	Forest Area Loss (ha)	Power generation Capacity (MW)	Aquatic Biodiversity Values	Terrestrial Biodiversity Values
Bal ganga	Bal ganga II	Bal ganga	3250	NA	7.00	VH	-
	Jhala koti	Bal ganga	4750	NA	12.50		-
Bhagirathi II	Bharon ghati	Bhagirathi	18500		381.00	-	H
	Jalandrigad	Jalandharigad	3500	12.11	24.00	-	
	Siyangad	Siyangad	4500	4.96	11.50	-	
	Kakoragad	Kakoragad	3500	4.98	12.50	-	
Bhagirathi IV	Kotlibhel IA	Bhagirathi	18400	258.04	195.00	VH	H
Bhagirathi I	Karmoli	Jadhganga	11300	9.94	140.00	-	H
	Jadhganga	Jadhganga	2900	8.35	50.00	-	
Mandakini	Rambara	Mandakini	8000	NA	24.00	-	VH
Alaknanda I	Kotlibhel IB	Alaknanda	27500	599.75	320.00	VH	-
Alaknanda III	Alaknanda	Alaknanda	7000	49.648	30.00	-	H
	Khirao ganga	Khirao ganga	2750	NA	4.00	-	
Alaknanda II	Urgam II	Kalpganga	1750	NA	3.80	-	H
Dhauliganga	Lata tapovan	Dhauli ganga	8500	NA	170.00	-	VH
	Malari jhelam	Dhauli ganga	6500	NA	114.00	-	
	Jelam tamak	Dhauli ganga	8500	70	126.00	-	
	Tamak lata	Dhauli ganga	10500	24	250.00	-	
Bhyundar ganga	Bhyundar ganga	Bhyundar ganga	3250	NA	24.30	-	VH
Rishi ganga	Rishi ganga I	Rishi ganga	6525	8.06	70.00	-	H
	Rishi ganga II	Rishi ganga	5497	2.48	35.00	-	

Sub-basin	Name of the project	River	River length Affected (m)	Forest Area Loss (ha)	Power generation Capacity (MW)	Aquatic Biodiversity Values	Terrestrial Biodiversity Values
Birahi ganga	Birahi ganga I	Birahi ganga	6500	NA	24.00	H	H
	Gohana Tal	Birahi ganga	12000	NA	50.00		
Ganga	Kotlibhel II	Ganga	59200	647.45	530.00	VH	H
TOTAL	24		244572	1699.77	2608.6	-	-

H: High; VH: Very High

The rationale for recommending these 24 projects for re-appraisal has been amply elaborated in chapter 6 where the scenario 5A and B distinctly capture the potential of these proposed projects to significantly and cumulatively reduce the aquatic and terrestrial biodiversity values of the sub-basins.

In the final analysis, the combined footprint of all 24 projects have been considered for their potential to impact areas with biodiversity values (both aquatic and terrestrial), critically important habitats for RET and IWPA protected species in different sub-basins in the two larger landscape units, the Alaknanda and Bhagirathi basins. Some of these sub-basins harbour areas of Outstanding Universal Values. Ecological prudence therefore requires that securing long term biodiversity conservation should get precedence over economic considerations visualized in commissioning these 24 projects.

As may be seen from the figures given in Table 8.1 above, these 24 hydroelectric projects would cumulatively adversely affect a river length of 244572 m. The total river length affected by all 70 projects is 655512 m. This means that the overall river length that would be affected will get reduced from 655512 m to 410940 m, which is 37.31% reduction, in event of these 24 projects not being commissioned. This would be of significant value for conservation of aquatic biodiversity.

The total requirement of forest area for 70 hydropower projects is 9494.68 ha. These 24 hydropower project require 1699.77 ha of forest land. Thus the total requirement of forest land would decrease from 9494.68 ha to 7794.91 ha, which is 21.71% reduction, in event of these 24 projects not being commissioned. This would be a positive gain for forest biodiversity conservation.

The current power generation visualized from commissioning of all 70 projects is 9563 MW, of which these 24 projects contribute 2608.6 MW. Thus there would be a reduction in power generation capacity of 27%. In this context it is stated that India has one of the world's highest power transmission losses of about 30-40% against global average of 15% (OECD/IEA, http://www.iea.org/stats/index.asp and http://www.indexmundi.com/facts/india/electric-power-transmission-and-distribution-losses). Better and effective power transmission management system can to a large extent offset this loss in power generation.

References

Acreman, M. & Dunbar, M.J. (2004) Defining environmental flow requirements- a review. *Hydrology and Earth system sciences*, 8(5): 861-876.

Adams, W. (2000) *Downstream impacts of dams. World Commission on Dams*. Available from http://www.dams.org/docs/kbase/contrib/soc195.pdf .

ADB. (1997) *Chapter 4-Approaches to Impact Prediction.EIA for Developing Countries*. Downloaded from http://www.adb.org/documents/books/environment_impact/chap4.pdf

Adhikari, B.S., Uniyal S.K. & Rawat, G.S. (2009) Vegetation structure and community patterns of Tehri Dam Submergence Zone, Uttarakhand, India. *EurAsia J BioSci* 3, 40-49.

Ali, S., & Ripley, S.D. (1983) *Handbook of the birds of India and Pakistan*. Compact Edition. Oxford University Press, Bombay.

Andersson, E., Nilsson, C., & Johansson, M.E. (2000a) Effects of river fragmentation on plant dispersal and riparian flora. *Reg. Riv. Res. Manage.* 16:83-89

Antoniuk, T. (2000) *Cumulative effects assessment of pipeline projects*. In: Kennedy A, editor. Cumulative environmental effects management: tools and approaches. Calgary, Canada: Alberta Society of Professional Biologists;

Atkore V.M., Sivakumar, K., Johnsingh, A.J.T. (2011) Patterns of diversity and conservation status of freshwater fishes in the tributaries of Ramganga river, in the Shiwaliks of the Western Himalaya. *Current science* 100(4).

Badola, S.P. (2001) *Ichthyology of Central Himalaya*. Transmedia Publisher, Srinagar, India.

Bardach, J.E. & Dussart, B. (1973) Effects of man-made lakes on ecosystems. *Geophys. Monogr.,* 17:811-817.

Batalla, R.J., Gomez C.M., & Kondolf G.M. (2004) River impoundment and changes in flow regime, Ebro River basin, northeastern Spain. *Journal of Hydrology* 290: 117-136.

Beecher, H. A. (1990) Standards for instream flows. *Rivers* 1: 97–109

Berkamp, G., McCartney, M., Dugan, P., McNeely, J., Acreman, M. (2000) *Dams, Ecosystem Functions and Environmental Restoration*. Thematic Review II.1 prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

Berkamp, G., McCartney, M., Dugan, P., McNeely, J., Acreman, M. (2000) *Dams, Ecosystem Functions and Environmental Restoration*. Thematic Review II.1 prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

Bhardwaj, M. & Uniyal, V.P. (2009) *Wildlife survey in Nilang valley of the Gangotri National Park*. Wildlife Survey Report. Wildlife Institute of India. 23 pp.

Bhardwaj, M., Uniyal, V.P. & Sanyal, A. K. (2010) Estimating relative abundance and habitat use of Himalayan blue sheep Pseudois nayaur in Gangotri National Park, Western Himalaya, India. *Galemys* 22 (nº especial):545-560.

Bhatt, C.P. (1997) "Future of large projects in the Himalaya", PAHAR, Nainital, pp 46.

Bhatt, V. & Purohit, V.K. (2009) Floristic structure and phytodiversity along an elevational gradient in Peepalkoti-Joshimath area of Garhwal Himalaya, India. *Nature and Science* 7(9) 63-74

Bhattacharya, T. & Sathyakuma,r S. (2011) Natural Resource Use by Humans and Response of Wild Ungulates - A Case Study from Bedini-Ali, Nanda Devi Biosphere Reserve, India. *Mountain Research and Development* 31(3):209-219.

Bhattacharya, T. & Sathyakumar S. (2008) Abundance, Group Sizes and Habitat Use Patterns of Himalayan tahr (Hemitragus jemlahicus) and Goral (Nemorhaedus goral) in Chenab Valley, Chamoli District (Uttarakhand). *The Indian Forester* 134(10):1359-1370.

Bhattacharya, T. & Sathyakumar, S. (2007) An ornithological survey of Chenab Valley, Chamoli district, Uttaranchal, including notes on pheasants. *Indian Birds* 3(4):138-145.

Bhattacharya, T. & Sathyakumar, S. (2010) Sighting of Tibetan Wolf Canis lupus chanko in the Greater Himalayan range of Nanda Devi Biosphere Reserve, Uttarakhand, India: a new record. *Journal of Threatened Taxa* 2(12):1345-1348

Bhattacharya, T., Sathyakumar, S. & Rawat, G. S. (2009) Distribution and abundance of Galliformes in response to anthropogenic pressures in the buffer zone of Nanda Devi Biosphere Reserve. *International Journal of Galliformes Conservation* 1:78-84.

Bhattacharya, T., Sathyakumar, S. & Rawat, G.S. (2006) *Studies on the Animal – Habitat interactions in the buffer zone of Nanda Devi Biosphere Reserve.* Final Report to the Ministry of Environment and Forests, Govt. of India. New Delhi. 103 pp.

Bhattacharya, T., Sathyakumar, S. & Rawat, G.S. (2007) *Studies on Animal-Habitat Interactions in the Buffer Zone of the Nanda Devi Biosphere Reserve.* Final Report. Submitted to the Ministry of Environment & Forests, Government of India. Wildlife Institute of India, Dehradun. 103 pp

Biggs, B.J.F. (1996) Hydraulic habitat of plants in streams. *Regulated Rivers: Research and Management* 12:131–144.

Birtwell, I. K. (1999) The effects of sediment on fish and their habitat. Fisheries and Ocean Canada, Science branch, Marine Environment and Habitat Science Division, Fresh Environment and Habitat science Section, West Vancouver Laboratory, West Vancouver, B.C.

Blanch, S. J., Ganf, G. G. and Walker, K. F. (1999) Tolerance of riverine plants to flooding and exposure indicated by water regime. *Regulated Rivers: Research and Management* 15:43– 62.

Blanch, S. J., Walker, K. F. & Ganf, G. G. (2000) Water regimes and littoral plants in four weir pools of the River Murray, Australia. *Regulated Rivers: Research and Management* 16:445– 456.

Brisbane Declaration (2007) Available at http://www.nature.org / initiatives/freshwater/files/brisbane_declaration_with_organizations_final.pdf.

Bonetto, A. A., Wais, J. R., & Castello, H. P. (1989) The increasing damming of the Parana´ Basin and its effect on the lower reaches. *Regulated Rivers: Research and Management* 4:333–346

Brismar, A. (2004) Attention to impact pathways in EISs of large dam projects. *Environ Impact Assess Rev*, 24: 59–87.

Bunn, S. E. & Arthington, A. H. (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* 30(4): 492-507.

Cada, G.F. & Hunsaker, C.T. (1990) Cumulative impacts of hydropower development: reaching a watershed impact assessment. *The Environmental Professional,* 12 :2–8.

Cadwallader, P. (1986) *Fish of the Murray-Darling system*. In: B. R. Davies and K. F. Walker (eds.), The ecology of river systems. Pp 679 – 694 Dr W. Junk, Publishers, Dordrecht.

Caltrans (with FHWA and EPA), (2005) "Guidance for Preparers of Cumulative Impact Analysis", June 30, 2005, Sacramento, California. http://www.dot.ca.gov/ser/cumulative_guidance/purpose.htm

Canadian Environmental Assessment Agency (1999). *Cumulative Effects Assessment Practitioners Guide.*

Canter, L. (1999) Cumulative Effects Assessment, In: Petts, J. (ed.) *Handbook of Environmental Impact Assessment,* Volume 1, Environmental Impact Assessment: Process, Methods and Potential, Blackwell Science, Oxford, 405– 440.

Canter, L.W. & Sadler, B. (1997) *A Toolkit for Effective EIA Practice – Review of Methods and Perspectives on their Application*. A Supplementary Report of the International Study of Effectiveness of Environmental Assessment. International Association of Impact Assessment.

Chakraborty, B.K., Mirza, Z.A., Miah, M.I., Habib, M.A.B. & Chakraborty, A. (2007) Reproductive cycle of the endangered sarpunti, *Puntius sarana* (Hamilton, 1822) in Bangladesh. *Asian Fisheries Science* 20: 145-164.

Chambers, P. A., Prepas, E. E., Hamilton, H. R. & Bothwell, M. L. (1991) Current velocity and its effects on aquatic macrophytes in flowing waters. *Ecological Applications* 1:249–257.

Champion, G. &. Seth, S.K. (1968) A revised survey of forest types of the India. Manager of publications, Government of India Press, New Delhi.

Chandola, S., H.B. Naithanai & Rawat, G.S. (2008) Nilang: A little known Transhimalayan valley in Uttarakhand and its floral wealth. In: Special habitats and threatened plants of India. ENVIS bulletin: Wildlife and protected areas Ed. Rawat, G.S., Vol. II (1). Wildlife Institute of India, Dehradun, India, 239 pp.

Cloquell-Ballester, V., Monterde-Díaz, R., Cloquell-Ballester, V., Santamarima-Siurana, M. (2007) Systematic comparative and sensitivity analyses of additive and outranking techniques for supporting impact significance assessments. *Environmental Impact Assessment Review* 27:62–83.

Contant, C.K. & Wiggins, L.L. (1993) *Toward Defining and Assessing Cumulative Impacts: Practical and Theoretical Considerations*. In Environmental Analysis: The NEPA Experience, S.G. Hildebrand and J.B.Cannon (eds). Boca Raton, Florida:Lewis Publishers.

Copp, G. H. (1989) The habitat diversity and fish reproductive function of floodplain ecosystems. *Environmental Biology of Fishes* 26:1–26.

Copp, G. H. (1990) Effect of regulation on fish recruitment in the Great Ouse, a lowland river. *Regulated Rivers: Research and Management* 5:251–163.

Council on Environmental Quality. (1997) *Considering Cumulative Effects under the National Environmental Policy Act*. Executive office of the President of the United States, Washington DC

Court, J.D., Wright, C.J. & Guthrie, A.C. (1994) *Assessment of Cumulative Impacts and Strategic Assessment in Environmental Impact Assessment.* Document prepared for Commonwealth Environmental Protection Agency by J D Court and Associates Pty Ltd and Guthrie Consulting, Commonwealth of Australia. Day 1875-1878; 1889.

Curtis, J.T. & Cottam, G.(1956) Plant Ecology Work Book. Laboratory Field Reference Manual. Burges Publishing Co. Minnesota.

Deall, G., McCleland, W. & Hawkes, P. (2010) *Environmental Impact Assessment Appendix B: Terrestrial Ecology Specialist study*. Groot Letaba River Water Development Project.

DEAT. (2004) *Cumulative Effects Assessment, Integrated Environmental Management, Information Series 7*. Department of EnvironmentalAffairs and Tourism (DEAT), Pretoria.

Department of Environmental Affairs & Tourism, DEAT. (2004) *Cumulative Effects Assessment, Integrated Environmental Management*, Information Series 7, Department of Environmental Affairs and Tourism (DEAT), Pretoria.

Dickert, T.G. & Tuttle, A.E. (1985) Cumulative Impact Assessment in Environmental Planning – A Coastal Wetland Watershed Example. *Environmental Impact Assessment Review*, 5: 37-6

Dimri, N. K. (2010) *Aspects of habitat use and conservation status of Otters in Alaknanda-Ganga basin, Uttarakhand*. M.Sc. dissertation. HNB Garhwal Central University.

Dubé, M. (2003) Cumulative effect assessment in Canada: a regional framework for aquatic ecosystems. *Environmental Impact Assessment Review* 23:723–45.

Dubé, M.G. (2003) 'Cumulative effects assessment in Canada: a regional framework for aquatic ecosystems, Environmental Impact Assessment Review, 23, 723-745.

Duinker, P. & Greig, L. (2006) The impotence of cumulative effects assessment in Canada: ailments and ideas for redeployment. *Environmental Management* 37(2):153–61.

Duinker, Peter N. & Greig, Lorne A. (2007) Scenario analysis in environmental impact assessment: Improving explorations of the future. *Environmental Impact Assessment Review* 27, 206–219

Dunbar, M.J., Gustard, A., Acreman, M.C. & Elliott, C.R.N. (1998) *Review of overseas approaches to setting river flow objectives*. Environment Agency R&D Technical Report W6B(96)4. Institute of Hydrology, Wallingford, United Kingdom.61 pp.

Dynesius, M. & Nilsson, C. (1994) Fragmentation and Flow Regulation of River Systems in the Northern Third of the World. *Science,* 266:753-762.

Edds, D.R. (2007) Fishes in Nepal: ichthyofaunal surveys in seven nature reserves. *Ichthyol. Explor. Freshwat.* 18(3):277-287.

Estes, C.C., & Orsborn, J.F. (1986) Review and analysis of methods for quantifying instream flow requirements. *Water Resources Bulletin* 22(3): 389–398

Felley, J. D., & Felley S. M. (1987) *Relationships between habitat selection by individuals of a species and patterns of habitat segregation among species: fishes of the Calcasieu drainage*. Pp. 61–68 *in* D. C. Matthews and W. J. Heins (eds.), Community ecology of North American stream fishes. University of Oklahoma Press, Norman.

Fischer,Thomas B. (2012) On the role(s) of (strategic) environmental assessment in '*greening*' decision making. http://www.twoeam-eu.net/role.pdf accessed on 21st January 2012.

Forest Survey of India (2009) India State of Forest Report, 2009. Forest Survey of India, Dehradun. 199 pp.

Forman, R. T. T., & Godron M. (1986) *Landscape ecology*. John Wiley & Sons, New York, New York, USA.

French, T. D., & Chambers, P.A. (1996) Habitat partitioning in riverine macrophyte communities. *Freshwater Biology* 36:509–520.

Froend, R. H., & McComb, A. J. (1994) Distribution, productivity and reproductive phenology of emergent macrophytes in relation to water regimes at wetlands of South-western Australia. *Australian Journal of Marine and Freshwater Research* 45:1491–1508.

FSI (1999) State of Forest Report, 1999. Forest Survey of India, Ministry of Environment and Forests, Government of India.

FSI (2007) State of Forest Report, 2007. Forest Survey of India, Ministry of Environment and Forests, Government of India.

FSI, (2009) *State of Forest Report, 2009*. Forest Survey of India, Ministry of Environment and Forests, Government of India.

Futuring, Cornish E. (2004) The exploration of the future. Bethesda, MD: World Future Society. 313 pp.

Gallopin, G., Hammond, A., Raskin, P. & Swart, R. (1997) Branch Points: Global Scenarios and Human Choice. PoleStar Series Report No. 7, Global Scenarios Group, Stockholm Environment Institute, Stockholm.

Gartner Lee Limited (GLL). (2001) *Evaluating significance: an initial scan of relevant literature and guidance materials*. Markham: Gartner Lee Limited.

Gaur, R.D. (1999) Flora of the district Garhwal North West Himalaya (with ethnobotanical notes) :752

Gaur, R.D. (2007) "Biodiversity and river valley projects in Uttarakhand", Proceedings of National Academy of Sciences India, 77 (BIII), pp 253-262.

Gleick, P.H., Cooley, H., Katz, D., Lee, E., Morrison, J., Palaniyappan, M., *et al.,* (2007) *The World's Water 2006–2007: The Biennial Report on Freshwater Resources*. Pacific institution for studies in development, environment and security.

Goldsmith, E. & Hildyard, N. (1984) *The Social and Environmental Effects of Large Dams*. SanFrancisco, CA, USA:A Sierra Club Book. 404 pp.

Goodland, R., Juras, A., & Pachauri, R.. (1993) Can Hydro-Reservoirs in Tropical Moist Forests Be Environmentally Sustainable?. *Environmental Conservation* 20: 122–130.

Gorman, O. T., & Karr, J. R. (1978) Habitat structure and stream fish communities. *Ecology* 59:507–515.

Gouyon, P.H., King, E.B., Bonnet, J.M., Valdyron, G. & Vernet, P. (1987) Seed migration and the structure of plant populations. An experimental study on Thymus vulgaris L. *Oecologia* 72:92-94

Graf, W.L. (1999) Dam Nation: A geographic census of American dams and their large-scale hydrologic impacts. *Water Resources Research*, 35(4): 1305-1311.

Green, M.J.B. (1985) *Aspects of the ecology of the Himalayan musk deer*. Ph. D. Dissertation, Cambridge Univ. 292 pp.

Green, M.J.B. (1986) The birds of the Kedarnath Sanctuary, Chamoli district, Uttar Pradesh: Status and distribution. *J. Bombay Nat. Hist. Soc*. 63:603-617.

Greig, L., Pawley, K., Duinker, P. (2004) Alternative scenarios of future development: an aid to cumulative effects assessment. Gatineau, QC: Canadian Environmental Assessment Agency. 35 pp.

Grimmet, R., Inskipp, C. & Inskipp, T. (1998) Birds of Indian subcontinent. Oxford university press, Delhi. 888 pp.

Habib, M. A., (2005) Strategic environmental assessment can help solve environmental impact assessment failures in developing countries. *Environ. Impact Assess. Rev.*, 25, 307–317.

Hajra, P.K. (1983) *A Contribution to the Botany of Nanda Devi National Park.* Botanical Survey of India, Calcutta.

Hall L. S., Krausman P.R. & Morrison M. L. (1997) The habitat concept and a plea for standard terminology. *Wildlife Society Bulletin* 25(1):173-182

Hamilton, F. (1822) *An account of the fishes found in the river Ganges and its branches*. Constable and Co, Edinburgh, UK.

Harriman, J. & Noble, B. (2008) Characterizing project and strategic approaches to regional cumulative effects assessment in Canada. *Journal of Environmental Assessment Policy & Management* 10(1):25–50.

Harris, J. H. (1984a) A survey of fishways in streams of coastal south-eastern Australia. *Australian Zoologist* 21:219 –233.

Harris, J. H. (1984b) Impoundment of coastal south-eastern Australia, and a review of its relevance to fish migrations. *Australian Zoologist* 21:235–250

Hegmann, G., Cocklin, C., Creasey, R., Dupuis, S., Kennedy, A., Kingsley, L., Ross, W., Spaling, H. & Stalker, D. (1999) Cumulative Effects Assessment Practitioners Guide, Prepared by AXYS Environmental Consulting Ltd. and the CEA Working Group for the Canadian Environmental Assessment Agency, Hull, Quebec.

Henry, C.P., Amoros, C. & Bornette, G. (1996) Species traits and recolonization processes after flood disturbances in riverine macrophytes. *Vegetatio* 122:13-27

Hora, S. L. (1933) Siluroid fishes of India, Burma and Ceylon. 1. Loach-like fishes of the genus *Amblyceps* Blyth. *Records of the Indian Museum* 35: 607–621.

Horak, G.C., Vlachos, E.C. & Cline, E.W. (1983) *Methodological Guidance for Assessing Cumulative Impacts on Fish and Wildlife.* Prepared for the U.S. Department of the Interior, Eastern Energy and Land Use Team, Kearneysville, West Virginia. 102 pp.

Horne, B.V. (1983) Density is a misleading indicator of habitat quality. *Journal of Wildlife Management* 47(4):893-901

Humphries, P., King, A. J., & Koehn, J. D. (1999) Fish, flows and floodplains: Links between freshwater fishes and their environment in the Murray-Darling River system, Australia. *Environmental Biology of Fishes* 56:129 –151.

ICEM. (2007) *Pilot Strategic Environmental Assessment in the Hydropower Sub-sector, Vietnam*. Final Report: Biodiversity Impacts of the hydropower components of the 6th Power Development Plan. Prepare for The World Bank, MONRE, MOI & EVN, Hanoi, Vietnam.

Imbert, E. & Lefèvre, F. (2003) Dispersal and gene flow of Populus nigra (Salicaceae) along a dynamic river system. *Journal of ecology* 91, 447-456.

Indian Institute of Techology, IIT Roorkee. (2011) Assessment of Cumulative Impacts of Hydroelectric projects in Alaknanda-Bhagirathi basins. Report prepared by AHEC, IIT, Roorkee. Submitted to the Ministry of Environment and Forests, Govt. of India.

IUCN. (2011) IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>

Jansson , R., Nilsson, C., & Renofalt, B. (2000) Fragmentation of riparian floras in rivers with multiple dams. *Ecology* 81:899-903

Johansson, M.E., Nilsson, C. & Nilsson, E. (1996) Do rivers function as corridors for plant dispersal? *Journal of Vegetation Science* 593-598

Joshi, M.C. (2007) *Hydro Power Potential in Uttarakhand*. International Conference on Small Hydropower - Hydro Sri Lank a, 22-24 October 2007. Available at <http://www.ahec.org.in/links/International%20conference%20on%20SHP%20Kandy%20Srilan a%20All%20Details/Papers/Policy,%20Investor%20and%20Operational%20Aspects-C/C29.pdf> downloaded on 15th May 2011.

Joy, M. K., & Death, R. G. (2001) Control of fish and crayfish community structure in Taranaki, New Zealand: Dams, diadromy or habitat structure. *Freshwater Biology* 46:417– 429.

Junk, W. J., Bayley, P. B. & Sparks, R. E. (1989) *The flood pulse concept in river-floodplain systems*. Pages 110–127 *in* D. P. Dodge (ed.), Proceedings of the international large river symposium (LARS). Canadian Journal of Fisheries and Aquatic Sciences Special Publication 106.

Junk, W.J., Bayley, P.B. & Sparks, R.E. (1989) The Flood Pulse Concept in River-Floodplain Systems in Doge, D.P. (ed) Proceedings of the International Large River Symposium (LARS). *Can. J. Fish. Aquat. Sci*., 106: 110-127.

Kala, C. P. (2004) The *Valley of Flowers: Myth and Reality.* International Book Distributors, Dehradun,

Kala, C.P. (1998) Ecology and conservation of alpine meadows in the Valley of flower National Park, Garhwal Himalaya. PhD. Thesis Forest Research Insititute of India, Dehradun.

Kala, C.P. (2004) *The Valley of Flowers; Myth and Reality*. International Book Distributors, Dehradun, India.

Kala, C.P. (2005) Indigenous uses, population density and conservation of threatened medicinal plants in Protected Areas of the Indian Himalayas. Conservation Biology, 19 (2): 368-378.

Kala, C.P. (2005) The Valley of Flowers; A newly declared World Heritage Site. Current Science, 89 (6): 919-920.

Kandpal, V. & Sathyakumar, S. (2010) Distribution and Relative Abundance of Mountain Ungulates in Pindari Valley, Nanda Devi Biosphere Reserve, Uttarakhand, India Galemys 22 (nº especial): 277-294.

Kennett, S. (2002) *Lessons from Cheviot: Redefining government's role in cumulative effects assessment*. In: Kennedy A, editor. Cumulative Effects Assessment in Canada: From Concept to Practice. Calgary, AB: Alberta Society of Professional Biologists; 2002

Kent, M. & Coker, P. (1992) Vegetation Description and Analysis. John Wiley & Sons.

King, J.M., Tharme, R.E., & De Villiers, M. (2000) Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology. Water Research Commission Technology Transfer Report No. TT131/00. Water Research Commission: Pretoria, South Africa.

Kirk, D. (2001*) Using science to assess the adverse effects of impacts of migratory birds.* In: EA. Hull, Quebec: Canadian Environmental Assessment Agency.

Lawrence, D. P. (2007) Impact significance determination--Designing an approach. *Environmental Impact Assessment Review* 27(8): 730-754.

Lawrence, D.P. (1994) Cumulative effects assessment at the project level. *Impact Assessment*, 12: 253-273.

Ledec, G. & Quintero, J. D. (2003) *Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects*. Sustainable Development Working Paper No. 16. The World Bank Latin America and the Caribbean Region; Environmentally and Socially Sustainable Development Sector Management Unit.

Ledec, George & Quintero, Juan David (2003) Sustainable Development Working Paper No. 16. Good Dams and Bad Dams: The World Bank Latin America and the Caribbean Region. Environmentally and Socially Sustainable Development Sector Management Unit.

Leopold, L.B., Clarke, F.E., Hanshaw, B.B., & Balsley, J.R. (1971) *A Procedure for Evaluating Environmental Impact.* Geological Survey Circular No. 645. Washington D.C., United States Geological Survey

Loar, J.M., Sale, M.J. & Cada, G.F. (1986) Instream flow needs to protect fishery resources. Water Forum '86: World water issues in evolution. Proceedings of A.S.C.E. conference/HY. IR, EE, WR, WW Divs. Long Beach, California, August 4-6, 1986.

Lundqvist, J. (1998) Avert looming hydrocide. *Ambio* 27:428–433.

Maheshwari, A. & Sharma, D. (2010) *Snow leopard conservation in Uttarakhand and Himachal Pradesh*. WWF-India, pp: 1-67.

Malanson, G.P. (1993) *Riparian Landscapes*. Cambridge: Cambridge University Press.

McAllister, D.E., Hamilton, A.L., & Harvey, B. (1999) Global Freshwater Biodiversity: Striving for the Integrity of Freshwater Ecosystemsî, in Special Edition of *Sea Wind-Bulletin of Ocean Voice International*,11(3): 1-140.

McCartney, M.P., Sullivan, C.A. & Acreman, M.C. (1999) *Ecosystem impacts of large dams*, a review for International Union for Conservation of Nature, Gland, Switzerland, Centre for Ecology and Hydrology, Wallingford, UK.

McCully, P. (1996) *Silenced Rivers: the ecology and politics of large dams*. Zed Books, London. 350 pp.

Meffe, G. K., & Sheldon, A. L. (1988) The influence of habitat structure on fish assemblage composition in southeastern blackwater streams. *The American Midland Naturalist* 120:225–240.

Menon, A.G.K. (1999) *Check list - fresh water fishes of India*. Rec. Zool. Surv. India, Misc. Publ., Occas. Pap. No. 175, 366 p.

Menon, V. (2003) A field guide to Indian mammals. Handbook, dorling Kindersley, India pvt. Ltd. 201 pp.

Mishra, S. S., Acherjee, S. K. & Chakraborty, S. K. (2009) Development of tools for assessing conservation categories of siluroid fishes of fresh water and brackish water wetlands of South West Bengal, India. *Environmental Biology of Fishes* 84(4): 395-407.

Morhardt, 1986;

MRC (2005) Scenarios for strategic planning. BDP Library Volume 4. March 2005. Revised November 2005. Mekong River Commission.

Mueller-Dombois, D. & Ellenberg, H. (1974) Aims and Methods of Vegetation Ecology. John Wiley & Sons.

Munn, M. D., & Brusven, M. A. (1991) Benthic invertebrate communities in non-regulated and regulated waters of the Clearwater River, Idaho, USA. *Regulated Rivers: Research and Management* 6:1–11.

Naiman, R. J., Magnuson, J. J., McKnight, D. M. & Stanford, J. A. (1995) *The freshwater imperative: A research agenda*. Island Press, Washington, DC, 165 pp.

Naithani, B.D. (1985) Flora of Chamoli Volume I & II, Botanical survey of India.

Nanda Devi & Valley of Flowers National Parks Uttaranchal, India (2011) United Nation Environment Programme & World Conservation Monitoring Centre.

Nautiyal P, & Lal, M.S.. (1984) Food and feeding habit of fingerlings and juveniles of mahseer Tor putitora (Ham.) in Nayar River. *J Bombay Nat Hist Soc* 81:642–646

Nautiyal P,& Lal, M.S.. (1985) Fecundity of golden Himalayan mahseer Tor putitora. *J Bombay Nat Hist Soc* 82(2):253–257

Nautiyal, P., & Lal, M.S. (1985) Fecundity of golden Himalayan mahseer *Tor putitora*. *Journal of Bombay Natural History Society,* 82(2): 253-257

Nautiyal, P., & Lal, M.S. (1984) Food and feeding habit of fingerlings and juveniles of mahseer *Tor putitora* (Ham.) in Nayar River. *Journal of Bombay Natural History Society* , 81: 642-646

Nautiyal, P., Bhatt, J.P., Rawat, V.S., Kishor, B., Nautiyal, R., & Singh, H.R. (1998) Himalayan Mahseer: Magnitude of commercial fishery in Garhwal hills. *Fish Genetics and Biodiversity Conservation* 5: 107-114

Nayar, M. P. & Sastry, A.R.K. (1990) Red Data Book of Indian Plants – III. B.S.I. Howrah.

Nayar, M. P. & Sastry, A.R.K. (1987) Red Data Book of Indian Plants – I. B.S.I. Howrah.

Nayar, M. P. & Sastry, A.R.K. (1988) Red Data Book of Indian Plants – II. B.S.I. Howrah.

Negi, S. S. (1995) *Uttarakhand: land and people*. M D Publications Pvt. Ltd New Delhi. 49 pp.

Ng, H. H. & Kottelat, M. (2000) A review of the genus *Amblyceps* (Osteichthyes: Amblycipitidae) in Indochina, with descriptions of five new species. *Ichthyological Exploration of Freshwaters* 11(4): 335–348.

Nilsson, C. & Dynesius, M. (1994) Ecological effects of river regulation on mammals and birds: a review. *Regul. Rivers: Res. Manage*. 9:45-53.

Nilsson, C., & Svedmark, M. (2002) Basic principles and ecological consequences of changing water regimes: riparian plant communities. *Environmental Management* 30:468–480.

Ortolano, L. & Shepherd, A. (1995) "Environmental Impact Assessment: Challenges and Opportunities," *Impact Assessment*, Vol.13, No.1 (Spring, 1995), pp. 3-30.

Parmanand, G.C.P. & Singh R.L. (2000) *Management Plan of Gangotri National Park*. Wildlife Preservation Organisation, Forest Department Uttar Pradesh.

Payne, A.I., Sinha, R.K., Singh, H.R., & Haq, S. (2004) *A review of the Ganges Basin: its fish and fisheries*. In: Welcomme RL, Peter T (eds.), *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries*, Vol. 1, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, pp 229-251

Peterson, G. D., Cumming, G. S. & Carpenter, S. R. (2003) Scenario planning: a Tool for conservation in an uncertain world. *Conservation Biology* 17:358-366.

Pethiyagoda, R. (1991) Freshwater fishes of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Colombo. 362 .

Phondani, P.C., Maikhuri, R. K., & Bisht, N.S. (2009) Medicinal Plants Used in the Health Care System Practiced by Traditional Vaidyas in Alaknanda Catchment of Uttarakhand, India. *Ethnobotanical Leaflets* 13:1453-67.

Phondani, P.C., Maikhuri, R. K., Rawat, L. S., Farooquee, N. A., Kala, C.P., Vishvakarma, S.C.R., Rao, K.S & Saxena, K.G (2010) Ethnobotanical Uses of Plants among the Bhotiya Tribal Communities of Niti Valley in Central Himalaya, India. *A journal of Plant, People and Applied Research* 8 (2547-3465) : 8-233.

Poff, N. L., & Allan, J. D. (1995) Functional organization of stream fish assemblages in relation to hydrological variability. *Ecology* 76:606–627.

Prasad, M.S., Yadav, A.N. & Singh, B. (1997) Threatened fishes of the world: *Amblyceps mangois* Hamilton, 1822 (Amblycipitidae). *Environemntal Biology of Fishes* 49(1): 62.

Prater, S.H. (1980) *The Book of Indian Animals*. Bombay Natural History Society. Pp 324

PSL. (2006) *Towards Project Snow Leopard*; report of the National Workshop on Project Snow Leopard. 10–11 July 2006, Leh, Ladakh, Ministry of Environment and Forests, Government of India, Department of Wildlife Protection, Jammu and Kashmir, Nature Conservation Foundation and International Snow Leopard Trust, Mysore, India. Pp93

Pusey, B. J., Arthington, A. H. & Read, M. G. (1993) Spatial and temporal variation in fish assemblage structure in the Mary River, south-east Queensland: the influence of habitat structure. *Environmental Biology of Fishes* 37:355–380.

Pusey, B. J., Arthington, A. H. & Read, M. G. (1995) Species richness and spatial variation in fish assemblage structure in two rivers of the Wet Tropics of Northern Queensland, Australia. *Environmental Biology of Fishes* 42:181–199.

Pusey, B. J., Arthington, A. H. & Read, M. G. (1998) Freshwater fishes of the Burdekin River, Australia: Biogeography, history and spatial variation in assemblage structure. *Environmental Biology of Fishes* 53:303–318.

Pusey, B. J., Kennard, M. J. & Arthington, A. H. 2000. Discharge variability and the development of predictive models relating stream fish assemblage structure to habitat in north-eastern Australia. *Ecology of Freshwater Fishes* 9:30–50.

Rana, N. (2007) “Socioeconomic and Environmental Implications of the Hydroelectric projects in Uttarakhand Himalaya, India”, Journal of Mountain Science, 4(4), 344353 pp.

Rea, N., & Ganf, G. G. (1994) The role of sexual reproduction and water regime in shaping the distribution patterns of clonal emergent aquatic plants. *Australian Journal of Marine and Freshwater Research* 45:1469–1479,

Reed, T.M. (1979) A contribution to the ornithology of the Rishi Ganga valley and the Nanda Devi Sanctuary. *J. Bombay Nat. Hist. Soc.* 76(2): 270-82.

Regan H. M., Davis F. W., Andelman S. J., Widyanata A., & Freese M. (2007) Comprehensive criteria for biodiversity evaluation in conservation planning. *Biodiversity and Conservation* 16(9): 2715-2728.

Reid, L.M. (1998) Cumulative watershed effects and watershed analysis. In: *Naiman R, Bilby R, editors. River ecology and management: lessons from the pacific coastal ecoregion*. NY: Springer-Verlag, 476–501.

Resh, V. H., Brown, A. V., Covich, A. P., Gurtz, M. E., Li H. W., Minshall, G. W.,. Reice, S. R, Sheldon, A. L, Wallace, J. B. and Wismaar, R. C. (1988) The role of disturbance in stream ecology. *Journal of the North American Benthological Society* 7:433– 455.

Sadler, B & Verheem, R. (1996) *Strategic Environmental Assessment: Status, Challenges and Future Directions*. Ministry of Housing, Spatial Planning and the Environment, Publication No. 53, The Hague, The Netherlands, and the International Study of Effectiveness of Environmental Assessment.

Sand-Jensen, K., & Madsen, T. V. (1992) Patch dynamics of the stream macrophyte, *Callitriche cophocarpa. Freshwater Biology* 27:277–282.

Sankaran, R. (1993) *An ornithological survey of Nanda Devi National Park*. Scientific and Ecological Expedition to Nanda Devi. A report. pp. 16-34.

Sarkar, U. K., Pathak, A. K., Sinha, R. K., Sivakumar, K., Pandian, A. K., Pandey, A., Dubey, V. K., Lakra, W. S. (2011) *Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives*. Rev Fish Biol Fisheries, DOI 10.1007/s11160-011-9218-6.

Sathyakumar, S & Bhatnagar, Y.V. (2002) Mountain Ungulates. *ENVIS Bulletin: Wildlife and Protected Areas,* 1(1):130.

Sathyakumar, S & Kalsi, R.S. (2007) *Partridges, Quails, Francolins and Snowcocks. Galliformes of India*. ENVIS Bulletin. Wildlife and Protected Areas: Vol.10 (1). Wildlife Institute of India, Dehradun. Pp. 3-32.

Sathyakumar, S & Kaul, R. (2007) *Pheasants. Galliformes of India*. ENVIS Bulletin. Wildlife and Protected Areas: Vol.10 (1). Wildlife Institute of India, Dehradun. Pp. 33-52Sathyakumar 1992, 2006;

Sathyakumar, S. (1993) Status of mammals in Nanda Devi National Park. In: *Scientific and Ecological Expedition to Nanda Devi.* A report. Pp 5-15.

Sathyakumar, S. (1994) *Habitat Ecology of Major ungulates in Kedarnath Musk deer Sanctuary.* Ph.D Dissertation. Saurashtra Univ., Rajkot. 244 pp.

Sathyakumar, S. (2001) Musk Deer. *An Encyclopaedia of the Mammals of the World*. Second Edition.

Oxford University Press, Oxford. Pp. 502-503

Sathyakumar, S. (2004) *Conservation status of Mammals and Birds in Nanda Devi National Park – An assessment of changes over two decades*. Biodiversity Monitoring Expedition Nanda Devi 2003. A Report to the Ministry of Environment & Forests, Govt. of India. Uttaranchal State Forest Department, Dehradun. pp.1-14.

Sathyakumar, S. (2006a) Status and Distribution of Himalayan Brown Bear (Ursus arctos isabellinus) in India: An assessment of changes over ten years. *The Indian Forester* 132(12(a)): 89-96.

Sathyakumar, S. (2006b) Martens, Weasels and Civets of North-western and Western Himalayas. The *The Indian Forester* 132(12(a)):132-139

Sathyakumar, S., Kaul, R., Kalsi, R.S., & Sivakumar, K . (2007) Techniques for Monitoring Galliformes. In: *Sathyakumar, S and Sivakumar, K. (Eds.) Galliformes of India.* ENVIS Bulletin. Wildlife and Protected Areas, 10(1). Wildlife Institute of India, Dehradun. Pp. 177-182.

Sathyakumar, S., Prasad, S.N., Rawat, G.S. & Johnsingh, A.J.T. (1993) Conservation status of Himalayan musk deer and livestock impacts in Kedarnath Wildlife Santuary, Western Himalaya. High Altitudes of the Himalaya: Biogeography, Ecology and Conservation. Gyanodaya Prakashan, Nainital. Pp. 240-245.Schreiner 1976,

Sathyakumar, S., R.M Athreya & Athreya, V.R. (1992) The Cheer Pheasant - A new recording. *WPA News* 37:28.

Sati, V.P. (2008) Natural Resource Management and Food Security in the Alaknanda Basin of Garhwal Himalaya. Presented in Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hohenheim, October 7-9, 2008.

Schaller, G.B. (1977) *Mountain monarchs: wild sheep and goat of the Himalayas*. The University of Chicago Press, Chicago, Illinois, USA, 425p.

Schindler, D.W. & Donahue, W.F. (2006) An impending water crisis in Canada's Western prairie provinces. *Proc Nat Acad Sci*, 103(19):7210–6.

Schindler, D.W. (2001)The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Can J Fish Aquat Sci*, 58:18–29.

Schlosser, I. J. (1982) Fish community structure and function along two habitat gradients in a headwater stream. *Ecological Monographs* 52:395– 414.

Schreiner, K. M. (1976) Critical habitat: what it is and is not. Endangered Species Tech. Bull. 1:1-4

Semwal, D.P., Saradhi P. Pardha, Nautiyal, B.P., & Bhatt, A.B. (2007) Current status, distribution and conservation of rare and endangered medicinal plants of Kedarnath Wildlife Sanctuary, Central Himalayas, India. *Current Science*, 92 (12) : 1733-1738.

Sharma, R. (2003) *Protection of an endangered fish Tor tor and Tor putitora population impacted by transportation network in the area of Tehri Dam project, Garhwal Himalaya, India*. ICOET Proceedings

Sharma, R. (2003) *Protection of an endangered fish Tor tor and Tor putitora population impacted by transportation network in the area of Tehri Dam project, Garhwal Himalaya, India*. ICOET Proceedings.

Sharma, R.C. (1983) Sustainable utilization and preservation of living aquatic resources of Garhwal Himalaya with special reference to coldwater fisheries. *Himalayan Research and Development.* 2(1):15-18.

Sharma, R.C. (1984) Potamological studies on lotic environment of the upland river Bhagirathi of Garhwal Himalaya. .*Environment and Ecology* 2:239-242

Sharma, R.C. (1985-86) Ecology and problem of survival of Mahaseer in Garwhal Himalayas. *Johsard* 9 and 10:57-61.

Shrestha, J. 1999 Coldwater fish and fisheries in Nepal. FAO Fish. Tech. Pap. 385:13-40.

Sing, G. & Rawat, G.S. (2011) Ethnomedicinal Survey of Kedarnath Wildlife Sanctuary in Western Himalaya, India. *Indian Journal of Fundamental and Applied Life Sciences* 1 (1) 35-46.

Singh, D., & Sharma, R.C. (1998) Biodiversity, ecological status and conservation priority of the fish of the River Alaknanda, a parent stream of the River Ganges (India). *Aquatic Conservation: Marine and Freshwater Ecosystems,* 8: 761-772

Singh, H.R. (1988) *Bio ecological studies on the mahseer and snow trout of Garhwal Himalaya*. Final Technical Report, ICAR

Singh, J. S., (2006) Sustainable development of the Indian Himalayan region: linking ecological and economic concerns. *Curr. Sci,* 90:784–788.

Sinha, R.K. (2007) Impact of Man-Made and Natural Hazards on Fisheries of the River Ganga in India. In: *Goswami UC (eds.), Natural and Anthropogenic Hazards on Fish and Fisheries*. Inland Fisheries Society of India, Barrackpore, India pp 245-261

Sippe, R. (1999) *Criteria and standards for assessing significant impacts*. In: Petts J, editor. Handbook of environmental impact assessment. Malden, MA: Blackwell Science, p. 74–92.

Sivakumar, K & Choudhury, B. C. (2008) Chambal River, Rajasthan:Importance of water flow and minimum water level in conservation of all tropic levels in different habitats and biodiversity. *J. Landscape Architecture* 19: 52-57.

Sivakumar, K. (2008) Species richness, distribution pattern and habitat use of fishes in the Trans-Himalayas, India. *Elc. J. Ichthyology* 1:31-42

Smit, B. & Spaling, H. (1994) Methods for cumulative impact assessment. *Environ Impact Assess Rev*,15: 81-106.

Smith, P. G. R. & Theberge, J. B. (1986) A review of criteria for evaluating natural areas. *Environmental Management* 10(6): 715-734.

Sonntag, N.C., Everitt, R.R., Rattie, L.P., Colnett, D.L.,. Wolf, C.P, Truett, J., Dorecy, A., & Holling, C.S. (1986) *Cumulative Effects Assessment: A Context for Further Research and Development*. A Report to the Canadian Environmental Assessment Research Council (CEARC), Hull, Quebec.

Prepared by ESSA Environmental and Social Systems Analysts Ltd., Vancouver, B.C. 99 pp. + appendix.

Sparks, R. E. (1995) Need for ecosystem management of large rivers and floodplains. *BioScience* 45:168 –182.

Stanford, J. A., & Ward, J. V. (1986a) *Reservoirs of the Colorado River system*. Pp 375–383 *in* B. R. Davies and K. F. Walker (eds.), The ecology of river systems. Dr W. Junk, Publishers, Dordrecht.

Stockholm Environment Institute, SEI. (2008) *Strategic environmental assessment of the hydropower master plan in the context of the power development plan VI*. Final report.

Swart, R., Raskin, P. & Robinson, J. (2004) The problem of the future: sustainability science and scenario analysis. Global Environmental Change 14:137-146.

Tak, P.C. and G. Kumar. (1987) Wildlife of Nanda Devi National Park – an update. *Ind. J. For.* 10:184-190.

Therivel, R., & Ross, B. (2007) Cumulative effects assessment: Does scale matter? *Environmental Impact Assessment Review (Special Issue on Data and Scale Issues for SEA)*, 27:365–385.

Tiwari, J.K., Ballabha, R. & Tiwari, P. (2010) Diversity and Present Status of Medicinal Plants in and around Srinagar Hydroelectric Power Project in Garhwal Himalaya, India: Needs for Conservation. *Researcher* 2(2) 50-60.

Treweek, J. (1999) *Ecological impact assessment*. Wiley-Blackwell.

U.S. Fish & Wildlife Service. (1988) *Endangered species act of 1973, as amended through the 100th Congress*. U.S. Dep. Inter., Washington, D.C.

U.S. Fish & Wildlife Service. (2002) *Critical Habitat: What is it?* Downloaded on 11 January 2012 http://www.fs.fed.us/r9/wildlife/tes/docs/esa_references/critical_habitat.pdf

Uniyal, B. (2006) Traditional Knowledge and conservation of medicinal plants for sustainable livelihoods in the Garhwal Himalayan region of Uttaranchal, India. International Symposium towards Sustainable Livelihoods and Ecosystems in Mountainous Regions, 7-9 March, Chang Mai, Thailand.

Uniyal, S., Awasth,i A. & Rawat, G.S. (2002) Traditional and ethnobotanical uses of plants in Bhagirathi Valley, Western Himalaya. *Indian J. of Traditional Knowledge* 1 (1): 7-19.

Uniyal, V.P. & Ramesh K.. (2004) *Wildlife survey in Gangotri National Park*. Wildlife Institute of India and Uttarakhand Forest Department, Dehradun, India, pp.10.

Valdiya, K. S. (1997) *Developing a paradise in peril*. Proceedings of 7th Pandit Govind Ballabh Pant Memorial Lecture, G.B. Pant Institute of Himalayan Environment and Development, Kosi- Katarmal, Almora, 1997.

Vanclay, F. (1999) *Social impact assessment*. In: Petts J, editor. Handbook of environmental impact assessment, vol. 1. Oxford: Blackwell Science; 1999. p. 301–26.

Vasudevan, K. & Sondhi, S. (2010) Amphibians and Reptiles of Uttarakhand, India. Wildlife Institute of India, Dehradun. 94 pp.

Walker, K. F., Thoms, M. C. & Sheldon, M. C. (1992) *Effects of weirs on the littoral environment of the River Murray, South Australia.* Pages 271–292 *in* P. J. Boon, P. Calow and G. E. Petts (eds.), River conservation and management. John Wiley & Sons, Chichester, UK.

Ward, J. V., Tockner, K. and Schiemer, F. (1999) Biodiversity of floodplain ecosystems: Ecotones and connectivity. *Regulated Rivers: Research and Management* 15:125–139.

Webb, R.H., Schmidt, J.C., Marzolf, G.R. & Valdez, R.A. (1999) *The Controlled Flood in Grand Canyon*. Geophysical Monograph Series, 110, Geological Survey 368 pp.

Welcomme, R. L. (1985) *River Fisheries. FAO Fisheries Technical Paper 262*. Food and Agriculture Organisation of the United Nations, Rome, 330 pp,

Welcomme, R. L. (1992) *River conservation—future prospects*. Pages 454 – 462 in P. J. Boon, P. Calow and G. E. Petts (eds.), River conservation and management. John Wiley & Sons, Chichester, UK

Wetmore, S. H., Mackay, R. J. & Newbury, R. W. (1990) Characterisation of the hydraulic habitat of *Brachycentrus occidentalis*, a filter feeding caddisfly. *Journal of the North American Benthological Society* 9:157–169.

Wildlife Institute of India, WII. (1998) *Assessment of ecological values of proposed Chamera Stage II Hydroelectric Power Project area in Chamba, Himachal Pradesh*. WII-EIA Technical Report Wildlife Institute of India, Dehra Dun. 51 pp. (Unpublished).

Wollenberg, E., Edmunds, D. & Buck, L. (2000) Using scenarios to make decisions about the future: anticipatory learning for the adaptive co-management of community forests. Landscape and Urban Planning 47:65-77.

World Bank, (2011) Uttarakhand. Available at http://go.worldbank.org/FE04IF2IP0. Downloaded on 16th May 2011.

World Commission on Dams (WCD) (2000) Dams and Development: A New Framework for Decision-Making the Report of The Earthscan Publications Ltd., London and Sterling, VA.

World Health Organization, WHO. (2005) *Ecosystems and human well-being: health synthesis.* A Report of the Millennium Ecosystem Assessment. Available at http://www.who.int/globalchange/ecosystems/ecosys.pdf.

World Wildlife Fund, WWF-India. (2011) *Assessment of Environmental Flows for the Upper Ganga Basin.* WWF-Report.

Zoological Survey of India, ZSI. (1995) *Fauna of Nanda Devi Biosphere Reserve.* Zoological Survey of India, Northern Regional Station, Dehra Dun.

Smakhtin, V. & Anputhas, M. (2006) *An assessment of environmental flow requirements of Indian river basins*. Colombo, Sri Lanka: International Water Management Institute. 42p. IWMI Research Report 107.

Smakhtin, V., Arunachalam, M., Behera, S., Chatterjee, A., Das, S., Gautam, P., Joshi, G. D., Sivaramakrishnan, K. G., & Unni, K. S. (2007) *Developing procedures for assessment of ecological status of Indian river basins in the context of environmental water requirements*. Colombo, Sri Lanka: International Water Management Institute. 40p. IWMI Research Report 114.

Stalnaker, C.B. & Arnette, S.C. (1976) *Methodologies for the Determination of Stream Resource Flow Requirements: An Assessment.* US Fish and Wildlife Services, Office of Biological Services Western Water Association

Stalnaker, C.B. (1982) Instream flow assessments come of age in the decade of the 1970's. In Research *on Fish and Wildlife Habitat, Mason WT, Iker S (eds). EPA-600/8-82-022*. Office of Research and Development. US Environmental Protection Agency: Washington, DC; 119–142.

Stewardson ,M., & Gippel, C. (1997) *In-stream Environmental Flow Design: A Review*. Draft Report. Cooperative Research Centre for Catchment Hydrology, Department of Civil and Environmental Engineering, University of Melbourne: Victoria, Australia.

Talwar, P. K. & Jhingran, A.G. (1991) *Inland Fishes of India and Adjacent Countries - Vol. I*. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 541 pp.

Tharme, R. E. (2003) A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. *River res. Applic.* 19: 397– 441

Wesche, T.A., & Rechard, P.A. (1980) *A Summary of Instream Flow Methods for Fisheries and Related Needs*. Eisenhower Consortium Bulletin No. 9. Water Resources Research Institute, University of Wyoming, for the USDA Forest Service.

Rajvanshi, A., Mathur, V.B., Iftikhar, U.A. (2007) Best practice guidance for biodiversity-inclusive impact assessment:a manual for practitioners and reviewers in South Asia. CBBIA-IAIA Guidance Series. Capacity Building for Good practice in Biodiversity and Impact Assessment (CBBIA) Project, International Association of Impact Assessment (IAIA), North Dakota, USA.

International Union for Conservation of Nature and Natural Resources and the United Nations Environmental Programme. *(2001) Ecosystem Impacts of Large Dams.* Background Paper Nr. 2, Prepared for IUCN / UNEP / WCD by M.P. McCartney, C. Sullivan and M.C. Acreman

Lane, P.A., Wallace, R.R., Johnson, R.J., & Bernard, D. (1988) *A Reference Guide to Cumulative Efsects Assessment in Canada.* Volume 1, Hull, Quebec: Canadian Environmental Assessment Research Council.

Witmer, G.W., Bain, M.B. & Irving, J.S. (1987) *Cumulative impact assessment: application of a methodology*. CONF-8708124-1, presented at Waterpower 1987 Conference, American Society of Civil Engineers, 19-21 August 1987, Portland, OR, USA.

Lamba, B. S. (1987) Status survey of fauna. Nanda Devi National Park. Occasional Paper No. 103. Zoological Survey of India, Dehradun.

Rasmussen, P. C. & Anderton, J. C. (2005) *Birds of South Asia. The Ripley Guide.* ISBN 84-87334-67-9

Sharma, R.C., Gusain, O.P. and Juyal, C.P., 1990. Ecology of high altitude river Builangana of Garhwal Himalaya. In. Trivedy, R.K. (ed) River Pollution in India. Ashish Publ. House, New Delhi: 11-30

Sharma, R.C., Bhanot, G. and Singh, D., 2004. Aquatic macro invertebrate diversity in Nanda Devi Biosphere Reserve, India. The Environmentalist. 24:211-221.Sharma *et al.,* 2008

Sharma, R.C., and Rawat, J.S., 2009. Monitoring of aquatic macroinvertebrates as bioindicator for accessing the health of Asan Conservation Reserve, India: A case study. Ecological Indicators, 9:118-128.

Payne, A.I., & Temple, S.A., 1996. *River and floodplain fisheries in the Ganges basin*. Final Report. Marine Resources Assessment Group Ltd. London.

Trihey, E. W., & Stalnaker, C. B. (1985) Evolution and application of instream flow methodologies to small hydropower development: an overview of the issues. In: F. W. Olson, R. G. White, and R. H. Hamre, eds. Proceedings of the symposium on small hydropower and fisheries. American Fisheries Society, Bethesda, 176-183.

Urgent
Speed Post/ Fax

F. No. 8-9/ 2008-FC
Government of India
Ministry of Environment & Forests
(FC Division)

Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi – 110003.
Dated: 23rd July, 2010.

To,

The Director,
Wildlife Institute of India
Post Box # 18,
Chandrabani, Dehradun 248001
Uttrakhand

Sub.: Study on cumulative environmental impact of various hydro electric projects particularly on the riverine eco system and land and aquatic biodiversity.

Sir,

I am directed to refer to the proposals submitted by the Government of Uttrakhand to obtain prior approval of the Central Government, in terms of Section-2 of the Forest (Conservation) Act, 1980, for diversion of forest land required for construction of Kotlibhel Stage-I-A, Kotlibhel Stage-IB and Kotlibhel-Stage-II Hydroelectric Project on river Bhagirathi, River Alaknanda and river Ganga respectively, and to say that it has been decided by this Ministry that a study on cumulative environmental impact of various hydro electric projects, particularly on the riverine eco system and land and aquatic biodiversity; and effectiveness of the mitigative measures and compliance of the stipulated conditions on which various projects have earlier been cleared shall be undertaken by the Wildlife Institute of India in collaboration with other appropriate institutions having special knowledge and practical experience in the field of terrestrial, aquatic flora & fauna and bio-diversity. These institutions could be IIT, Roorkee, Central Water Commission *etc.* A draft note on need and scope of the said study is enclosed.

I am further directed to say that a report on findings of the said study may be submitted to this Ministry as early as possible.

Yours faithfully,

Encl.: As above.

23/07/2010

(H.C. Chaudhary)
Assistant Inspector General of Forests

Annexe

Brief Note on Need and Scope of Study On Cumulative Environmental Impact of Various Hydro Electric Projects Particularly On the Riverine Eco System Etc. To Be Undertaken By the Wildlife Institute of India

1. Government of Uttrakhand submitted proposal seeking prior approval of Central Govt. for diversion of forest land as detailed below, for construction of following Hydroelectric Power Plants by the National Hydro Electric Power Corporation Limited (NHPC):

   (a) 261.047 ha. forest land (including 2.310 ha. for underground works) for construction of Kotlibhel Stage-IA, HEP at 3.80 km upstream of the confluence of river Bhagirathi and Alaknanda at Devprayag, on river Bhagirathi near village Muneth.

   (b) 551.519 ha. forest land for construction of 320 MW capacity Kotlibhel Stage-IB HEP at 2.20 km upstream of the confluence of River Bhagirathi and Alaknanda at Devprayag, on Alaknanda River in Tehri and Pauri Garhwal districts of the Uttrakhand.

   (c) 681.103 ha. forest land for construction of Kotlibhel Stage-II, HEP 30 km upstream of the confluence of River Bhagirathi and Alaknanda, on river Ganga near village Kaudiyala.

2. Proposal indicated at clause (a) and (b) related to Kotlibhel Stage-IA and Kothlibhel Stage-IB were placed before the Forest Advisory Committee (FAC), constituted by the Ministry of Environment & Forests, in terms of Section 3 of the Forest (Conservation) Act, 1980, in its meeting convened on 29.04.2008.

3. After detailed discussions on the issues of carrying capacity of the Alaknanda river basin in Uttarakhand, vulnerability of the area to landslides and impact on biological diversity of the area, the FAC recommended the proposed diversion of the forest land subject to certain conditions *viz.* payment of cost of compensatory afforestation, Net Present Value, preparation of resettlement and rehabilitation plan, bio-diversity management plan, afforestation activities along the periphery of reservoir/dam and obtaining environment clearance etc.

4. In pursuance to the Hon'ble Supreme Court's order dt. 27.04.2007, in IA No. 1413, 1414 etc. in WP (C) No. 202/1995, which *inter-alia* states that "*...fresh cases may be cleared Project wise by the FAC and thereafter such clearances shall be placed before this Court for approval, ..*", the said proposals along with said recommendation of the FAC were placed before the Central Empowered Committee (CEC) for its examination and appropriate recommendation to the Hon'ble Supreme Court.

5. On examination of the said proposals and FAC recommendations the CEC recommended as follows:-

(a) "the CEC of the view that it would be prudent that the reconstituted FAC reviews these projects after considering the findings of the studies regarding

(b) cumulative environmental impact of various hydro electric projects particularly on the riverine eco system and land and aquatic biodiversity; and

(c) effectiveness of the mitigative measures and compliance of the stipulated conditions on which various projects have earlier been cleared."

6. After examination of the above recommendations of the CEC, the Hon'ble Supreme Court vide order dated 30.02.2009 directed as below:

"CEC had made certain recommendations regarding diversion of 258.737 ha of forest land for Kotlibhel (State-1A) Hydro electric projects in favour of the National Hydro Power Corporation Ltd and diversion of 496.793 ha of forest land for Kotlibhel (Stage (1-B) Hydro electric project in favour of the National Hydro Power Corporation Ltd. The FAC will review these projects on the basis of recommendation made by CEC. The FAC will review its earlier order and take a fresh decision and decision may be taken at the earliest at least within a period of five months."

7. In pursuance to the order dated 30.02.2009, the above proposals were placed before the newly constituted FAC in its meeting convened on 02.04.2009. After careful consideration the FAC recommended that a Sub-committee under the chairmanship of Dr. Mahesh Rangarajan may be constituted to prepare a detailed report on cumulative environmental impact of various hydro electric projects, particularly on the riverine eco system and land and aquatic biodiversity, effectiveness of the mitigative measures and compliance of the stipulated conditions on which various projects have earlier been cleared.

8. The sub-committee met on 06th June for the first time. On 30th June, 2009, all the project proponents of major hydroelectric projects on river Ganga made their presentation on cumulative environmental impact of projects on river Ganga and study done so far, mitigative measures suggested therein and their compliance.

9. The sub-committee also conducted a field visit of Kotlibhel-Statge-1A, Kotlibhel-Stage-1B, Kotlibhel-Stage-II and Srinagar HEP on 29th October to 1st November, 2009. The Committee also interacted with NGO, local people and User Agency and considered their views and representations.

10. After thorough study and site visits the sub-committee submitted its report containing following major recommendations:

(a) Minimum natural water flow (i.e. ecological water flow) should be maintained for continuity of aquatic ecosystem of river Ganga. This may be decided by the National Ganga River Basin Authority (NGRBA), constituted in February, 2009. However, till time it should be 16 cumecs or 20% of the lean season flow whichever is higher.

(b) Mahasheer Conservation Reserve as proposed by State Wildlife Department should be established.

(c) Aquatic Otter Conservation Area should be properly demarcated as suggested in the Environmental Management Plan and should have restricted access.

(d) A corpus of 5% of the project costs of these three projects should be established for sustaining above mentioned activities.

(e) The corpus should be managed by a society registered under Society Act, with representative of the Ministry of Environment & Forests (MoEF), representative of State Forest Department and State Wildlife Department, two independent experts and representative of NHPC. This will be constituted by the State Government.

11. The report of the sub-committee was placed before the FAC in its meeting convened on 11-12.12.2009.

12. After through deliberations, the FAC in general, agreed with the report submitted by the sub-committee and observed that in view of preliminary assessment done and the fact that several dozen more small, medium and large similar projects are on various stages of formulation, there is potential for irreparable and irreversible damage to the entire river eco-system in the future. The Committee therefore, recommended that no further projects of this nature can be considered by the FAC, without a comprehensive study of carrying capacity of River Ganga in the hilly terrain upto Haridwar.

13. Accordingly, the NGRBA was requested to study and fix the minimum ecological water flow with terms of reference having issues like minimum ecological water flow in Ganga *vis-a-vis* sustainable aquatic eco-system and bio-diversity therein, as per their mandate. The NGRBA was also requested that the study should include suitable provision to assess the level of minimum water flow to have a sustainable aquatic eco-system and bio-diversity, impact of these projects on terrestrial flora and fauna, etc.

14. The Secretary, Forests & Forests convened a meeting on 25.06.2010 to discuss the matter. During the meeting, it was observed that environmental and forestry clearances for projects are to be processed in terms of statutory provisions. It was also observed that the NGRBA has not been envisaged as a separate project clearance body.

15. During the meeting it was also observed that in the Hon'ble Supreme Court's order dated 30.02.2009 in the I. A. 1413, 1414 and 1426, main emphasis is to reconsider the Kotlibhel (State-1A) and Kotlibhel (Stage- 1B) Hydro-Electric Power Projects in light of the findings of the studies regarding cumulative environmental impact of various hydro electric projects on the riverine eco system, in general, and terrestrial and aquatic biodiversity, in particular, and effectiveness of the mitigative measures and compliance of the stipulated conditions on which various projects have earlier been cleared.

16. It was therefore, decided that the Forest Conservation Division in the Ministry would itself commission the study involving the Wildlife Institute of India, Dehradun and other appropriate institutions having special knowledge and practical experience in the field of terrestrial, aquatic flora & fauna and bio-diversity. These institutions could be IIT, Roorkee and Central Water Commission etc.

17. The Wildlife Institute of India, Dehradun, is therefore requested to undertake the said study and submit a report to the Ministry of Environment & Forests as early as possible.

****

भारत सरकार
पर्यावरण एवं वन मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT & FORESTS

Dated: 23/7/2010

To

The Director,
Wildlife Institute of India,
Chandrabani,
Dehradun.

Sub: Study of Wildlife impact with respect to various forestry clearance projects -

Sir,

Please recall our discussions on the above subject on 16th instant. There is an important study in relation to hydro electric power projects on river Alkananda and Bhagirathi in the State of Uttrakhand. This matter is before the Forest Advisory Committee and the Hon'ble Supreme Court has directed the FAC to examine these projects and file an affidavit before the Supreme Court. Since this is a very important project, it is requested that Wildlife Institute of India may kindly take up this study, if necessary additional expertise may be integrated in the study team. TOR for this particular study is being sent separately by IG (FC).

Besides, there are a good number of FCA clearance cases wherein wildlife concern including specific impact on aquatic fauna, avi-fauna, bio-diversity concern in and around the project area is of important concern. This requires assessment of the wildlife impact and the mitigative measures necessary to be adopted in case the project is recommended for approval. Wildlilfe Institute may suggest a panel of experts with their suggested remuneration for engagement for carrying out the study. A mechanism of fund flow, and payment to consultants may also be suggested where Wildlife Institute cannot take up the study. You are requested to kindly take suitable action at the earliest.

Yours faithfully,

(Dr. P. P. Gangopadhyay)
ADG (FC)

जहाँ है हरियाली।
वहाँ है खुशहाली।।

पर्यावरण भवन, सी.जी.ओ. कॉम्पलैक्स, लोदी रोड, नई दिल्ली - 110 003
PARYAVARAN BHAWAN, C.G.O. COMPLEX, LODHI ROAD, NEW DELHI - 110 003

CHAPTER -1

INTRODUCTION

1.1. Assignment

The National River Conservation Directorate (NRCD), Ministry of Environment and Forests (MoEF), Government of India (GoI), vide letter no. J11022/1/2010-NRCD-II dated July 15, 2010 assigned a study to Alternate Hydro Energy Centre (AHEC), IIT Roorkee, for "Assessment of Cumulative Impact of Hydroelectric Projects in Alaknanda- Bhagirathi Basins". The Terms of Reference of the study are given as Annexure 1.1.

1.2. Geographical Area of Study

The study area, comprising of Alakananda and Bhagirathi Basins, is shown in the index map (Fig. 1.1). Ganga Basin is the largest river basin in India with an area of 8,61,404 sq.km and home to for nearly 43% of India's population (448.3 million as per 2001 census) (Fig. 1.2, Anon, 2009). The Alaknanda and Bhagirathi rivers are in the North Western part of the State of Uttarakhand, which is cradled in the Himalayas. These rivers have their confluence at Devprayag and lose their names to acquire a new one "Ganga".

Fig. 1.1 Index Map of Alaknanda and Bhagirathi Basins

Fig. 1.2 Map of Ganga Basin (from National River Conservation Directorate, Ministry of Environment and Forests, "Status paper on River Ganga" 2009.)

As a result of a combination of various factors Alaknanda and Bhagirathi basins are rich in water resources. Additionally the topography provides a large number of sites for setting up hydropower projects to generate large quantity of electricity with relatively low investments. Some hydropower projects have already been commissioned and many more are either under construction or are planned. For this study hydropower projects with installed capacity exceeding 1 MW have been considered as the smaller ones will have much smaller impact.

The present generation capacity of the commissioned hydropower projects is 1,850.8 MW. Hydropower projects under construction and development will add another 7,712.5 MW of power to the existing capacity and if all the identified sites are made operational 9,563.3 MW of additional power will be added. (Annexure 1.2).

1.3. Components of the Ecosystem for Cumulative Impact Assessment

There is an apprehension that if hydropower potential of the study area is developed without a study of their impact on various components of the ecosystem (response components), then cumulative impact of these projects on various components of the ecosystem of the basin could be significantly adverse and would therefore be unacceptable. The components on which the impact of development of hydropower projects needs to be assessed, identified by NRCD, MoEF are as follows:

a) geological (tectonic) stability,
b) stability of glaciers resulting in more frequent avalanches,

c) stability of slopes resulting in landslides,
d) soil erosion reducing productivity of land and producing frequent floods,
e) requirement of environmental flow,
f) altered surface and ground water regime affecting drinking and irrigation water sources and their potential to provide water,
g) flows in streams, tributaries and rivers and, above all, environmental flows necessary for sustaining biotic life and observing religious practices,
h) impact on places of cultural and religious importance and
i) details of submergence area under protected area network,

1.4. Objectives of the Study

Objectives of this study are the following

a. To assess the cumulative impact of commissioned, under construction and proposed hydro power projects in Alaknanda and Bhagirathi basins. The assessment would consider, interalia, factors mentioned in paragraph 1.2 of ToR, and mentioned in Section 1.3 from a) to i) above.
b. To estimate the extent to which hydropower potential identified in the basins should be developed without risking stability of landforms and environment. At the same time ensuring that the quality, quantity, and timing of water flows required to maintain functions, assimilative capacity and aquatic ecosystems that provide goods and services to people are maintained.
c. Restrictions, if any, that need to be placed in the development of hydropower in the two basins.

1.5. Other Requirements of the Study

1.5.1. Collection of Maps

The following maps were collected

a) topographical maps of the two basins,
b) satellite imageries and geological maps of the basins.
c) satellite imageries of large completed projects to detect any discernible change between preconstruction period and post construction period.

1.5.2. Collection of Reports

The following reports were collected

a) Detailed Project Reports and Prefeasibility reports (DPRs/PFRs) of all commissioned / proposed Hydropower Projects and
b) EIA studies and Environmental Management Plans (EMPs) of all commissioned/ proposed HPs.
c) Clearances accorded to all HPs.
d) Monitored observations and activities under taken post clearances as per requirement
e) Meteorological data
f) Surface and ground water hydrology

i. discharge upstream of hydropower sites.
ii. discharge downstream of the hydropower sites.

g) Available ground water levels in affected areas.
h) Available socio-economic data of affected areas.
i) Water quality data at each potential site.

1.5.3. Collection of Data Relating to Completed Projects With Capacity Above 25 MW

This study includes an assessment of impact of large hydropower projects on environment and other factors mentioned in paragraph 1.2. In particular the following data was gathered:

a) landslides
b) loss of irrigation potential, if any
c) Health hazards
d) Socio-economic survey of the area to assess the socio-economic impact of completed projects.
e) Water quality and discharge studies in the immediate vicinity and d/s of the project
f) Study the impact on springs.

1.5.4. Deliverables

Based on this study the following reports are to be delivered

a) The impact of large completed hydropower projects in the basin of rivers Alaknanda and Bhagirathi, up to Devprayag.
b) Based on the above study, drawing empirical inferences in assessing impact of hydropower projects under implementation / proposed.
c) Cumulative impact of
   i. All projects on a stream on the tributary.
   ii. All projects located on a tributary at its confluence with river Alaknanda.
   iii. All projects located on a tributary at its confluence with river Bhagirathi.
   iv. All hydropower projects proposed / established on river Alaknanda and Bhagirathi upto Devprayag.
d) This report addresses the following issues
   i. Whether acceptable limits of geomorphologic stability or of environmental sustainability, particularly of environmental flows, are likely to exceed at any small or large hydropower project site(s).
   ii. Whether there will be a depletion of irrigation potential or availability of drinking water in habitations as a result of any project.
   iii. Impact on ground water and springs in the basin.
   iv. Impact of these projects on places of cultural, religious or of tourism importance.
   v. Whether any restrictions should be placed on development of hydropower in the basin.
   vi. The impacts should be expressed qualitatively and quantitatively.

The Terms of Reference (ToR) of the assignment are given at Annexure 1.2.

1.6. Background of the Problem

As is well known, the state of Uttarakhand and the country are acutely short of electricity, a prerequisite for development. In view of rapid economic growth the gap between demand and supply of electricity has been increasing. In this context all sources of power generation need to be harnessed. In the last 50 years, although the role of hydropower in meeting the power requirement of the country has increased in terms of output, its share in the mix of power has significantly reduced and is far below the desirable level.

Any form of power generation affects the environment. Hydrocarbons and coal release a large amount of green house gases and particulate matter which pollutes the atmosphere and may also contribute to global warming. Wind, tidal and geothermal related power plants can be located only in very specific and limited areas where suitable conditions exists, moreover, cost of power production by these plants is invariably high. Solar energy requires panels which are made from rare earth elements. The rare earth elements are expensive and available at the moment only in very limited regions of the world and hence have to be imported. Moreover, cost of production of solar panels by the present known technology is high and large scale use of solar energy in the next few decades seems unlikely. Material required to generate nuclear energy (nuclear fuel) is available only with large constraints and serious environmental hazards are associated with this form of electrical energy generation in case of an accident. The occurrence of such accidents, however few, are serious environmental hazards.

Considering the above, hydropower generation appears to be a viable alternative to meet the ever increasing power demand. Before a decision is taken to harness this considerable hydropower potential in the basin under study it is necessary to understand the cumulative impact of development of this hydropower potential on the response components of the ecosystem. In view of the above an attempt is made in this study to assess the cumulative impact of hydropower projects in Alaknanda and Bhagirathi Basins.

1.6.1 Cumulative Impact Assessment

1.6.1.1 Concept

The impact of human activity or a project on an environmental resource or eco-system may be considered insignificant when assessed in isolation, but may become significant when evaluated in the context of the combined effect of all the past, present, and reasonably foreseeable future activities that may have or have had an impact on the resources in question. The Council for Environmental Quality established under the US National Environmental Policy Act of 1969 (NEPA) came to the view that a conventional project and site-specific approach to environmental assessment has its limitations when it comes to assessing potential cumulative effects on environmental resources.

1.6.1.2 Definition of Cumulative Impact

Cumulative impact is defined by the US Council on Environmental Quality as "the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (RFFA) regardless of what agency undertakes such other actions." Thus the practice of Cumulative Effects Assessment (CEA) of projects in a region began. Various aspects of CEA began to be studied.

There are several reasons why Cumulative Impact Assessments should be carried out i.e.,

i. Conceptual reasons – For a group of projects, the environmental effects of primary concern tend to be cumulative and it will not be advisable to consider simply the effects of individual projects
ii. Pragmatic reasons – CEA guidance and other EIA legislation of the 1990s requires that CEs be assessed
iii. Regulatory reasons – make "room" for future developments
iv. Idealistic reasons – minimize negative CEs, promote resource sustainability

In India, so far, there is no law requiring the conduct of Cumulative Environmental Impact Assessment before a development project is given Environmental Clearance.

During 1980s and 1990s, it became the practice in many countries to include Cumulative Effects in Environmental Impact Statements. CEA processes were also developed. Litigation in courts also clarified some of the concepts. With the dawn of the present millennium i.e., 2000s practice for project CEAs was improved; methods of analysis developed and existing methods expanded.

In view of the above the present study attempts to deal with the issue of cumulative impact assessment of hydropower projects in Alaknanda and Bhagirathi basins in light of the prevailing concepts of cumulative impact assessment of hydropower projects.

1.7. Description of Area

1.7.1. Uttarakhand State

Uttarakhand (formerly known as Uttaranchal) was carved out of Uttar Pradesh as the 27th state of India on 9th November 2000. The state lies between latitudes 28°43′N to 31°27′N and longitudes 77°34′E to 81°02′E, with a total geographical area 53,484 sq km (1.6% of total area of the country). Forest area of 34,651 sq km, is 63.99% of the total area of the state (Kumar, 2010).

This state is predominantly mountainous, with hilly area covering 46035 sq km (86.07%) and the plains having an area of 7448 sq km (13.93%). The state is divided into two divisions Kumaon and Garhwal, and has 13 districts, with 78 Tehsils, 95 Development Blocks, 670 Nyaya Panchayats, 7541 Gram Panchayats and 16826 villages, excluding forest settlements, of which 15761 are inhabited. Total population of the state, as per 2001 census, was 84,89,000. Bulk of the population, 46.24%, lives in the three plain districts of Hardwar, Dehradun and Udham Singh Nagar. Population density of the state is 159 persons/ sq km as against 324 at the national level. Urban component of population is 25.59 per cent, slightly lower than the national average of 27.78 per cent. The female population is 962 per thousand males, a little higher than the national average of 933 recorded by the last census. However, rural areas have a better sex ratio with 1007 females per thousand males.

In the overall ranking of different states in the country, the state ranks 20th in terms of population, 18th in terms of area, 25th in terms of population density and 14th in terms of literacy. District wise data for the state is given in Table 1.1.

Table 1.1 Statistical Data on Uttarakhand as per 2001 Census

District	Headquarter	Area (sq km)	Population	Male	Female	Population Density (persons /sq km)	Literacy rate (%)
Uttarkashi	Uttarkashi	8016	295013	152016	142997	37	65.71
Tehri Garhwal	New Tehri	3796	604747	295168	309579	166	66.73
Pauri Garhwal	Pauri	5230	697078	331061	366017	124	77.49
Rudraprayag	Rudraprayag	2439	227439	107535	119904	115	73.65
Chamoli	Gopeshwar	7520	370359	183746	186614	43	75.43
Pithoragarh	Pithoragarh	7169	462289	227615	234674	65	75.95
Bageshwar	Bageshwar	2246	249462	118510	130952	111	70.42
Champawat	Champawat	1766	224542	111084	113458	126	71.29
Udham Singh Nagar	Rudrapur	3055	1235614	649484	586130	486	64.96
Nainital	Nainital	4251	762909	400254	362655	179	78.36
Almora	Almora	3689	630567	293848	336719	201	73.64
Hardwar	Hardwar	2360	1447187	776021	671168	613	63.75
Dehra Dun	Dehra Dun	3088	1282143	679583	602560	415	78.99
Total	**Uttarakhand**	**53,484**	**8489349**	**4325925**	**4163427**	**159**	**71.6**

The state is also known as Dev Bhumi ("Abode of Gods) and tourism plays an important role in the economy of the state. It has the famous pilgrim centers: four dhams (Badrinath, Kedarnath, Gangotri and Yamnotri), five prayags (Vishnuprayag, Nandprayag, Karnprayag, Rudraprayag and Devprayag), besides Hardwar and Rishikesh which are prominent religious centres for Hindus. The famous "Kumbh Mela" is held every twelve years at Hardwar. Hemkund Sahib, a prominent pilgrim centre for Sikhs is also situated in Uttarakhand. Besides centres of religious importance, many hill stations are very popular tourist destinations like Nainital, Mussorie, Kausani, Ranikhet, Almora and Lansdown. These places are famous for their natural beauty. The state also has several sites for winter, river and adventure sports at Auli, Dayara Bugyal, Tehri Dam, Kodiyala etc.

The Alaknanda basin lies mainly in Chamoli, Rudraprayag, Tehri Garhwal and Pauri Garhwal districts with small areas of Pithoragarh and Bageshwar districts also included in it. The Bhagirathi basin is confined within Uttarkashi, Tehri Garhwal and Pauri Garhwal districts. After the confluence of Alaknanda and Bhagirathi Rivers, at Devprayag, the river is called Ganga. Fig. 1.3, shows districts and towns of the state,

Fig. 1.4 shows villages in Alaknanda and Bhagirathi basins and Fig. 1.5 shows the location of commissioned and under development power projects along with protected areas.

Uttarakhand has consistently recorded a high rate of economic growth even though more than 61 per cent of the area is covered by forests which contributes very little directly to the State Domestic Product, and only a little over 13 per cent of the area is available for any meaningful agriculture. Per capita income has been slightly higher than the national average. Level of literacy recorded in the last census was 71.6 percent, with 83.3 percent for males and 59.6 per cent for females, much higher than the national average.

Since the formation of the State its GDP has generally been higher than the national GDP, except for a few years.

A decade has passed since the formation of this State. In this period contribution of primary sector to the State GDP, which was 31%, has declined to 18% and that secondary sector increased from 18% to 35%. Thus, roles of the two sectors have been reversed. The share of tertiary sector has marginally declined. The secondary sector comprises of manufacturing, organized and unorganized; construction; and electricity, gas and water supply. Trade, hotels and restaurants, as a sub-sector, had the largest share in the tertiary sector followed by public administration and transport in most districts.

Contribution of Alaknanda and Bhagirathi Basins to the state GDP is low, being only ₹ 400 million against the state GDP of ₹ 207 million, as is to be expected because of the rugged terrain. The districts constituting the basin under had in 2008-09 per capita NDDP about half of that of Hardwar the district with the highest per capita NDDP.

1.7.2. Climatic Conditions

The state has two distinct climate regions (a) the predominant hilly terrain and (b) the plain region. Alaknanda and Bhagirathi Basins fall under the first category. The mountain regions do not have a uniform type of climate and variations are due to location, altitude, aspect and morphology. Places situated on southern slopes of the Himalaya receive more sunshine and a larger amount of rainfall. But due to a high rate of evaporation and transpiration, these slopes remain generally dry. The duration of sunshine is shorter on northern slopes, with the result that the moisture retaining capacity of the soil is higher, even though these slopes receive less rainfall. Uttarakhand has been divided into seven broad climatic zones based primarily on altitude as given in Table 1.2.

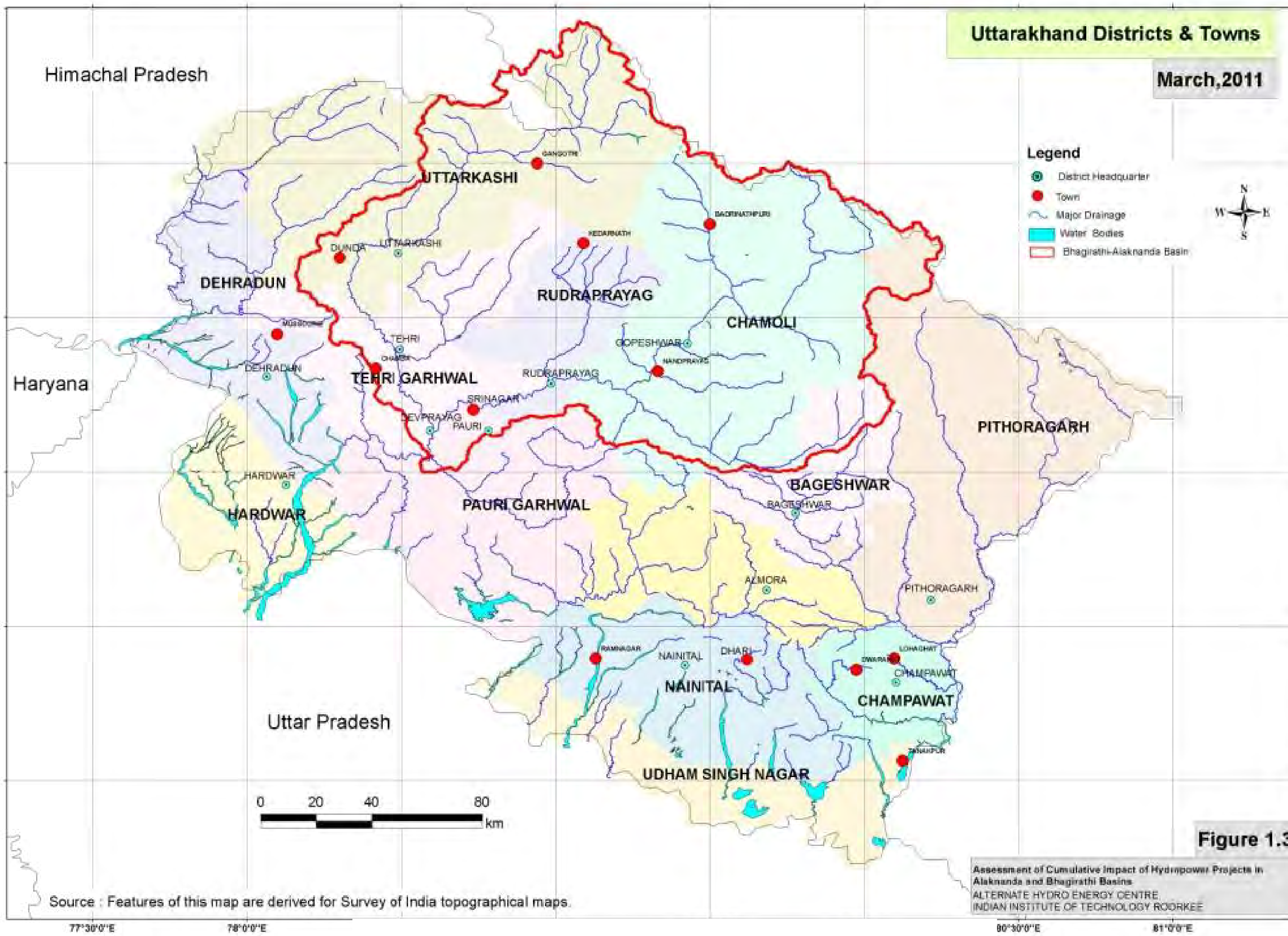


Fig. 1.3 Uttarakhand Districts and Towns

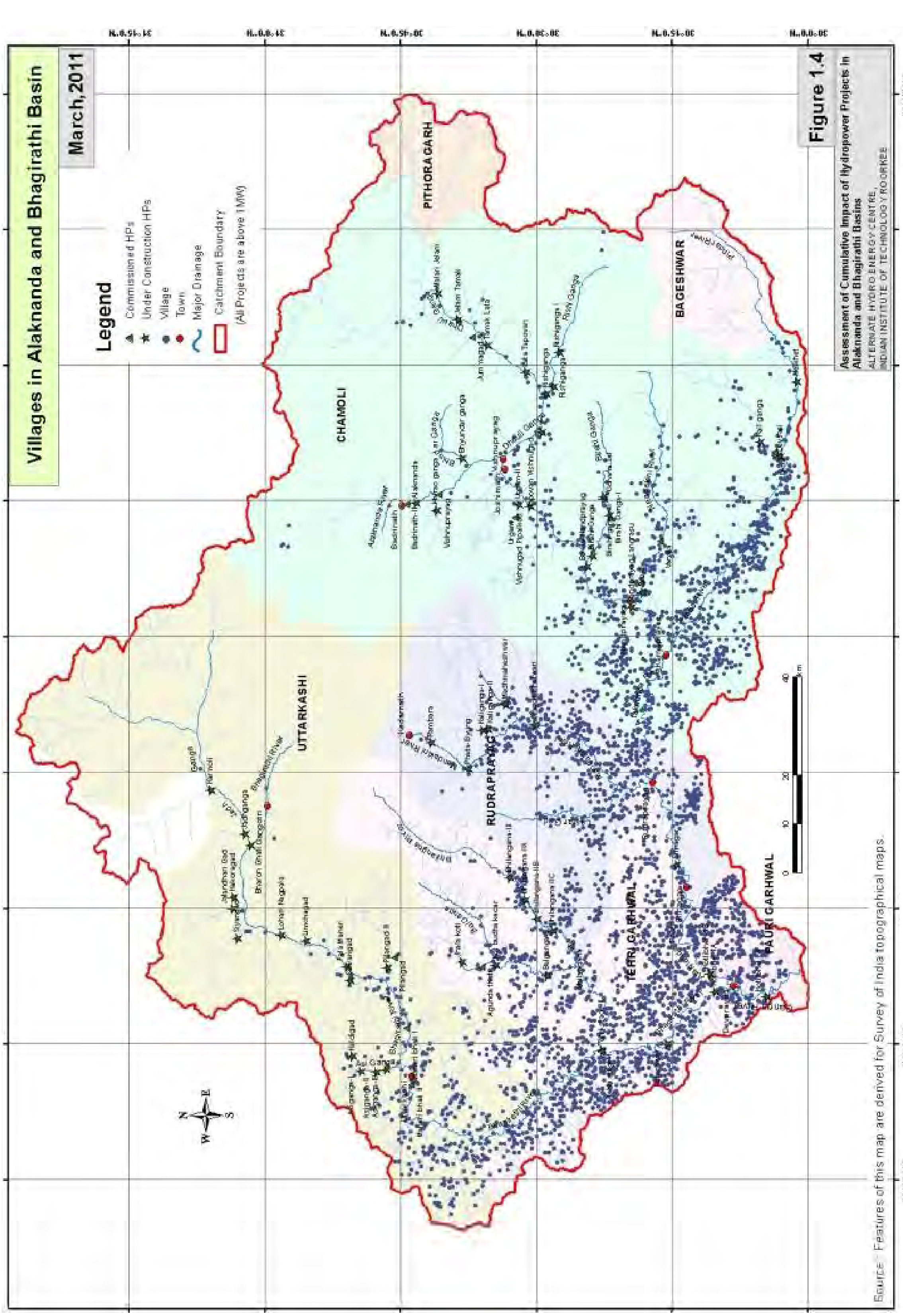


Fig. 1.4 Villages in Alaknanda and Bhagirathi Basins

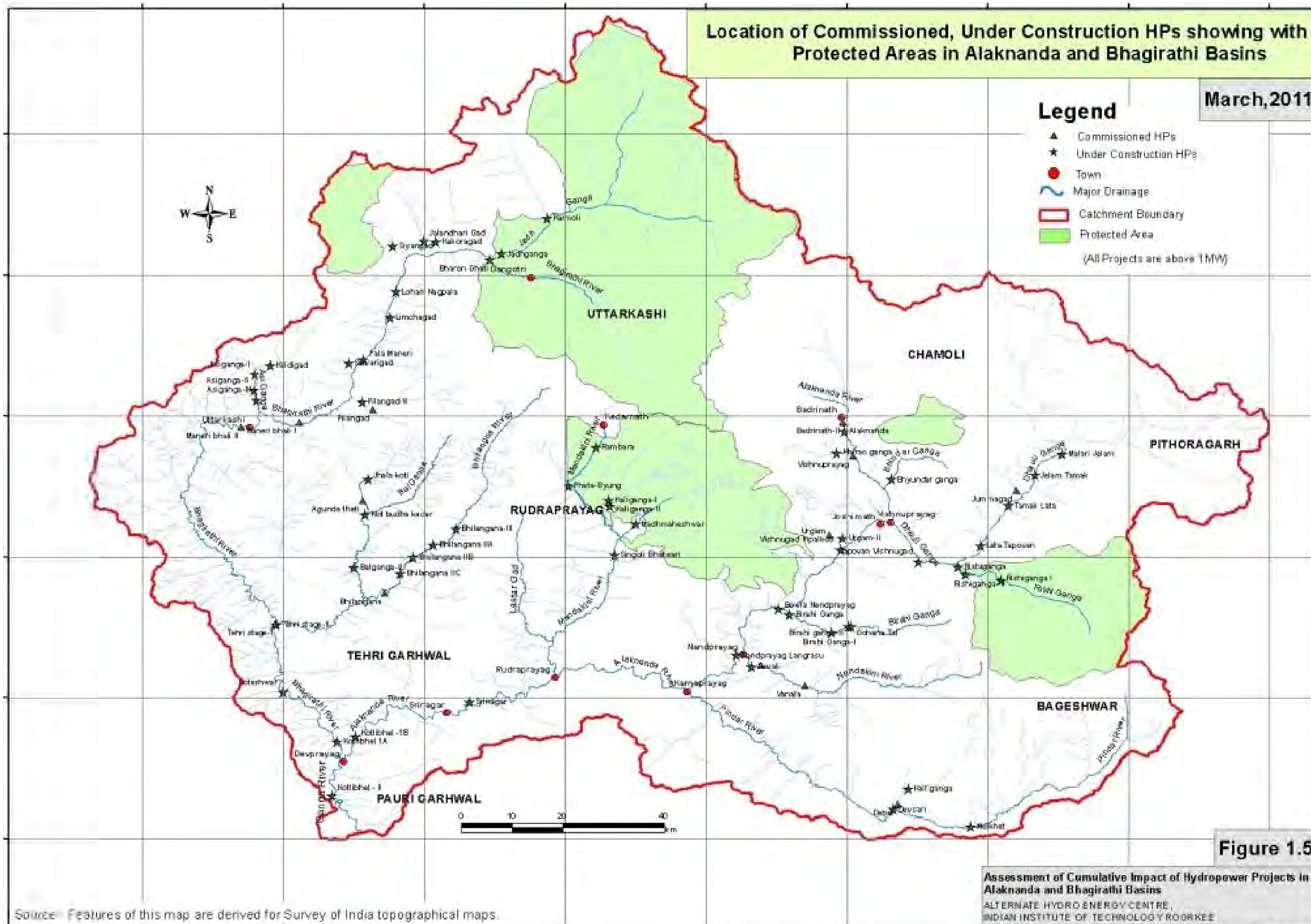


Fig. 1.5 Location of commissioned, under construction HPs shown with protected areas in Alaknanda and Bhagirathi Basins

Table 1.2 Climatic Zones in Uttarakhand

Climatic Zone	Altitude (m)	Average Temperature Range (°C)		
		Annual	June	January
• Tropical Zone	300–900	18.9–21.1	27.2 – 29.4	11.1–13.3
• Warm Temperature (Sub-Tropical)	900–1800	13.9–18.9	21.1–27.2	6.1–11.1
• Cool Temperature	1800–2400	10.3–13.9	17.2–21.1	2.8–6.1
• Cold Zone	2400–3000	4.5–10.3	13.3–17.2	1.7–2.8
• Alpine Zone	3000–4000	3.0–4.5	5.6–13.3	Below Zero
• Glacial Zone	4000–4800	For ten months, below zero, and in July and August between 2.2°C and 3.9°C		
• Perpetually Frozen Zone (Cold desert, No vegetation)	Above 4800			

1.7.3. General Geological Setup

Uttarakhand is located in the central part of the Himalayan mountain chain, in the northern part of the Indian subcontinent. The Himalaya in the Uttarakhand is subdivided into east-west trending linear belts with their specific physiographic features. These belts are, from north to south, Tethys Himalaya, Great Himalaya (Higher Himalaya), Lesser Himalaya and Sub-Himalaya (Himalayan Foot hills i.e., Siwalik hills). In the south of the Himalayan belt, the Ganga alluvial plain is located.

These physiographic belts of the Himalaya also show specific geological and rock characteristics. The Tethys Himalaya is made of sedimentary rocks (Tethys zone), the Great Himalaya is made up of metamorphic rocks (central crystalline zone), the Lesser Himalaya is made up of Precambrian sedimentary rocks and some metamorphic rocks (Krol belt, Inner Sedimentary belt) and the Sub-Himalaya is made up of young friable sedimentary rocks (Siwalik zone). These belts are also separated by regional tectonic lineaments, namely Basement Thrust Front (BTF) between Tethys and Central Crystalline zone, Main Central Thrust between Central Crystalline zone and Inner Sedimentary belt, Main Boundary Thrust between Krol belt and Siwalik belt and Himalayan Frontal Thrust between Siwalik belt and Ganga Alluvial Plain. These thrusts and faults are the main deep-seated weak zones. Additionally, there are a large number of small faults crisscrossing the entire area.

The study area is a part of the seismically active regions of the world. According to seismic zoning map of India it falls in seismic zones IV and V. The area has witnessed many earthquakes of medium to large size in the recent past. These earthquakes are related to two major tectonic features, namely Main Central Thrust (MCT) and Main Boundary Thrust (MBT). The study area is part of local seismicity zone extending from Barkot to Chamoli towns. The study area has the Main Central Thrust (MCT) in the central part of the Bhagirathi and Alaknanda river basins. Geology in detail is discussed in Chapter 4 and seismicity is discussed in Chapter 5.

1.7.4. Alaknanda – Bhagirathi Basins

Both Bhagirathi and Alaknanda rivers originate from glaciers, namely Gangotri glacier and Satopanth and Bhagirathi Kharak, respectively. Several tributaries also originate from glaciers and snow fields. However, contribution of snow melt in the river system is rather limited. Rivers of the region show strong fluctuation in discharge depending upon the season of the year. Total catchment of Alaknanda and Bhagirathi basins up to Devprayag is 19,600 sq. km. Alaknanda and Bhagirathi rivers meet at Devprayag and downstream, the river acquires the name Ganga.

The area occupied by river drainage is rather rugged with deep, steep river valleys separated by linear narrow ridges in between. In general the pattern of drainage is dendritic. In several segments the tributaries show preferred parallelism and other preferred orientation indicating a tectonic or lithological control on the drainage development.

An important feature of rivers of the area is that these are deeply incised and possess steep valley slopes. Many minor tributaries meet the trunk river with steep slopes and often bring large quantities of debris. The Himalaya is undergoing fast erosion and large quantities of sediment are generated due to intense physical weathering. This sediment is quickly moved along steep slopes and downstream by rivers.

In some segments of river valleys, particularly in the upper reaches, valley slopes are very steep and unstable. These segments regularly witness landslides and sediment movement as debris flow. Landslides are very intense and cause destruction of forest cover on hill slopes. Due to this phenomena large parts of valley slopes are barren, without any vegetation cover.

A regular feature of the river system of the area is that it receives intermittently huge amount of sediment from valley slopes; but most commonly from steep gradient minor tributaries. Often this sediment transfer takes place as a quick single event of few hours. The amount of sediment is so large that it blocks flow in the channel by making a temporary dam, and converting the river upstream into a temporary lake. This natural damming may exist for a few hours, days, weeks or in exceptional cases several decades. The breaking of these natural dams releases large amount of water and sediment debris. It may cause local flooding in downstream areas and also huge amount of sediment can be deposited on fertile agricultural land. Some important such lakes are Barital in Rishiganga, Chinatal in Patalganga, and Gauna lake in Alaknanda.

In higher reaches, particularly during winter, snow avalanches take place which may temporarily block flow in the river. Breaking and melting of snow avalanches causes flash flood in downstream areas locally.

In monsoon season the main source of water discharge is surface runoff of rainwater, along with some contribution from snow melt water and groundwater. In the post-monsoon season discharge is essentially from groundwater. In summer season discharge is from melt water and groundwater.

These rivers, along with their catchment, are depicted in Fig 3.6. Other hydrological details of the basin may be seen in Chapter 7 on Hydrological Studies.

In the study area several high altitude protected areas (national parks) are present, namely Govinda National Park, Gangotri National Park, Kedarnath Wild Life

Sanctuary, Valley of Flowers National Park, and Nanda Devi National Park. These areas are partly located above the snowline and partly incorporate drainage basins of tributaries of Bhagirathi and Alakhnanda rivers in their upper reaches. The study shows a rich biodiversity. The flora shows a wide range from low altitude to high altitude alpine flora. This region is well-known for growth of a wide variety of medicinal and aromatic plants.

In the last few decades changes in Himalayan landforms and ecosystem have been observed. One important factor for changes has been population growth and haphazard developmental activities, namely, unplanned construction of residential and commercial buildings. Road construction and mining activity has not been properly planned. In some areas unplanned construction activity has caused land subsidence and increased landslides. Improper building design and construction has been responsible for large-scale damage of humans and buildings in case of recent Uttarkashi and Chamoli earthquakes.

This study does not include socio-economic survey of the area, the effect of Hydropower Projects on landscape, livelihood of people living in the area around hydropower projects, development of transportation and other infra structural facilities due to coming up of hydropower projects in the region, effect of hydropower projects on fauna in the region and health of people living in the region. This is because these aspects were not covered in the terms of reference of the study and because of time constraints. It may, however, be added that it is felt that major conclusions and recommendations of the study would not change even if these were included.

References:

Anon ((2009): Status Paper on Ganga, National River Conservation Directorate, Ministry of Environment and Forest 31p.

Sanjay Kumar (2010): Know Your State Uttarakhand, Arihant Publications (i) Pvt. Ltd., Meerut 208p.

ANNEXURE 1.1

Terms of Reference to undertake study for the Assessment of Cumulative Impact of Hydropower Projects in Alaknanda and Bhagirathi Basins as per The National River Conservation Directorate (NRCD), Ministry of Environment and Forests (MoEF), Government of India (GoI), letter no. J11022/1/2010-NRCD-II dated July 15, 2010.

Terms of Reference

1. Background

1.1. Alaknanda and Bhagirathi Basins

The rivers Alaknanda and Bhagirathi, which have their confluence at Devprayag, give birth to the holy river Ganga. Their basins comprise glaciers in the higher reaches of the mighty Himalayas, which feed the rivers. The entire region has enormous social and cultural significance.

Both these rivers, along with their tributaries, are rich in water resources. Because of the hilly terrain huge falls are available and the identified potential for hydropower in the area is large. There are a number of identified sites for large and small hydropower projects.

Hydroelectric projects in the area may have major implications for the environment, for flow in stream/rivers, ground water etc. The risks in many cases may not be obvious but could be latent. Among the environmental conditions the quantity and quality of water during different parts of the year (environmental flow) is very important.

1.2. Probable Impact of Hydropower Projects

Before taking up any hydropower project of more than 25 MW capacity an EIA is mandatory and the project can be implemented only if the environmental clearance is accorded and the environmental safeguards prescribed are complied with. However, environmental impact assessment of isolated projects, on a case to case basis, may not present the true picture of the cumulative impact of all the projects that are proposed/ under implementation in due course. Against a large number of sites with potential to develop large/medium/small hydro power projects in the basin, only few projects have so far been set up or are under execution. With the projects proposed / being developed, it is important to ensure that their cumulative impact does not exceed the limits in terms of the following parameters:-

a) geological (tectonic) stability,
b) stability of glaciers resulting in more frequent avalanches,
c) stability of slopes resulting in landslides,
d) soil erosion reducing productivity of land and producing frequent floods,
e) requirement of environmental flow,
f) altered surface and ground water regime affecting drinking and irrigation water sources and their potential to provide water,
g) flows in the streams, tributaries and rivers and, above all, environmental flows necessary for observing religious practices and sustaining biotic life,

h) impact on the places of cultural and religious importance,

i) details of submergence area under protected area network,

2. Objective of the Study

2.1. To assess the cumulative impact of existing/ proposed/ under construction hydro power projects in the Alaknanda and Bhagirathi basins. The assessment should consider, inter alia, the factors mentioned in paragraph 1.2.

2.2. To assess the extent to which the hydropower potential identified in the basins should be developed without risking stability and environment and at the same time ensuring that the quality, quantity, and timing of water flows required to maintain the functions and assimilative capacity that provide goods and services to people are maintained.

2.3. Restrictions, if any, that needs to be placed in the development of hydropower in the two basins.

3. Approach

There are three kinds of hydropower project sites. One where hydropower projects are operational. The second which are under implementation and the third those sites where work is yet to commence.

Study of the impact of projects that have already been implemented will give empirical evidence of the consequences of activities whose impact otherwise is difficult to precisely predict. This will help in drawing suitable inferences of the impact of activities w.r.t. the projects which are under implementation or where implementation has not begun.

The impact of the hydropower projects may be studied stream, tributary and river wise in series moving from upstream to downstream. The project most u/s on the uppermost stream may be taken first and its impact should be taken in to account while assessing the impact on the next d/s project. Tributaries and streams should also be studied in the same sequence. This approach will ensure that at any particular site the impact of all the u/s sites is reflected.

There are already a few projects which have been set up and are operational. The projected impact of u/s identified projects that may come up in the future needs to be superimposed on the impact of the existing Hydropower Project. The cumulative impact of the project should then be superimposed on the assessed impact of the identified d/s projects that have not been set up so far upto Devprayag.

The available EIA reports of all existing/proposed projects in the two river basins may be used. Prudence will require that impacts of these projects when implemented do not exceed the limits of safety or sustainability.

4. Methodology

4.1. Identification of Stakeholders

The stake holders shall be identified and they be taken in to confidence in the process of impact assessment at various stages.

4.2. Assessment of the requirement of data

The impact assessments that need to be made will have their own requirements of data. This requirement shall be identified. Whatever data is available shall be collected. This will enable identification of the gaps in the data which will be filled up through primary collection of data.

4.3. The hydropower projects may have implications on geologic stability, stability of slopes, landslides and erosion of soil in the catchment. Geological information will, therefore, need to be gathered.

4.4. Maps, Reports & Data

The following data shall be collected:

a) Topographical maps, satellite imageries and geological maps of the basins. For completed projects, three satellite imageries, one pertaining to pre-project period, second pertaining to the period immediately after completion and the third pertaining to the latest period. These can be used to:
   i. Mark the streams, tributaries and the completed projects, projects under implementation, Sites with potential for the development of hydropower, both large and small.
   ii. Identify the area upstream and downstream likely to be affected by the hydro-power potential sites and mark the villages.
   iii. Natural features – glaciers, tributaries, streams, other drainage lines.
   iv. Geological Features in the affected areas.
   v. Present land use
   vi. Subsidence Erosion Intensity Maps, Relief and Aspect Maps should be prepared.
   vii. Changes that have taken place over the time – since the establishment of hydropower projects in the basin
   viii. Sites from where building material was either extracted or material is proposed to be extracted.

b) Reports

j) DPRs *I* PFRs of all commissioned *I* proposed Hydropower Projects and
k) EIA studies and Environmental Management Plans (EMPs) of all commissioned/ proposed HEPs.
l) Clearances accorded to all HEPs.
m) Monitored observations and activities under taken post clearances as per requirement
n) Meteorological
o) Surface and ground water hydrology
   discharge upstream of the hydropower sites.
   discharge downstream of the hydropower sites.
p) Ground water levels in the affected areas.
q) Socio-economic data of the affected areas.

r) Water quality data at each potential site.

4.5. Completed Projects -Data Collection for Impact Assessment

The projects with capacity 25 MW and above which have been completed and are operational would have made an Impact. The study should include an assessment of their impact on environment and other factors mentioned in paragraph 1.2 in particular the following data should be gathered:

a) landslides
b) loss of irrigation potential, if any
c) Health hazards
d) Socio-economic Survey of the area to assess the socio-economic impact of the completed projects.
e) Water quality and discharge studies in the immediate vicinity and d/s of the project
f) Study the impact on springs

4.6. This data should be compared with the base line data as available in the EIA report of the project.

4.7. Use of the above data to generate further outputs such as

i. Develop Digital Elevation Models (DEM), wherever needed.
ii. Mark existing and new transmission lines that will need to be erected.
iii. Mark villages which get their drinking water and or irrigation water from streams likely to be affected by hydropower plants
iv. Mark areas which are prone to land slides
v. Mark areas which are prone to soil erosion.

4.8. Analysis of Data and Recommendations:

The data will be analysed to assess the impact of each activity necessary to implement the hydropower projects. The safe limits of parameters for geological and slope stability, environmental flows, availability of water for various traditional uses and other natural resources and environmental sustainability should be determined based on the standard methodologies. It should be examined if any of these limits will exceed at any site or sites and if so what measures need to be taken to take care of safety and sustainability norms.

5. Deliverables

a) Study the impact of large completed hydro-electric projects in the basin of the rivers Alaknanda and Bhagirathi up to Devprayag. It will include all factors mentioned in paragraph 1.2.
b) Based on the above study, drawing empirical inferences in assessing impact of hydroelectric projects under implementation / proposed.
c) A report, on the cumulative impact of
   i. all projects on a stream on the tributary.
   ii. all projects located on a tributary at its confluence with the river Alaknanda.
   iii. all projects located on a tributary at its confluence with the river

Bhagirathi.

iv. all hydroelectric projects proposed / established on river Alaknanda and Bhagirathi up to Devprayag.

(i). The report should, inter-alia, address whether the acceptable limits of geomorphologic stability or of environment al sustainability, particularly of environmental flows, are likely to exceed at any small or large hydropower project site(s).

(ii). Whether there will be a depletion of irrigation potential or availability of drinking water in habitations as a result of any project.

(iii). Impact on ground water and springs in the basin.

(iv). Impact of these projects on places of cultural, religious or tourism importance.

(v). Whether any restrictions should be placed on the development of hydropower in the basin.

d) The impacts should be expressed qualitatively and quantitatively.

6. Time to Cary out the Assignment

Six months

ANNEXURE 1.2

Table Showing Operational, Under Construction and Under Development Hydropower Projects in Alaknanda and Bhagirathi Basins

S. No.	Project Name	Basin	Name of River/ Tributary	Installed Capacity (MW)
In Operation				
1	Agunda thati	Bhagirathi	Dharamganga	3
2	Badrinath II	Alaknanda	Rishi ganga	1.25
3	Bhilangana	Bhagirathi	Bhilangana	22.5
4	Debal	Alaknanda	Kailganga	5
5	Jummagad	Alaknanda	Jummagad	1.2
6	Maneri bhali I	Bhagirathi	Bhagirathi	90
7	Manaeri bhali-II	Bhagirathi	Bhagirathi	304
8	Pilangad	Bhagirathi	Pilangad	2.25
9	Rajwakti	Alaknanda	Nandakini	3.6
10	Tehri stage-I	Bhagirathi	Bhagirathi	1000
11	Urgam	Alaknanda	Kalpganga	3
12	Vanala	Alaknanda	Nandakini	15
13	Vishnuprayag	Alaknanda	Alaknanda	400
			Total Capacity	**1850.8**
Under Development – At Construction Stage				
1	Bhilangana-III	Bhagirathi	Bhilangana	24
2	Birahi Ganga	Alaknanda	Birahi Ganga	7.2
3	Kail ganga	Alaknanda	Kailganga	5
4	Kaliganga-I	Alaknanda	Kaliganga	4
5	Kaliganga-II	Alaknanda	Kaliganga	6
6	Koteshwar	Bhagirathi	Bhagirathi	400
7	Lohari Nagpala	Bhagirathi	Bhagirathi	600
8	Madhmaheshwar	Alaknanda	Mandakini	10
9	Phata Byung	Alaknanda	Mandakini	76
10	Rishi Ganga	Alaknanda	Rishi ganga	13.2
11	Singoli Bhatwari	Alaknanda	Mandakini	99
12	Srinagar	Alaknanda	Alaknanda	330
13	Tapowan Vishnugad	Alaknanda	Dhauliganga	520
14	Vishnugad Pipalkoti	Alaknanda	Alaknanda	444
			Total Capacity	**2538.4**
Under Development – At Other Stages				
1	Alaknanda	Alaknanda	Alaknanda	300
2	Asiganga-I	Bhagirathi	Asiganga	4.5
3	Asiganga-II	Bhagirathi	Asiganga	4.5
4	Asiganga-III	Bhagirathi	Asiganga	9
5	Balganga-II	Bhagirathi	Balganga	7
6	Bharon Ghati	Bhagirathi	Bhagirthi	381
7	Bhilangna-II A	Bhagirathi	Bhilangana	24
8	Bhilangna-II B	Bhagirathi	Bhilangana	24
9	Bhilangna-II C	Bhagirathi	Bhilangana	21

S. No.	Project Name	Basin	Name of River/ Tributary	Installed Capacity (MW)
10	Bhyundar ganga	Alaknanda	Bhyundar ganga	24.3
11	Birahi Ganga-I	Alaknanda	Birahi ganga	24
12	Birahi Ganga-II	Alaknanda	Birahi ganga	24
13	Bowla Nandprayag	Alaknanda	Alaknanda	300
14	Devsari	Alaknanda	Pinder	252
15	Dewali	Alaknanda	Nandakini	13
16	Gohana Tal	Alaknanda	Birahi ganga	50
17	Jadh Ganga	Bhagirathi	Jadhganga	50
18	Jalandharigad	Bhagirathi	Jalandhari	24
19	Jelam Tamak	Alaknanda	Dhauliganga	126
20	Jhala koti	Bhagirathi	Balganga	12.5
21	Kakoragad	Bhagirathi	Kakoragad	12.5
22	Kaldigad	Bhagirathi	Kaldigad	9
23	Karmoli	Bhagirathi	Jadhganga	140
24	Khirao ganga	Bhagirathi	Khaiaoganga	4
25	Kot Budha Kedar	Bhagirathi	Balganga	6
26	Kotli Bhel-I A	Bhagirathi	Bhagirathi	195
27	Kotli Bhel-I B	Alaknanda	Alaknanda	320
28	Kotli Bhel-II	Ganga	Ganga	530
29	Lata Tapovan	Alaknanda	Dhauliganga	170
30	Limcha Gad	Bhagirathi	Limcha Gad	3.5
31	Malari Jelam	Alaknanda	Dhauliganga	114
32	Melkhet	Alaknanda	Pinder	15
33	Nandprayag Langrasu	Alaknanda	Alaknanda	100
34	Pala Maneri	Bhagirathi	Bhagirthi	480
35	Pilangad- II	Bhagirathi	Pilangad	4
36	Ram Bara	Alaknanda	Mandakini	24
37	Rishi Ganga-I	Alaknanda	Rishi ganga	70
38	Rishiganga II	Alaknanda	Rishi ganga	35
39	Siyangad	Bhagirathi	Siyangad	11.5
40	Suwari Gad	Bhagirathi	Suwari Gad	2
41	Tamak Lata	Alaknanda	Dauliganga	250
42	Tehri Stage-II	Bhagirathi	Bhagirathi	1000
43	Urgam-II	Alaknanda	Kalpganga	3.8
			Total Capacity	**5174.1**

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Terms of Reference for a study on the "Assessment of Cumulative Impacts of Hydroelectric Projects on aquatic and terrestrial biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand"

1. BACKGROUND

The Government of Uttarakhand has submitted proposals to the Ministry of Environment & Forests, (MoEF), Government of India to grant environmental and forestry clearances for construction of Kothibhel Stage 1A, Kothibhel Stage IB and Kothibhel Stage-II hydroelectric projects on river Bhagirathi and Alaknanda in the State of Uttarakhand.

The MoEF vide letter No. F 8-9/2008-FC dated 23rd July, 2010 (**Annexure-I**) has requested the Wildlife Institute of India to conduct a study on the cumulative environmental/ecological impacts of hydroelectric projects in the Bhagirathi and Alaknanda river basins on the riverine ecosystem including terrestrial and aquatic biodiversity in collaboration with appropriate specialized institutions.

The MoEF has also entrusted the Alternate Hydro Energy Centre (AHEC), IIT Roorkee to study the cumulative impacts on the environmental side of the projects in Bhagirathi and Alaknanda river basins in Uttarakhand. The Terms of Reference (ToR) for the AHEC study are enclosed in **Annexure-II**.

Accordingly, the WII approached AHEC, Roorkee to work out the modalities for the study on cumulative environmental impacts of hydroelectric projects in Bhagirathi and Alaknanda river basins. In the meeting held with the Head, AHEC on 17th August, 2010 it was agreed that close cooperation in the conduct of study and sharing of data, information and products would be required for successful completion of the study in order to deliver outputs/outcomes requested by the MoEF.

The existing and proposed hydroelectric projects in Bhagirathi and Alaknanda river basins are shown in **Figure 1**.

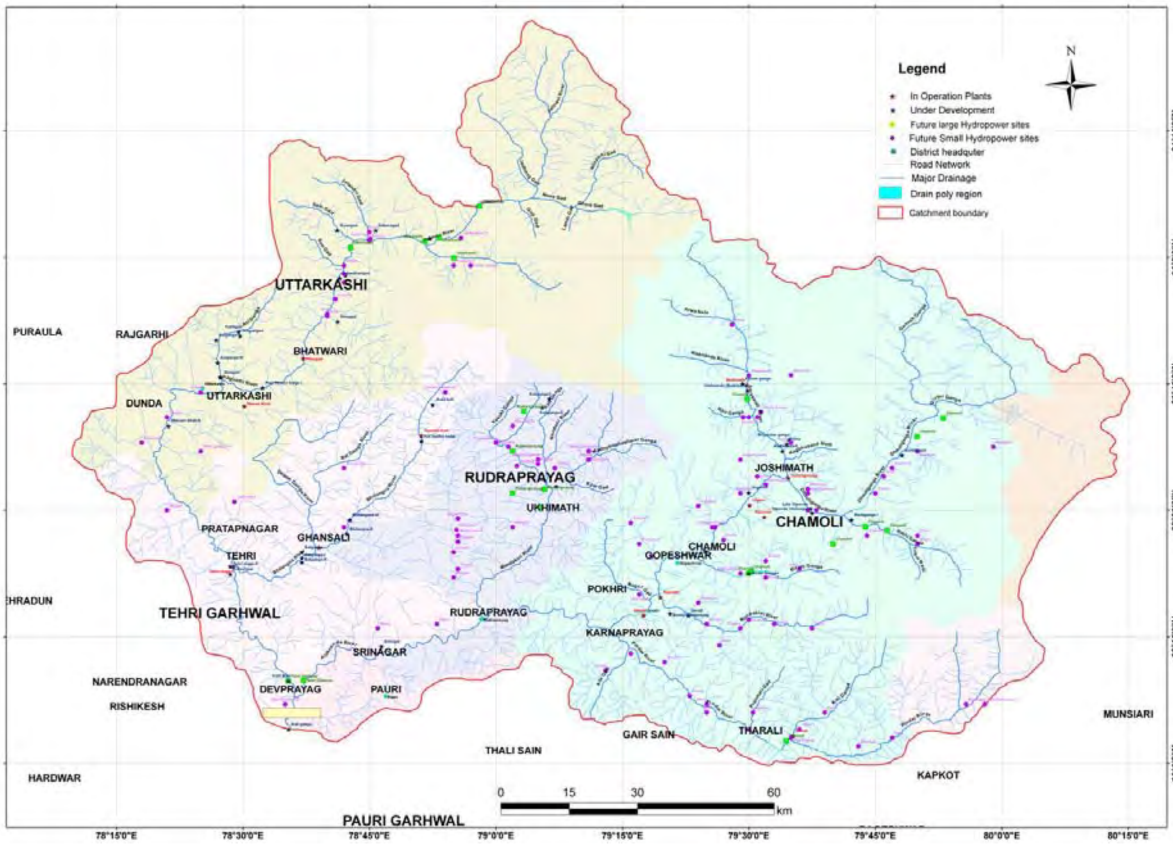


Figure 1. Existing and proposed hydroelectric projects in Bhagirathi and Alaknanda river basins

Source: AHEC, 2010

2. SCOPE OF STUDY

The broad scope of the study will be as follows:

a) Assessment of ecological flows required for conservation of rare, endangered and threatened (RET) floral and faunal species.

b) Assessment of the cumulative impacts of hydropower projects in the two basins on the riverine ecosystem in general and terrestrial and aquatic biodiversity in particular

Considering the interdisciplinary nature of the work, the AHEC will provide the necessary data, information and products relating to environmental flows and water budget. The WII will provide AHEC data, information and products relating to protected area network and ecological requirements of RET species.

3. CONTEXT

Riverine habitats generally occupy a small proportion in the total landscape yet play a critical role as corridors and migration pathways for several faunal and floral species. They also serve as '*edge*' habitats, facilitate river courses and also assist in prevention of soil erosion. They are often designated as '*sensitive habitats*'. The courses of Bhagirathi and Alaknanda support a number of forest formations which are typically riverine in nature such as Khair – sissoo (*Acacia catechu – Dalbergia sissoo*) and Jamun – Putranjiva (*Syzygium cuminii – Putranjiva roxburghii*) in the lower areas, alder (*Alnus nepalensis*), *Hippophae – Myricaria* and Willow (*Salix*) communities at higher altitudes. The riverine forests support a large number of rare, threatened and endangered (RET) species of flora and fauna. Among the faunal groups several species of herpetofauna, riverine birds such as laughing thrushes, red starts, forktails, whistling thrush and mammals especially otters, weasels and fishing cats are of high conservation significance. Among fishes, there are several threatened species including golden mahseer, snow trout etc that breed in this landscape. Many species of fish require the riverine habitats as well as the floodplains for their breeding. Some of the threatened taxa of flora typically found along the riverine forests and stream courses of Bhaigrathi and Alaknanda include *Datisca cannabina, Itea nutans, Eriocaulon pumilio, Eria occidentalis, Flickingeria hesperis, Nervilia mackinnonii* and *Cautleya petiolaris*, among others. Several species of medicinal and aromatic plants are also confined to riverine areas.

Status and distribution of the above mentioned taxa and several faunal species which might use riverine forests as dispersal corridors needs to be assessed on a priority basis so as to determine the cumulative impacts of hydropower projects and to develop/evolve appropriate mitigation / conservation plans.

4. APPROACH

The study merits inter-institutional cooperation for achieving all the study objectives. While the WII will contribute towards generating ecological baseline for evaluating the impacts on aquatic and terrestrial ecology, AHEC will provide the major data inputs for evaluating cumulative environmental impacts. WII will collect the data on status and distribution of rare, threatened and endangered species both aquatic and terrestrial, using standard methods. Similarly, ecological requirements of select individual species that command conservation significance will be collected observing their habitat use and behavior. Secondary data wherever available will be utilized for this study.

Based on the locations of the proposed and existing projects an assessment of quantum of change on the loss and gain of seasonal flow regimes in the two river basins also needs to be calculated, so that appropriate measures for a critical minimum flow for maintenance of riverine ecology for RET species can be worked out.

Implications on environmental flow with special reference to water flow impacts on aquatic and associated terrestrial species would be subsequently determined using outputs generated by AHEC. These are seen as critical inputs to the outputs to be ultimately generated by the WII.

5. OBJECTIVES OF THE STUDY

5.1. To assess the baseline status of rare, endangered and threatened (RET) species of flora and fauna dependent on riverine habitats and floodplains of Alaknanda and Bhagirathi river basins.

5.2. To identify the critical wildlife habitats along the existing and planned hydroelectric projects located on rivers Alaknanda and Bhagirathi upto Devaprayag.

5.3. Delineate river stretches critical for conservation of rare, endangered and threatened (RET) aquatic species.

5.4. To assess the key habitat variables for RET species, including minimum flows and volume of water for ecological sustainability of the two rivers.

6. DELIVERABLES

1. Baseline status of RET species in the Alaknanda and Bhagirathi river basin.
2. Report on critical wildlife habitats along the existing and planned hydroelectric projects on rivers Alaknanda and Bhagirathi upto Devaprayag.
3. Report on cumulative impacts on the RET flora and fauna.

7. REPORTING

1. Inception report within one month of the receipt of 1st installment of funds.
2. Interim report after four months of the receipt of 1st installment of funds.
3. Draft final report after 8 months of the receipt of 1st installment of funds.
4. Final report on the completion of the study period.

8. RELEASE OF FUNDS

1. 50% of the total amount with the approval of ToR.

2. 40% of the total amount upon submission of the interim report.

3. 10% of the total amount upon submission of final report.

9. TIME TO CARRY OUT THE ASSIGNMENT

Nine months from the receipt of first installment of funds.

10. PROJECT TEAM

Project Coordinator

Dr. V.B. Mathur
Dean, WII

Principal Scientists

Dr. G.S. Rawat
Scientist-G

Shri B.C. Choudhury
Scientist-G

Dr. V.K. Melkani
Scientist-F

Shri V.K. Uniyal
Scientist-F

Dr. Asha Rajvanshi
Scientist-F & Nodal Officer, EIA Cell

Dr. S. Sathyakumar
Scientist-F

Dr. K. Sivakumar
Scientist-E

Dr. K. Ramesh
Scientist-C

Project Associate/ Assistants

To be engaged

11. PROJECT BUDGET

	COMPONENT	Nos.	RATE (Rs.)	DURATION	TOTAL (Rs.)
1	**MANPOWER**				
	Project Associate	01	25000/month	09 months	2,25,000
	Project Assistant – Level I	04	15000/month	09 months	5,40,000
	Project Assistant – Level II	04	8000/month	09 months	2,88,000
				Sub-Total	**10,53,000**
2	**TRAVEL**				
	Hiring of Vehicle	01	30000/month	09 months	2,70,000
	WII Faculty	06	--	--	1,50,000
				Sub-Total	**4,20,000**
3	**PROCUREMENT OF SPECIALIZED SERVICES FROM EXPERT INSTITUTIONS**				5,00,000
				Sub-Total	**2,00,000**
4	**DEVELOPMENT OF SPATIAL DATABASE**	--	--	LS	5,00,000
				Sub-Total	**5,00,000**
5	**ESTABLISHMENT AND OPERATION OF BASE-CAMP**	02	30000/month	9 months	5,40,000
				Sub-Total	**5,40,000**
6	**FIELD EQUIPMENT**			LS	1,00,000
				Sub-Total	**1,00,000**
7	**MISCELLANEOUS**			LS	50,000
				Sub-Total	**50,000**
				GRAND TOTAL	**31,63,000**

(Rupees Thirty-one lakhs sixty-three thousand only)

***

F. No. 8-9/2008-FC
Government of India
Ministry of Environment and Forests
(F.C. Division)

Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi - 110003.
Dated: 16th November, 2010

To

The Principal Chief Conservator of Forsts,
Government of Uttarakhand,
Dehradun.

Sub: Study to assess cumulative environmental impact of various hydro electric projects (HEP) etc. being undertaken by the Wildlife Institute of India.

Sir,

I am directed to refer to the above mentioned subject and to say that in compliance to the Hon'ble Supreme Court of India's Order dated 30.02.2009 in a matter pertaining to approval of Central Government in terms of Section-2 of the Forest (Conservation) Act, 1980, for diversion of forest land required for construction of Kotlibhel Stage-IA and the Kotlibhel Stage-IB in the Uttarkhnad State, this Ministry assigned a study to assess cumulative environmental impact of various hydro electric projects, particularly on the riverine eco system and land and aquatic biodiversity; and effectiveness of the mitigative measures and compliance of the stipulated conditions on which various projects have earlier been cleared to the Wildlife Institute of India (WII), Dehradun.

After careful consideration by this Ministry, of the request of the WII, Dehradun to make payment of Rs. 31.63 lakh, being the estimated expenditure to be incurred on the said study and on the basis of the recommendations of the Forest Advisory Committee, I am directed to say that the Principal Chief Conservator of Forests, Government of Uttarakhand may recover the above amount from the concerned User Agencies whose proposals seeking diversion of forest land for construction of HEP in Ganga river basin are presently pending before the Ministry, proportionate to the area of forest land applied for diversion by them, and transfer the same to the Director, WII, Dehradun. As per the area of forest land proposed to be diverted, the amount to be recovered from each of the HEPs, whose proposal for diversion of the forest land are presently pending before the Ministry, will be as below:

Sl. No.	Name of the Project	Developer	Capacity	Forest Area Proposed to be Diverted	Amt. to be recovered (Rs.)
1.	Kotlibhel Hydro Electric Project - (Stage -IA)	NHPC	195 MW	258.737 ha.	5,26,316

Sl. No.	Name of the Project	Developer	Capacity	Forest Area Proposed to be Diverted	Amt. to be recovered (Rs.)
2.	Kotlibhel Hydro Electric Project – (Stage -IB)	NHPC	320 MW	496.793 ha.	10,10,562
3.	Kotlibhel Hydro Electric Project – (Stage -II)	NHPC	530 MW	658.282 ha.	13,39,059
4.	Vishnugarh Pipalkoti Hydro Electric Project	THDC	444 MW	80.607 ha.	1,63,969
5.	Alaknanda Hydro Electric Project	GMR	300 MW	60.513 ha.	1,23,094
	Total			**1554.932 ha.**	**31,63,000**

Accordingly, I am directed to say that the amount as indicated may be recovered from the concerned User Agencies ad be transferred to the Director WII with intimation to this Ministry, at the earliest possible.

Yours faithfully,

Sd/-

(H.C. Chaudhary)
Assistant Inspector General of Forests

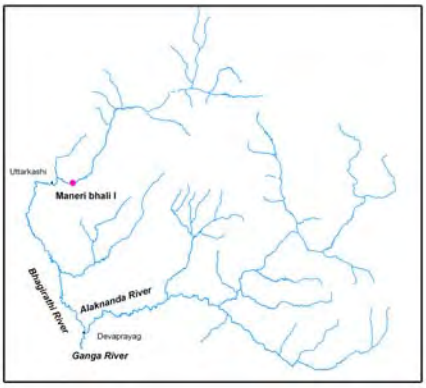
Copy to:-

1. The Principal Secretary (Forests), Government of Uttarakhand, Dehradun.
2. The Director, Wildlife Institute of India, Dehradun for information and necessary action.
3. The Chairman & Managing Director, National Hydro Power Corporation Limited for information and necessary action..
4. The Chairman & Managing Director, Tehri Hydro Development Corporation Limited for information and necessary action..
5. M/s GMR Power Corporation Limited, for information and necessary action.
6. The Nodal Officer, Office of the PCCF, Government of Uttarakhand, Dehradun.
7. The Chief Conservator of Forests, Regional Office, MoEF, Lucknow
8. Guard File.

(H.C. Chaudhary)
Assistant Inspector General of Forests

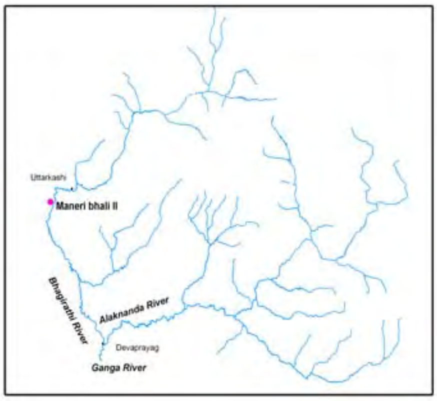
Profile of 70 HEPs in Alaknanda and Bhagirathi Basins

MANERI BHALI-I H.E.PROJECT



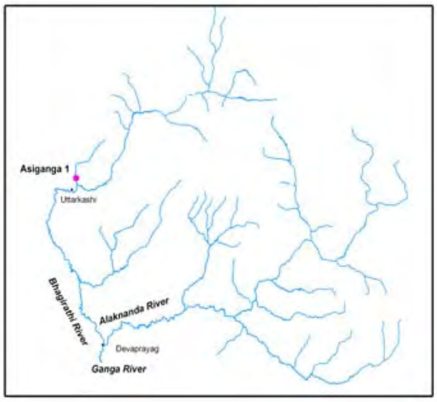
Location:	Maneri
Tehsil:	Bhatwari
District:	Uttarkashi
Catchment area:	4024 Km^2
Longitude:	78°032'E
Latitude:	30°044.5'N
Developer:	UJVNL
River:	Bhagirathi
Tributary:	Ganga
Up stream \Downstream HEP projects :	Kaldigad /Maneribhali II
Diverted river length:	18000
Type:	Reservoir
Height of the Dam:	39.00 m
Volume content of Dam:	600000.00 cum
Full Reservoir level (FRL):	1294.50 m
Head race Tunnel Type: Length:	8.63 Km
Tail Race-Length:	120.00 m
Penstock- Nubmer and type:	415 m long
Power House Size:	Under ground
Installed Capacity:	90 MW
Firm Power Capacity:	33.23 MW at 90% Availability of Discharge.
Annual Power generation:	545.829x106 K.W.H.
Status:	Construction completed Power house under production.

MANERI BHALI –II HYDRO-ELECTRIC PROJECT



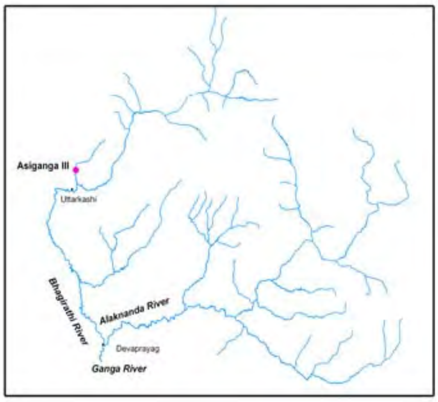
Location:	Joshyara
Tehsil:	Uttarkashi
District:	Uttarkashi
Longitude:	78°24' 07''E
Latitude:	30°42' 36''N
Developer:	UJVNL
River:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Maneribhali I/ Tehri I
Diverted river length:	22000 M
Type:	Run of River
Height/ length of the Dam/Barrage:	81 meters long barrage
FRL:	1108 m
Volume content of Dam:	7.55 lac cum
Head Race Tunnel:	16.8 km long
Tail Race- Length:	
Power House:	over ground located near Dharasu on left bank of river Bhagirathi.
Installed Capacity:	304 mw
Anuual generation:	1566 MU
Status:	Construction completed Power house under production.
Source:	http://hydropowerstation.com/?cat=1 - Archive for the 'Uncategorized' Category . Maneri Bhali Stage-II (4×76 = 304) Head Race Tunnel and Appurtenant Civil Structures.

ASIGANGA –I HYDRO-ELECTRIC PROJECT



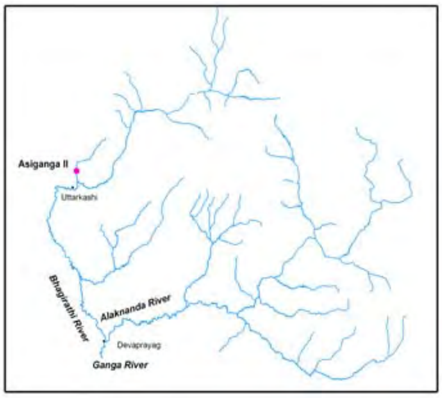
Location:	On the way Gangori to sangamchatti
Tehsil:	Bhatwari
District:	Uttarkashi
Catchment area:	147 km^2
Longitude:	78°27'12" E
Latitude:	30°46'56" N
Developer:	UJVNL
River catchment :	Asi ganga
River:	Assi Ganaga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	Kaldigad/ Assi ganga II
Diverted river length:	3000 m
Type:	Run off (ROR)
Height/ length of the Dam weir/ trench:	22 m long trench
Full Reservoir level (FRL):	1491.05
Head race Tunnel Type:	700 m Long
Tail Race-Length:	90.00 m
Power House:	On surface
Installed Capacity:	4.5 MW
Annual generation:	19.11 MU
Source:	Summary provided by Maneri Bhali dam authority-SF1:

ASIGANGA –III HYDRO-ELECTRIC PROJECT



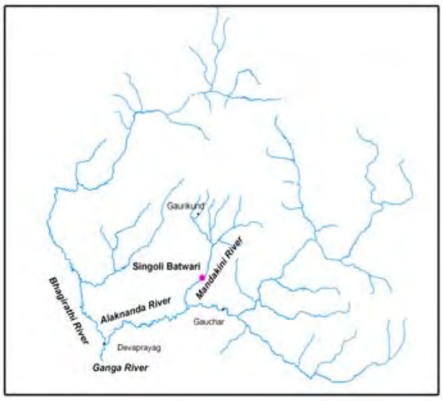
Location:	Sangam chatti
Tehsil:	Bhatwari
District:	Uttarkashi
Catchment area:	190.32 km^2
Longitude:	78°27'05" E
Latitude:	30°48'05" N
Developer:	UJVNL
River:	Assi Ganga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	Assi Ganga I/ Maneri Bhali I
Diverted river length:	4500 m
Type:	Run off river
Height of the Dam:	Ungated weir 20.7 m long.
Full reservoir level:	1294.50 m
Head race Tunnel:	700 m
Tail Race-Length:	90.00 m
Penstock- Number and type:	Single underground Penstock pf 3.80 m Dia Length: 415 m
Power House Size:	Surface
Installed Capacity:	9 mw
Annual Power generation:	48.5 MU
Project capital cost:	48.5 million Rs.
Status:	Under construction
Source:	Summary provided by Maneri Bhali dam authority-SF1

ASIGANGA –II HYDRO-ELECTRIC PROJECT



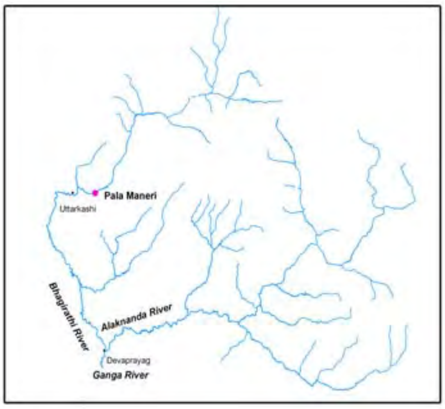
Location:	Sangam chatti
Tehsil:	Bhatwari
District:	Uttarkashi
Longitude:	78º26'40" E
Latitude:	30º47'40" N
Developer:	UJVNL
River:	Assi Ganga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects :	Assi Ganga I/ Assi Ganga II
Diverted River length:	2000
Type:	Run off river.
Height of the Dam:	
Full Reservoir level (FRL):	1376 m
Head race Tunnel Type:	
Tail Race-Length:	90.00 m
Power House:	On surface
Installed Capacity:	4.5 mw
Annual generation:	22.76 MU
Status:	Under various stages of development.
Source:	Summary provided by Maneri Bhali dam authority-SF1

SINGOLI BATWARI HYDRO-ELECTRIC PROJECT



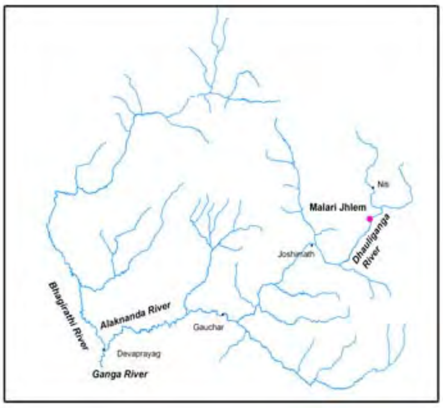
Location:	Near Tilwara village.
Tehsil:	Ookhimath
District:	Rudraprayag
Catchment area:	963.2 km^2
Longitude:	79°05'22"
Latitude:	30°30'70"
Developer:	L& T
River:	Mandakini
Tributary:	Alaknanda
Up stream \Downstream HEP projects :	Phata Bhyung/Srinagar
Diverted river length:	14500 m
Type:	Reservoir
Height of the Dam/ weir/trench:	22 m
Volume content of Dam:	0.495mm^2
Full Reservoir level (FRL):	1294.50 m
Head race Tunnel:	11.87km
Tail Race-Length:	90.00 m
Penstock- Number and type:	Single underground Penstock pf 3.80 m Dia Length: 415 m
Power House:	On surface
Installed Capacity:	99 mw
Annual Power generation:	28.0MU
Status:	Under construction
Source:	Summary provided by dam authority-

PALA MANERI HYDRO-ELECTRIC PROJECT



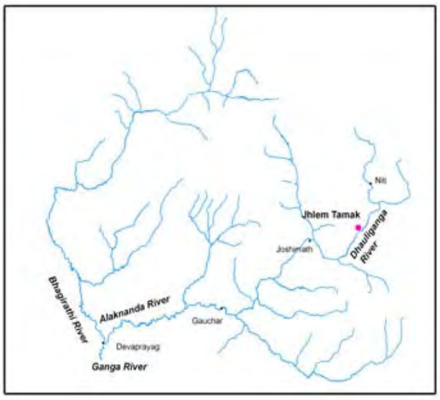
Location:	Between Pala and Maneri
Tehsil:	Bhatwari
District:	Uttarkashi
Longitude:	78°35’ 15” E
Latitude:	30°46’ 25” N
Catchment area:	3667 KM^2
Developer:	UJVNL
Project river:	Bhagirathi
Tributry of:	Ganga
Type:	Reservoir type
Height of the Dam:	78 m
Full Reservoir level (FRL):	624.90m
Head race Tunnel Type:	12.64 km
Tail Race-Length:	1.37 km
Power House:	Under ground on the right bank of the river
Installed Capacity:	480 mw
Annual generation:	1993 MU
Status:	Work on halt due to environment clearance
Source:	Salient features as provided by dam authorities

MALARI JHLEM HYDRO-ELECTRIC PROJECT



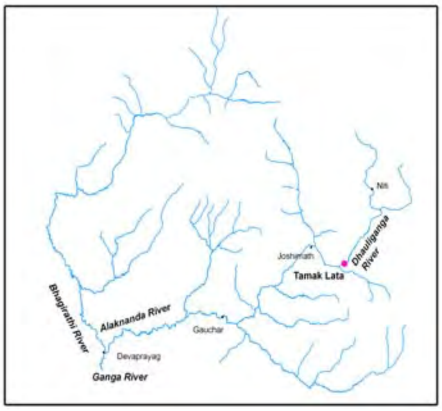
Location:	Malari to Jhlem
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°53’ 4.5” E
Latitude:	30°40’ 54.7” N
Catchment area:	1504 km^2
Developer:	THDC
Project river:	Dhauliganga
Tributry of:	Alaknanda
Type:	Reservoir type
Up stream \Downstream HEP projects:	-----/Jhleum-Tamak
Height of the Dam:	28.77 m
Volume content of Dam	
Full Reservoir level (FRL):	2879
Head race Tunnel Type:	4.04 km
Tail Race-Length:	2.1 km
Power House:	Under ground on the right bank of the river
Installed Capacity:	114 mw
Annual generation:	466.7MU
Status:	Under various stages of development
Source:	Summary provided by dam authority-

JHLEM TAMAK HYDRO-ELECTRIC PROJECT



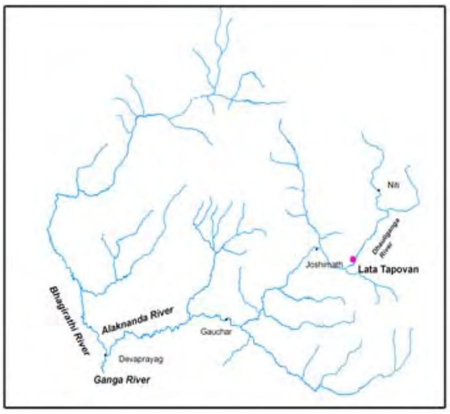
Location:	Between Jhlem and Tamak
Tehsil:	Joshi math
District:	Chamoli
Longitude:	79°37'35.4" E
Latitude:	30°37'35.4" N
Catchment area:	1652 km^2
Developer:	THDC
Project river:	Dhauliganga
Tributry of:	Alaknanda
Type:	Reservoir type
Height of the Dam:	28.0 m
Full Reservoir level (FRL):	2648.5 m
Head race Tunnel Type:	12.64 km
Tail Race-Length:	1.37 km
Power House:	Under ground on the right bank of the river
Installed Capacity:	480 mw
Annual generation:	434.0 MU
Status:	Under various stages of construction
Source:	Salient features as provided by dam authorities

TAMAK LATA HYDRO-ELECTRIC PROJECT



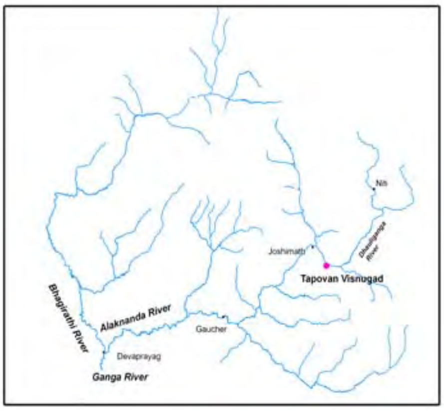
Location:	Lata village
Tehsil:	Joshi math
District:	Chamoli
Catchment area:	2000 km^2
Longitude:	79°47'13" E
Latitude:	30°35'46" N
Developer:	UJVNL
Project river:	Dhauliganga
Tributry:	Alaknanda
Up stream \Downstream HEP projects :	Jhleum –tamak \ Lata tapovan
Diverted river length:	10500 m
Type:	Run off river (ROR)
Height of the Barrage :	
Full Reservoir level (FRL):	2422
Head race Tunnel Type:	12.0 Km
Tail Race-Length :	
Power House:	Under ground
Installed Capacity:	250 mw
Annual generation:	1041.5 MU
Status:	Under various stages of construction
Source:	NT website PC.co.in

LATA TAPOVAN HYDRO-ELECTRIC PROJECT



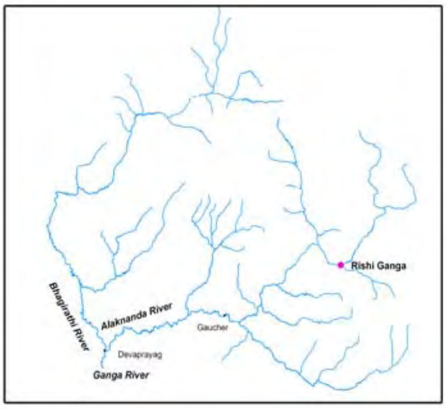
Location:	Lata village
Tehsil:	Joshi math
District:	Chamoli
Longitude:	79°45' 5" E
Latitude:	30°31' 20" N
Catchment area:	599 km^2
Developer:	NTPC
Project river:	Dhauliganga
Tributry of:	Alaknanda
Up stream \Downstream HEP projects :	Tamak Lata/ Tapovan Vishnugad
Diverted river length:	8500 m
Type:	Run off the river type
Height of the Barrage:	????
Full Reservoir level (FRL):	2103 m
Head race Tunnel Type:	7.51 Km
Tail Race-Length:	4.1 m
Power House:	Under ground
Installed Capacity:	125 mw
Annual generation:	221.6 MU
Status:	Under various stages of development
Source:	NT website PC.co.in

TAPOVAN VISHNU GAD HYDRO-ELECTRIC PROJECT



Location:	Between Tapovan and Helang
Tehsil:	Joshi math
District:	Chamoli
Longitude:	79°37' 30" E
Latitude:	30°44' 30" N
Catchment area:	3100 km^2
Developer:	NTPC
Project river:	Dhauliganga
Tributry of:	Alaknanda
Up stream \Downstream HEP projects:	Lata Tapovan/ Tapovan- Vishnugad
Diverted river length :	
Type:	Reservoir type
Height of the Dam:	22 m
Full Reservoir level (FRL):	1794 m
Head race Tunnel Type:	11.77 km
Tail Race-Length:	439 m
Power House:	Under ground on the left bank of the river
Installed Capacity:	520 mw
Annual generation:	2486.41MU
Status:	Under construction
Source:	Summary as provided by dam authority- Anonymous. 2007. India: *NTPC Capacity Expansion Financing II (Tapovan–Vishnugad Hydroelectric Project and Loharinag–Pala Hydroelectric Project) : Summary Environmental Impact Assessment* Asian Development Bank (ADB).

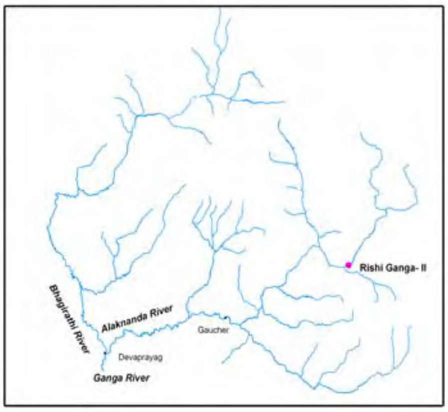
RISHI GANGA HYDRO-ELECTRIC PROJECT



Location:	Near Raini village
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°41' 59''E
Latitude:	30°28' 59''N.
Catchment area:	545 km²
Developer:	Rishiganga Power Corporation Ltd
Project River:	Rishiganga
Tributary of:	Dhauliganga
Up stream/ Downstream HEP:	Rishiganga II / Tapovan vishnugad
Diverted river length :	
Type:	Run off type
Height of the Dam/ Barrage:	diversion weir 5 m in height,
Full Reservoir level (FRL):	2012 M
Head raise Tunnel:	597 m
Tail Race-Length :	??
Power House:	Over ground on the left bank of the river
Installed Capacity:	13.2 mw
Annual generation:	82.204 MU
Status:	Construction complet, power house under production

Source:http://cdm.unfccc.int/filestorage/Y/U/S/YUSJCLMIK16F3ON2ZW4BXTHV9REAP8/RGHEP%20PDD.pdf?t=M218bHJnN3R0fDDBE1q4SZEoBbEAaJWaM7de PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD) - Version 03

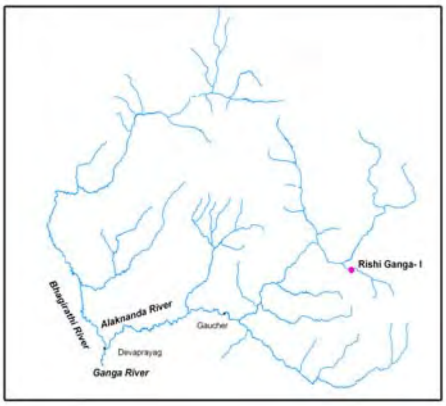
RISHI GANGA II HYDRO-ELECTRIC PROJECT



Location:	Down stream of Raunthi gad with Rishi ganga
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°46 26
Latitude:	30°27 37
Catchment area:	680 km²
Developer:	Uttarakhand Jal vidut Nigam limited (UJVNL)
River:	Rishiganga
Tributary of:	Dhauliganga
Up stream \Downstream HEP projects:	Rishi ganga I/Rishiganga
Diverted river length :	
Type:	Storage
Height of the Dam/ Barrage:	29 m high dam
Full Reservoir level (FRL):	2060 m
Head race Tunnel:	3.24 km
Tail Race-Length:	300 m
Power House:	Under ground
Installed Capacity:	35 mw
Annual generation:	164.6 MU
Project Capital Cost (Million Rs.):	2129.8

Source : http://hydropowerstation.com/?s=Rishiganga+II Salient features of RISHI GANGA-II Hydroelectric Project (35 MW)

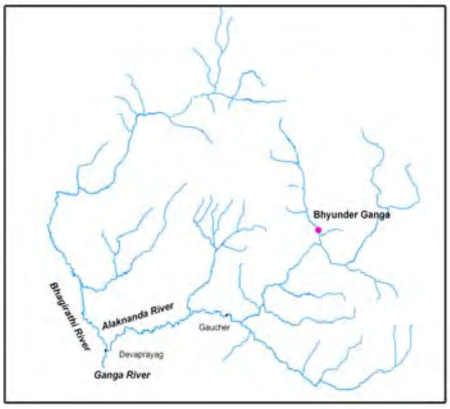
RISHI GANGA I HEP



Location:	Raini
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°46' 26"
Latitude:	30°27' 37"
Catchment area:	599 km2
Developer:	Uttarakhand Jal vidut Nigam limited (UJVNL)
Project River:	Rishiganga
Tributary of:	Dhauliganga
Up stream \Downstream HEP projects:	No project/Rishiganga
Diverted river length:	
Type:	Storage
Height of the Dam/ Barrage:	29 m high dam
Full Reservoir level (FRL):	2306 m
Volume content of Dam:	1.52 M cum
Head race Tunnel :	3.24 km
Tail Race-Length :	300 m
Power House:	Under ground
Installed Capacity:	35 mw
Annual generation:	327.3 MU
Status:	under various stages of development

Source : http://hydropowerstation.com/?s=Rishiganga+II Salient features of RISHI GANGA-II Hydroelectric Project (35 MW)

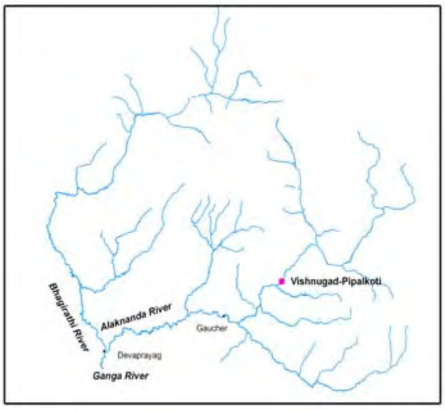
BHYUNDER GANGA



Location:	In Between Govindghat and ghangria near valley of flowers
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°41'59"E
Latitude:	30°28' 59"N.
Catchment area:	204.54 km2
Developer:	SHEPL
River:	Bhyunder (Laxman) Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects :	JP HEP ?
Diverted river length :	
Type:	Run off type
Height of the Dam/ Barrage:	diversion weir 4 m in height,
Full Reservoir level (FRL):	2204 m
Head raise Tunnel:	597 m
Tail Race-Length:	
Power House:	over ground on the left bank of the river
Installed Capacity:	13.2 mw
Annual generation:	149.5 MU
Status:	under various stages of development

Source : http://cdm.unfccc.int/filestorage/Y/U/S/YUSJCLMIK16F3ON2ZW4BXTHV9REAP8/RGHEP%20PDD.pdf?t=M218bHJnN3R0fDDBE1q4SZEoBbEAaJWaM7de PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD) - Version 03

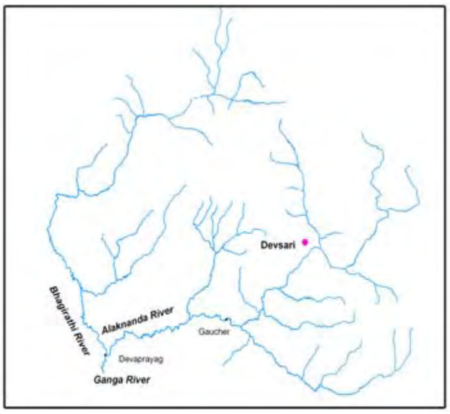
VISHNUGAD-PIPALKOTI HYDRO-ELECTRIC PROJECT



Location:	Helang
Tehsil:	Pipal koti
District:	Chamoli
Longitude:	79°25’20” E.
Latitude:	30°26’15” N;
Catchment area:	4682.5 km^2
Developer:	THDC
Project river:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Tapovan Vishnu gad / Bowla Nandprayag
Diverted river length :	
Type:	Run off type
Height of the Dam:	62 m
Full Reservoir level (FRL):	1267 m
Head race Tunnel Type:	13.4 km
Tail Race-Length:	3.7 km
Power House:	Under ground on the right bank of the river
Installed Capacity:	444 mw
Annual generation:	1813 MU
Status:	Under construction

Source: http://www.uttarakhandjalvidyut.com

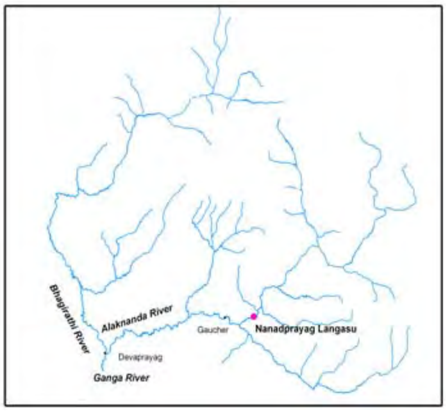
DEVSARI HYDRO-ELECTRIC PROJECT



Location:	Devasari
Tehsil:	Thalisain
District:	Chamoli
Longitude:	79°34’25” E.
Latitude:	30°02’40” N;
Catchment area:	1138 km^2
Developer:	SJVNL
Project river:	Pindar
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Debal/ Srinagar
Diverted river length:	
Type:	Reservoir type
Height of the Dam:	35.0 m
Full Reservoir level (FRL):	1300 m
Head race Tunnel Type:	7.37 km
Tail Race-Length :	1.5 km.
Power House:	Under ground on the right bank of the river
Installed Capacity:	200 mw
Annual generation:	1036.8 MU
Status:	Under various stages of development

Source: Summary provided by dam authority-

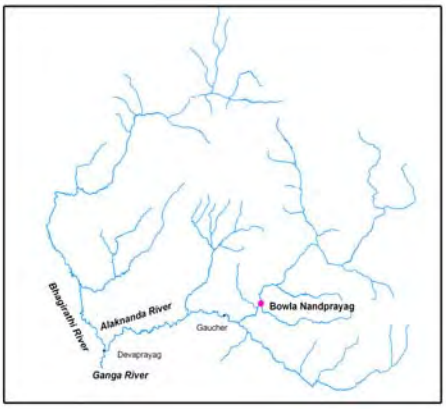
NANADPRAYAG LANGASU HYDRO-ELECTRIC PROJECT



Location:	Nanadprayag
Tehsil:	Nandprayag
District:	Chamoli
Longitude:	79°18' 55" E.
Latitude:	30°19' 55" N;
Catchment area:	6233 km^2
Developer:	UJVNL
Project river:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects :	Vishnugad Pipalkoti/ Bowla Nandprayag
Type:	Run off type
Height/ length of the Dam/ Barrage:	141 m long weir along the river
Full Reservoir level (FRL):	857 m
Head race Tunnel Type:	5 km
Tail Race-Length:	????
Power House:	Surface
Installed Capacity:	100 mw
Annual generation:	490.5 MU
Status:	Under various stages of development

Source : http://hydropowerstation.com/?tag=bowala-nand-prayag-hydro-electric-project; http://www.uttarakhandjalvidyut.com/cms_ujvnl/Bowala_Nanda.php

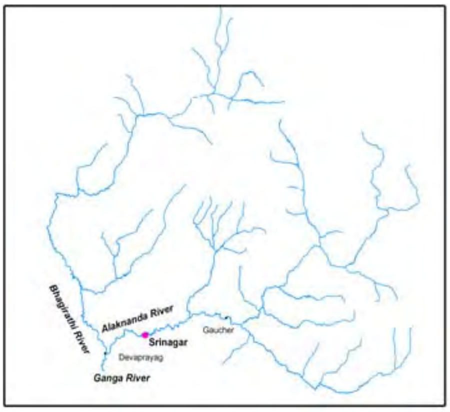
BOWLA NANDPRAYAG HYDRO-ELECTRIC PROJECT.



Location:	Bowla
Tehsil:	Nandprayag
District:	Chamoli
Longitude:	79°22' 00" E.
Latitude:	30°24' 00" N;
Catchment area:	6233 km^2
Developer:	UJVNL
Project river:	Alaknanda
Tributary of:	Ganga
Diverted river length:	
Up stream \Downstream HEP projects:	Nandprayag Langasu/ SrinagarHEP
Type:	Run off type
Height of the Dam/ Barrage:	8 M
Full Reservoir level (FRL):	1027
Head race Tunnel Type:	10.5 km
Tail Race-Length:	????
Power House:	Surface
Installed Capacity:	300 mw
Annual generation:	1102 MU

Source : http://hydropowerstation.com/?tag=bowala-nand-prayag-hydro-electric-project; http://www.uttarakhandjalvidyut.com/cms_ujvnl/Bowala_Nanda.php

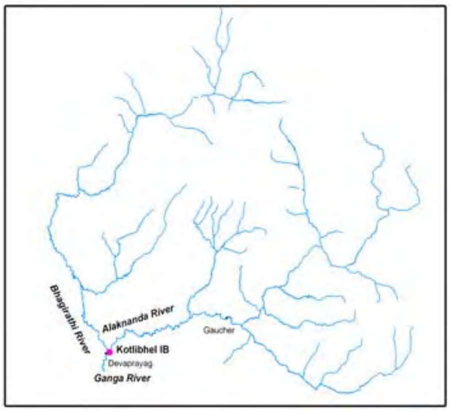
SRINAGAR HYDRO-ELECTRIC PROJECT.



Location:	Srinagar
Tehsil:	Srinagar
District:	Pauri
Longitude:	78°47' 00" E.
Latitude:	30°13' 40" N;
Catchment area:	11110 km^2
Developer:	GVK
Project River:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Bowla Nandprayag / Kotlibhel II
Diverted river length :	
Type:	Storage
Height of the Dam/ Barrage:	90 M
Full Reservoir level (FRL):	605.5 m
Head race Tunnel:	10.5 km
Tail Race-Length: ?	
Power House:	Surface on the right bank
Installed Capacity:	320 mw
Annual generation:	1515 MU
Status:	Under construction

Source: http://hydropowerstation.com/?tag=bowala-nand-prayag-hydro-electric-project; http://www.uttarakhandjalvidyut.com/cms_ujvnl/Bowala_Nanda.php

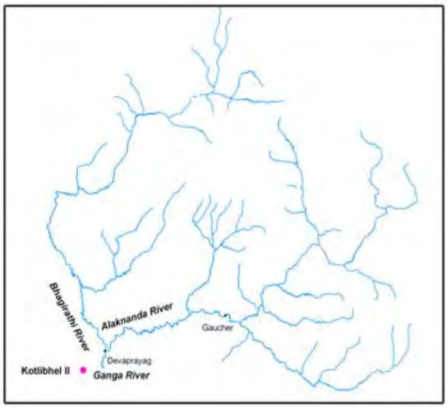
KOTLIBHEL IB HYDRO-ELECTRIC PROJECT.



Location:	Devprayag near Pali village
Tehsil:	Devprayag
District:	Tehri
Longitude:	78°35' 24" E.
Latitude:	30°9' 45" N;
Catchment area:	11471 km^2
Developer:	NHPC
Project river:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Srinagar HEP/ Kotlibhel II
Diverted river length :	
Type:	Storage type
Height of the Dam/ Barrage:	70.5 M
Full Reservoir level (FRL):	521 m
Head race Tunnel:	10.5 km
Tail Race-Length:	230 M
Power House:	Under ground
Installed Capacity:	300 mw
Annual generation:	1268.5 MU
Project Capital Cost (Million Rs.):	19113.3

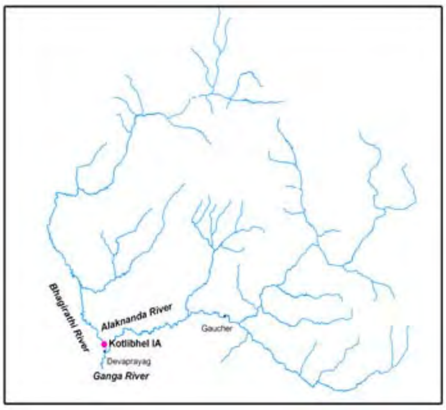
Source : Environment Management Plan

KOTLIBHEL II HYDRO-ELECTRIC PROJECT.



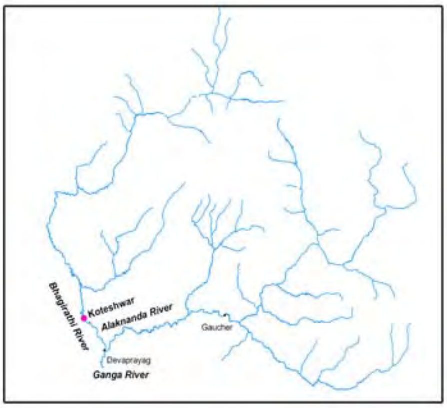
Location:	Kodiyala
Tehsil:	Devprayag
District:	Tehri
Longitude:	78°30p’ 00” E.
Latitude:	30°3’ 30” N;
Catchment area:	21375 km^2
Developer:	NHPC
Project river:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Kotlibhel IB (Up stream)
Diverted river length :	
Type:	Reservoir type
Height of the Dam/ Barrage:	82.5 M
Full Reservoir level (FRL):	458.5 m
Head race Tunnel:	145 m
Tail Race-Length:	50 M
Power House:	Under ground
Installed Capacity:	195 mw
Annual generation:	1993 MU
Project Capital Cost (Million Rs.):	19228
Status:	under various stages of development
Source:	EIA Report

KOTLIBHEL IA HYDRO-ELECTRIC PROJECT.



Location:	Muneth village
Tehsil:	Devprayag
District:	Tehri
Longitude:	78°35p’ 24” E.
Latitude:	30°09’45” N;
Catchment area:	7887 km^2
Developer:	NHPC
Project river:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Koteshwar HEP/ Kotlibhel II
Diverted river length :	
Type:	Reservoir type
Height of the Dam/ Barrage:	58.6 M
Full Reservoir level (FRL):	532 m
Head race Tunnel Type:	40 m
Tail Race-Length:	40 M
Power House:	Under ground
Installed Capacity:	195 mw
Annual generation:	973.1 MU
Project Capital Cost (Million Rs.):	12984.9
Source:	EIA and EMP

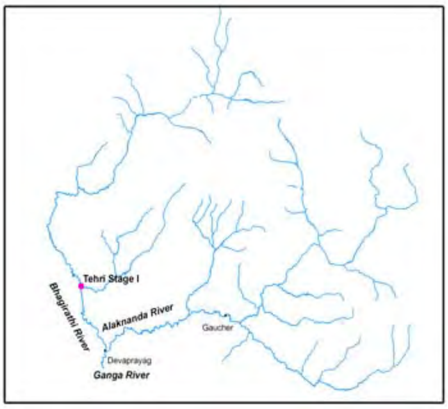
KOTESHWAR HYDRO-ELECTRIC PROJECT.



Location:	Near Pendaras Village
Tehsil:	Devprayag
District:	Tehri
Longitude:	78°33'39" E.
Latitude:	30°45' 02" N;
Catchment area:	7691 km²
Developer:	THDC
Project river:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Tehri HEP/Kotlibhel IA
Diverted river length:	
Type:	Reservoir type
Height of the Dam/ Barrage:	97.5 M
Full Reservoir level (FRL):	612 m
Divergence Tunnel:	593 m
Tail Race-Length:??	
Power House:	Surface at toe of the dam on the right bank of the river
Installed Capacity:	400 mw
Annual generation:	1209 MU
Status:	Under construction

Source: "Koteshwar Hydro Power Project". Tehri Hydro Development Corporation. http://thdc.gov.in/Projects/english/Scripts/Prj_Introduction.aspx?vid=134.
"Features". Tehri Hydro Development Corporation. http://thdc.gov.in/Projects/english/Scripts/Prj_ Features.aspx?Vid=134.
Koteshwar Dam http://en.wikipedia.org/wiki/Koteshwar_Dam.

TEHRI I HYDRO-ELECTRIC PROJECT.

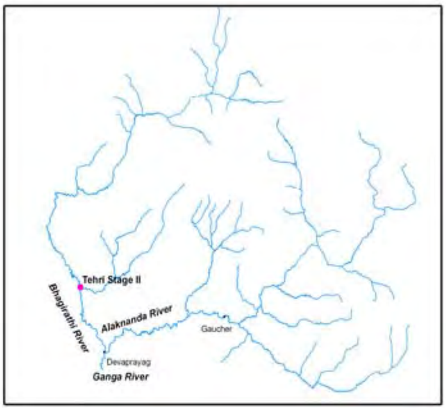


Location:	Tehri
Tehsil:	Tehri
District:	Tehri
Longitude:	78°29' 00" E.
Latitude:	30°24' 00" N;
Catchment area:	7700 km²
Developer:	THDC
River:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Maneri Bhali/Koteshwar
Diverted river length:	-
Type:	Reservoir type
Height of the Dam/ Barrage:	260.5 M
Full Reservoir level (FRL):	830
Divergence Tunnel:	593 m
Tail Race-Length:	
Power House:	Surface at toe of the dam on the right bank of the river
Installed Capacity:	1000 mw
Annual generation:	3497 MU
Status:	construction completed , power house under production

Source: "Koteshwar Hydro Power Project". Tehri Hydro Development Corporation. http://thdc.gov.in/Projects/english/Scripts/Prj_Introduction.aspx?vid=134.
"Features". Tehri Hydro Development Corporation. http://thdc.gov.in/Projects/english/Scripts/Prj_ Features.aspx?Vid=134.
Koteshwar Dam http://en.wikipedia.org/wiki/Koteshwar_Dam.

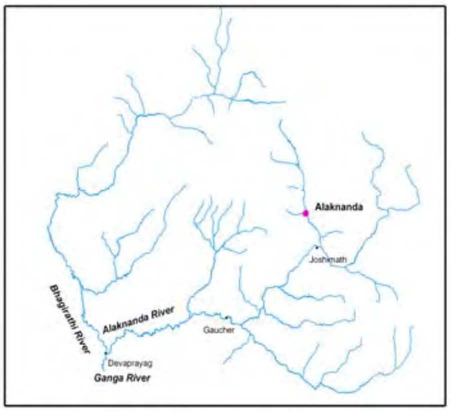
TEHRI STAGE II HYDRO-ELECTRIC PROJECT.

Location:	Tehri
Tehsil:	Tehri
District:	Tehri
Longitude:	78°28’ 51.6” E.
Latitude:	30°23’ 20” N;
Catchment area:	2000 km^2
Developer:	THDC
River:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Tehri I/Koteshwar
Diverted river length:	-
Type:	Reservoir type
Height of the Dam/ Barrage:	???M
Full Reservoir level (FRL):	830
Divergence Tunnel:	???
Tail Race-Length:	???
Power House:	Surface at toe of the dam on the right bank of the river
Installed Capacity:	1000 mw
Annual generation:	3497 MU
Status:	Under various stages of development

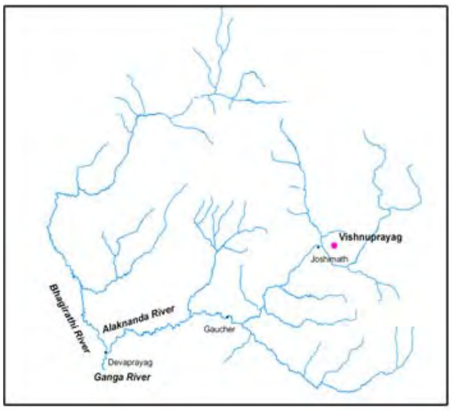


ALAKNANDA HYDRO-ELECTRIC PROJECT.

Location: Badrianth	Near 3 Km downstream of
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°29’42” E.
Latitude:	30°43’24” N;
Catchment area:	1010 km^2
Developer:	GMR
Project River:	Alaknanda
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Badrinath II/ Vishnuprayag
Diverted river length:	-
Type:	Run of the river
Height of the Dam/ Barrage: ?	
Full Reservoir level (FRL):	2922 m
Head Race Tunnel:	2886 m
Tail Race-Length:	1780 m
Power House:	under ground on the right bank of the river
Installed Capacity:	300 mw
Annual generation:	1199 MU
Project Capital Cost (Million Rs.):	14520.8
Status:	under various stages of development
Source:	EIA Reports



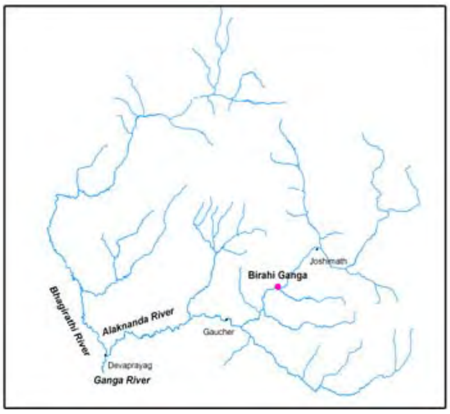
VISHNUPRAYAG HYDRO-ELECTRIC PROJECT.



Location:	Near 15 Km downstream of Badrianth
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°28' 0" N;
Latitude:	30°32' 0" E.
Catchment area:	1678 km^2
Developer:	JAYPEE
Project river:	Alaknanda
Tributary of:	Ganga
Up stream\Downstream HEP projects:	Alaknanda/ Vishnugad Pipalkoti
Diverted river length :	
Type:	Run of the river
Height of the Dam/ Barrage:	Barrage across the river
Full Reservoir level (FRL):	2276 m
Head Race Tunnel:	11.334 m
Tail Race-Length:	1920 m
Power House:	Under ground on the right bank of the river
Installed Capacity:	400 mw
Annual generation:	2060.5 MU

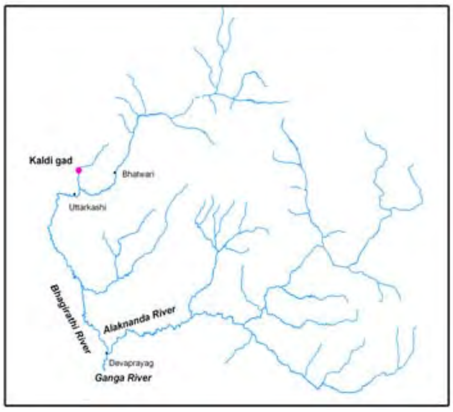
Source: http://www.docstoc.com/docs/26098671/VISHNUPRAYAG-HYDRO-ELECTRIC-PROJECT-_4X100MW_

BIRAHI GANGA HYDRO-ELECTRIC PROJECT.



Location:	Birahi village
Tehsil:	Pipalkoti
District:	Chamoli
Longitude:	79°23' 56" E.
Latitude:	30°24' 35" N;
Catchment area:	3000km^2
Developer:	Birahi Ganga Hydro power Ltd.
Project River:	Birahi Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Birahi Ganga II / Srinagar
Diverted river length:	
Type:	Run of the river
Height/length of the Dam/ Barrage:	25 m long weir
FRL:	1080 m
Full Reservoir level (FRL):	1105
Head Race Tunnel:	1648 m
Tail Race- Length:	100 m
Power House:	Over ground on the right bank of the river
Installed Capacity:	4.8 MW
Annual generation:	42.25MU
Status:	Under operation
Source:	http://indscan.weblogs.us/archives/530.

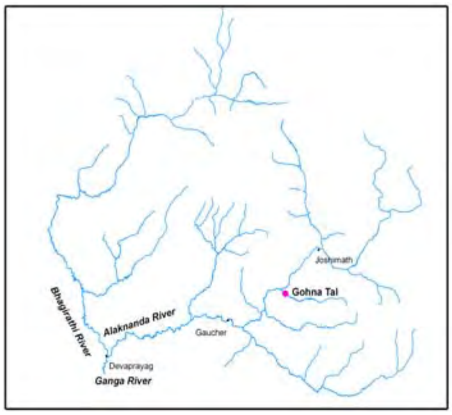
KALDI GAD HYDRO-ELECTRIC PROJECT.



Location:	Near Sangam chatti
Tehsil:	Bhatwari
District:	Uttarkashi
Longitude:	78°28' 39" E.
Latitude:	30°50' 27" N;
Developer:	UJVNL
Project river:	Kaldi gad
Tributary of:	Asiganga
Up stream \Downstream HEP projects:	Assi Ganga I (Down stream)
Diverted river length :	
Type:	Run of the river
Height/length of the Dam/ Barrage:	15 m long trench
Full Reservoir level (FRL):	1783 m
Head Race Tunnel:	2030 m
Pen stock:	560 m
Power House:	Over ground on the left bank of the river
Installed Capacity:	9 mw
Annual generation:	63.5MU
Status:	under various stages of development

Source : http://indscan.weblogs.us/archives/530; salient features provided by the authorities of HEP

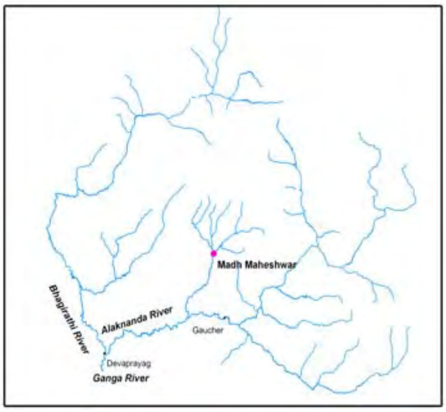
GOHNA TAL HYDRO-ELECTRIC PROJECT.



Location:	1.7 km d/s of confluence of Pui Gadhera joining river Birahi Ganga from Right Bank
Tehsil:	Pipalkoti
District:	Chamoli
Longitude:	79°30' 18"E
Latitude:	30°22' 43" N
Catchment area:	218 km^2
Developer:	THDC
Project river:	Birahi Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	--------/ Birahi II
Diverted river length:	
Type:	Run of the river
Height/ length of the Dam/ Barrage:	84 m long
Full Reservoir level (FRL):	1614 m
Area under submergence:	24.64 ha
Head Race Tunnel:	9 km
Tail Race- Length:	940 m
Power House:	Under ground
Installed Capacity:	60 mw
Annual generation:	180.9MU
Project Capital Cost (Million Rs.):	3538.7
Status:	Under various stages of development

Source : http://thdc.gov.in/Projects/english/Scripts/Prj_Features.aspx?Vid=143 Gohna Tal Features

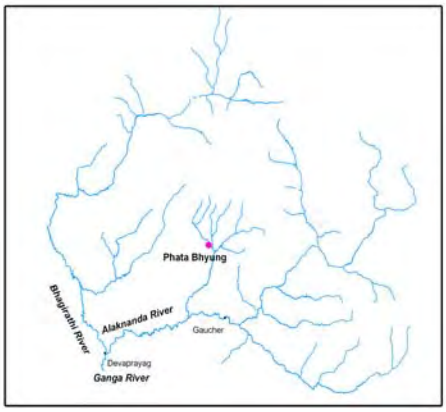
MADH MAHESHWAR HYDRO-ELECTRIC PROJECT.



Location:	Madmaheswar
Tehsil:	Okihmath
District:	Rudrya prayag
Longitude:	79°30' 18"E
Latitude:	30°22' 43" N
Catchment area:	429.67 km^2
Developer:	THDC
River:	Birahi Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	--------/ Singoli Bhatwari
Diverted river length:	
Type:	Run of the river
Height/ length of the Dam/ Barrage:	
Full Reservoir level (FRL):	1236 m
Head Race Tunnel:	…. km
Tail Race- Length:	….m
Power House:	Under ground
Installed Capacity:	10 mw
Annual generation:	60.38 MU

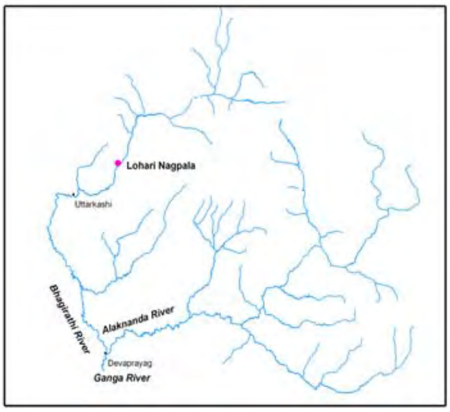
Status: Under various stages of development

PHATA BHYUNG HYDRO-ELECTRIC PROJECT.



Location:	Near Sita pur village
Tehsil:	Okhimath
District:	Rudrya prayag
Longitude:	79o 00' 28''E
Latitude:	30o 37' 35''N
Catchment area:	247.44 km^2
Developer:	LANCO
Project river:	Mandakini
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Rambara / Singoli Bhatwari
Diverted river length :	
Type:	Storage
Height/ length of the Dam/ Barrage:	26 m high
Full Reservoir level (FRL):	1635 m
Head Race Tunnel:	9.38 km
Tail Race- Length:	? m
Power House:	Under ground on the right bank
Installed Capacity:	76 mw
Annual generation:	340.5 MU
Project Capital Cost (Million Rs.):	4840
Status:	Under various stages of development
Source:	EMP report

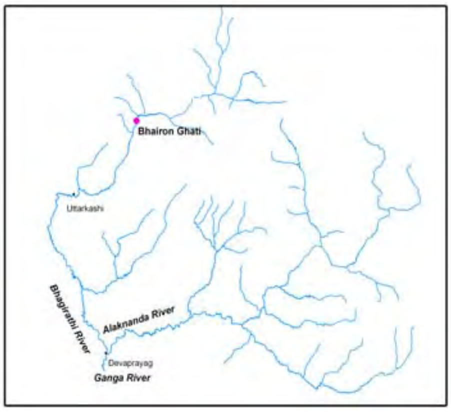
LOHARINAG PALA HYDROELECTRIC PROJECT.



Location:	Near loharinag Pala
District:	Uttarkashi
Longitude:	78°42' 00"E
Latitude:	30°58' 16"N
Catchment area:	3316 km^2
Developer:	NTPC
Project river:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Bhairon ghati / Limcha gad
Diverted river length :	
Type:	Run of River
Height/ length of the Dam/ Barrage:	13 m wide and 8.5 m high
Full Reservoir level (FRL):	2140.50
Head Race Tunnel:	13.5 km
Tail Race - Length:	510 m
Power House:	Under ground on the right bank near Pala Village
Installed Capacity:	600 mw
Annual generation:	2436.9MU
Status:	Under various stages of development

Source: Environmental Assessment Report (Anonymous 2007. India: NTPC Capacity Expansion Financing II (Tapovan–Vishnugad Hydroelectric Project and Loharinag–Pala Hydroelectric Project. NTPC)

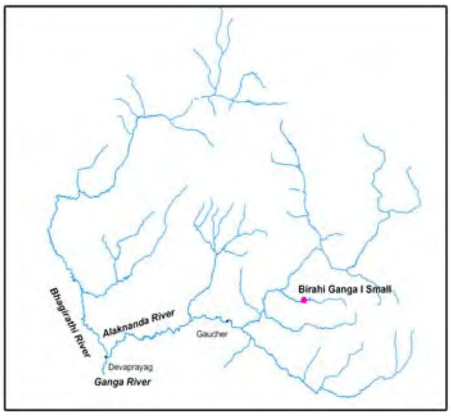
BHAIRON GHATI HYDROELECTRIC PROJECT.



Location:	Bhaironghati
District:	Uttarkashi
Longitude:	78°42' 52"E
Latitude:	31° 01' 02"N
Catchment area:	3290 km^2
Developer:	UJVNL
River:	Bhagirathi
Tributary of:	Ganga
Up stream \Downstream HEP projects:	Jadh Ganga/ Loharinag Pala
Type:	Run of River
Height/ length of the Dam/ Barrage:	12×9.5 m of barrage
Full Reservoir level (FRL):	3290 m
Head Race Tunnel:	4.7 km
Tail Race- Length :	??
Power House:	Under ground
Installed Capacity:	381 mw
Annual generation:	1462 MU
Status:	Work on hold due to environment issues in river Bhagirathi

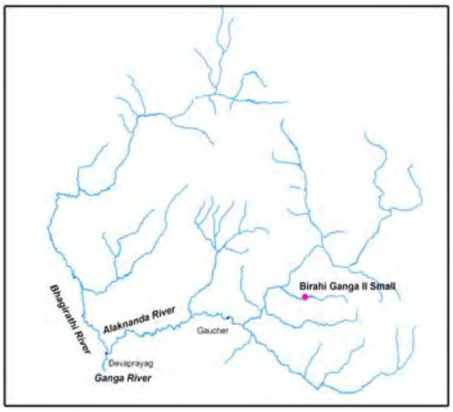
Source : http://hydropowerstation.com/?tag=bhairon-ghati-hydroelectric-project - Salient features of BhaironGhati Hydroelectric Project (381 MW).

BIRAHI GANGA I SMALL HYDROELECTRIC PROJECT.



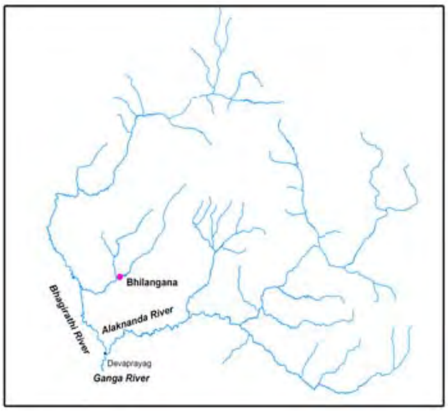
Location:	Birahi Ganga
Tehsil:	Pipalkoti
District:	Chamoli
Longitude:	79°30’ 00’’E
Latitude:	30°22’ 30’’N
Catchment area:	278.66 km^2
Developer:	PES Engineers Pvt. Ltd
Project River:	Birahi Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Birahi ganga II/ Birahi ganga
Type:	Run of river
Up stream \Downstream HEP projects:	Birahi Ganga II/ Birahi Ganga
Diverted river length :	
Type:	Run of River
Height/ length of the Dam/ Barrage:	67 m long concrete weir
Full Reservoir level (FRL):	1345 m
Head Race Tunnel:	5.6 km
Tail Race- Length:	
Power House:	Surface
Installed Capacity:	24 mw
Annual generation:	96.8 MU
Status:	Work on hold due to environment issues
Source:	Silent features provided by HEP authorities.

BIRAHI GANGA II SMALL HYDROELECTRIC PROJECT.



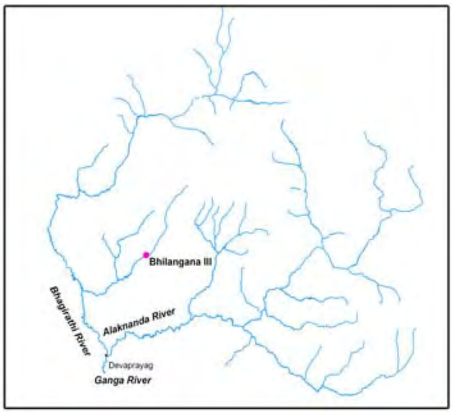
Location:	Birahi Ganga
Tehsil:	Pipalkoti
District:	Chamoli
Longitude:	79°30’ 00’’E
Latitude:	30°22’ 30’’N
Catchment area:	217.44 km^2
Developer:	PES Engineers Pvt. Ltd.
River:	Birahi ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Gohna Tal / Birahi Ganga I
Diverted river length :	
Type:	Run of River
Height/ length of the Dam/ Barrage:	46.5 m long concrete weir
Full Reservoir level (FRL):	1610 m
Head Race Tunnel:	2.76 km
Power House:	Surface
Installed Capacity:	24 mw
Annual generation:	96.8MU
Status:	Under various stages of development

BHILANGANA HYDROELECTRIC PROJECT



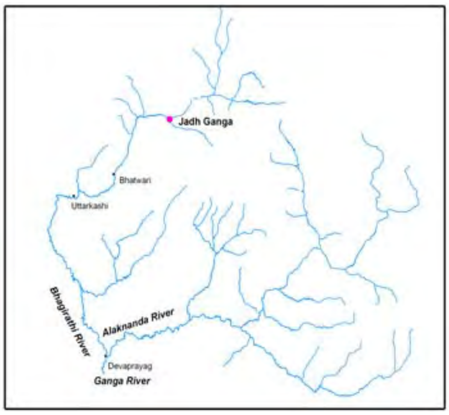
Location:	Ghansali
Tehsil:	Ghansali
District:	Tehri
Longitude:	78°39' 30''E
Latitude:	30°26' 07''N
Catchment area:	1149 km^2
Developer:	Swasti Hydro power Ltd.
River:	Bhilangana
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	Bhilangana IIC/ Tehri Stage II
Diverted river length :	
Type:	Run of River
Height/ length of the Dam/ Barrage :	30.0 m long weir
FRL:	965 m
Head Race Tunnel :	13.0km
Power House:	over ground
Installed Capacity:	24 mw
Annual generation:	121.956 MU
Status:	under operation
Source:	http://www.careratings.com/archive/9/5564.pdf;

BHILANGANA III HYDROELECTRIC PROJECT.



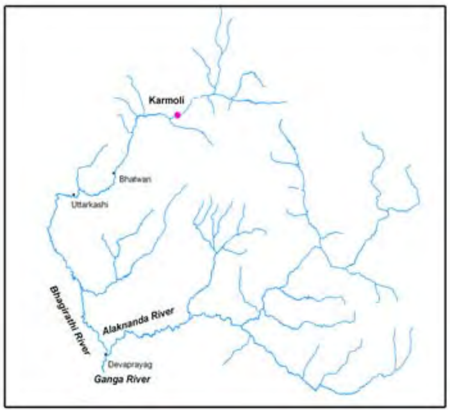
Location:	Bhilangana valley
Tehsil:	Ghansali
District:	Tehri
Longitude:	78°48' 26''E
Latitude:	30°33' 07''N
Catchment area:	407 km^2
Developer:	Bhilangana Hydro Power Limited (BHPL)
Project river:	Bhilangana
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	…./B
Diverted river length :	
Type:	Run of River
FRL:	1105 m
Head Race Tunnel:	4.7 km
Installed Capacity:	24 mw
Annual generation:	170.83 MU
Status:	Under construction
Source:	http://www.careratings.com/archive/9/5564.pdf;

JADH GANGA HYDROELECTRIC PROJECT.



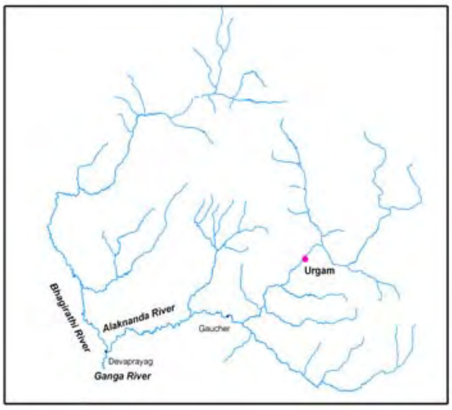
Location:	100 m D/S of confluence of Gartang gad with Jadhganga river.
District:	Uttarkashi
Longitude:	78°53' 17''E
Latitude:	31° 2' 18''N
Catchment area:	1679 km^2
Developer:	THDC
River:	Jadh Ganga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	Karmoli/Bhaironghati
Diverted river length :	
Type:	Storage
Height/ length of the Dam/ Barrage:	45 m High 110 m long
Full Reservoir level (FRL):	2802 m
Head Race Tunnel:	1.1 km
Tail Race- Length:	290 m
Power House:	Under ground
Installed Capacity:	50 mw
Annual generation:	220.9 MU
Status:	Under various stages of development
Source:	http://thdc.gov.in/Projects/english/Scripts/Prj_Features.aspx?Vid=165

KARMOLI HYDROELECTRIC PROJECT.



Location:	700 m D/S of confluence of Chorgad with Jadhganga river
District:	Uttarkashi
Longitude:	78°58' 5''E
Latitude:	31°6' 4''N
Catchment area:	1605 km^2
Developer:	THDC
Project river:	Jadh Ganga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	……/Jadh Ganga HEP
Diverted river length :	
Type:	Storage
Height/ length of the Dam/ Barrage:	56 m High 128 m long
Full Reservoir level (FRL):	3268.5 m
Head Race Tunnel:	8.6 km
Tail Race- Length:	600 m
Power House:	Under ground
Installed Capacity:	140 mw
Annual generation:	220.9 MU
Status:	Under various stages of development.
Source:	http://thdc.gov.in/Projects/english/Scripts/Prj_Introduction.aspx?Vid=141

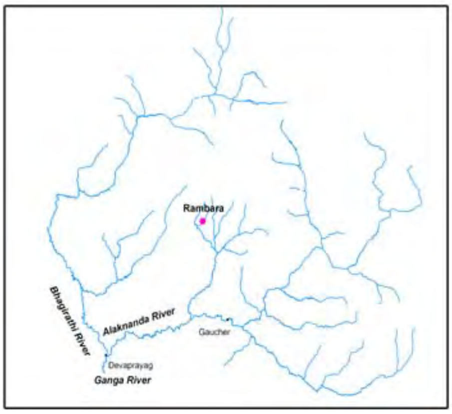
URGAM HYDRO-ELECTRIC PROJECT.



Location:	Near Helong
Tehsil:	Joshimath
District:	Chamoli
Longitude:	78°58' 5''E
Latitude:	31°6' 4''N
Catchment area:	107 km²
Developer:	UJVNL
River:	Kalpganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Urgam I/ Vishnuprayag pipaplkoti HEP
Type:	Run of the River
Height/ length of the Dam/ Barrage:	25 m long concrete weir
Full Reservoir level (FRL):	990
Head Race Tunnel:	1700 m
Power House:	Surface
Installed Capacity:	3 mw
Annual generation:	10.66MU
Status:	Under various stages of development

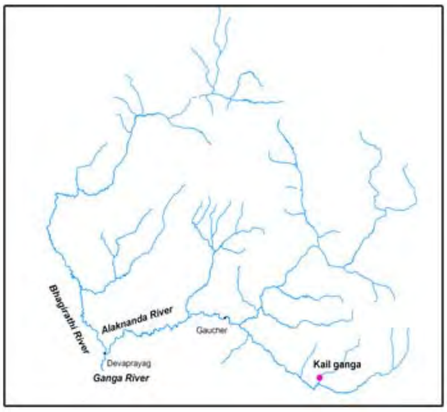
Source : http://hydropowerstation.com/?s=urgam

RAMBARA HYDRO ELECTRIC PROJECT



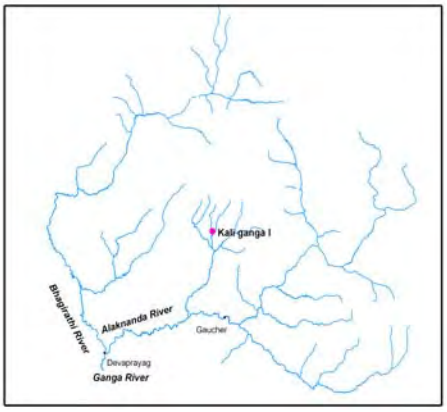
Location:	Rambara
Tehsil:	Ookhimath
District:	Rudrya prayag
Longitude:	79°03' 20.01''E
Latitude:	30°41' 42.3''N
Catchment area:	65 km²
Developer:	Lancod. Mandikini hydro Energy Pvt. Ltd.
Project River:	Mandakini
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	………..I/Phata bhyung
Type:	Run of the River
Full Reservoir level (FRL):	2673
Head Race Tunnel:	1700 m
Power House:	Surface
Installed Capacity:	76 mw
Annual generation:	121.6MU
Status:	Under various stages of development
Source:	http://hydropowerstation.com/?s=urgam

KAIL GANGA HYDRO ELECTRIC PROJECT



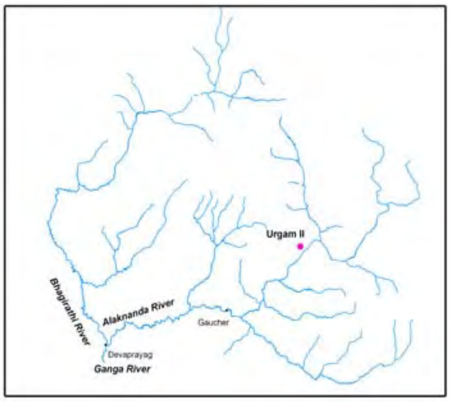
Location:	Near Debal village
Tehsil:	Tharali
District:	Chamoli
Longitude:	79°5' 10''E
Latitude:	30°5' 30''N
Catchment area:	342 km^2
Developer:	UJVNL
River:	Kail ganga
Tributary of:	Pinder
Up stream \Downstream HEP projects:	..------/Debal
Diverted river length:	
Type:	Run of the River
Height/ length of the Dam/ Barrage:	12 m long trench type Rcc
Full Reservoir level (FRL):	1443
Power House:	Surface
Installed Capacity:	5 mw
Annual generation:	31.93MU
Status:	Under construction

KALI GANGA I HYDRO ELECTRIC PROJECT



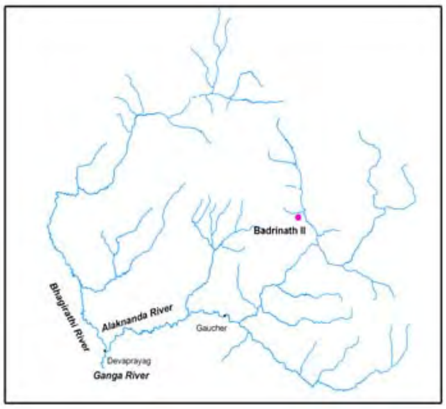
Location:	Jaitala village
Tehsil:	Okhimath
District:	Rudryaprayag
Longitude:	79°5' 10''E
Latitude:	30°36' 40''N
Catchment area:	69.55km^2
Developer:	UJVNL
River:	Kali ganga
Tributary of:	Mandakini
Up stream \Downstream HEP projects:	----/Kali ganga II
Diverted river length :	
Type:	Run of the River
Height/ length of the Dam/ Barrage:	12 m long trench type weir
Full Reservoir level (FRL):	69.55m
Head Race Tunnel:	400 m
Power House:	Surface
Installed Capacity:	4 mw
Annual generation:	26.37MU
Project Capital Cost (Million Rs.):	239.38
Status:	Under various stages of development
Source:	Salient features of the project

URGAM II HYDRO ELECTRIC PROJECT



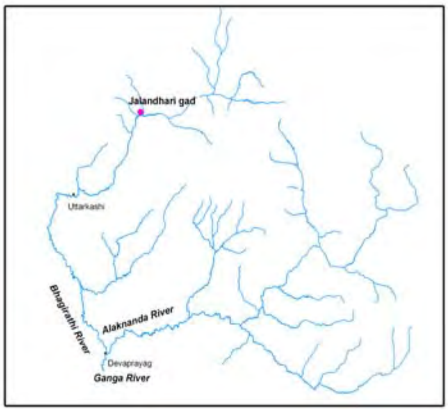
Location:	Near Urgam village
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°28' 40''E
Latitude:	30°32' 56''N
Catchment area:	89 km^2
Developer:	UJVNL
River:	Kalpganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	---/Urgam
Type:	Run of the River
Height/ length of the Dam/ Barrage:	?
Full Reservoir level (FRL):	1785
Head Race Tunnel:	?
Power House:	Surface
Installed Capacity:	3.8mw
Annual generation:	15.7 MU
Status:	Under various stages of development
Source:	http://hydropowerstation.com/?s=urgam

BADRINATH II HYDRO ELECTRIC PROJECT



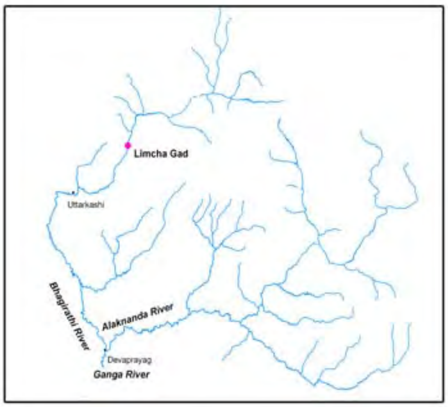
Location:	Badrinath
Tehsil:	Joshimath
District:	Chamoli
Longitude:	79°29' 48''E
Latitude:	30°43' 9.1''N
Catchment area:	4024km^2
Developer:	UJVNL
River:	Risi Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	-----/Alaknanda HEP
Type:	Run of the River
Height/ length of the Dam/ Barrage:	???
Full Reservoir level (FRL):	3221.50
Head Race Tunnel:	???
Power House:	Surface
Installed Capacity:	1.25 mw
Annual generation:	26.33 MU
Status:	under operation

JALANDHARIGAD HYDRO ELECTRIC PROJECT



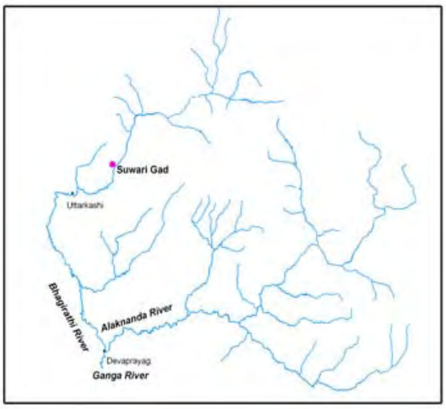
Location:	Near Harsil
Tehsil:	Harsil
District:	Uttarkashi
Longitude:	78°45’ 5’’E
Latitude:	31°2’ 51’’N
Catchment area:	107 km^2
Developer:	UJVNL
River:	Jalandharii gad
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	----/Lohari Nagpala HEP.
Type:	Run of the River
Height/ length of the Dam/ Barrage:	???
Full Reservoir level (FRL):	3108
Head Race Tunnel:	??
Power House:	Surface
Installed Capacity:	18.5 mw
Annual generation:	117.9 MU
Status:	Under various stages of development

LIMCHA GAD HYDRO ELECTRIC PROJECT



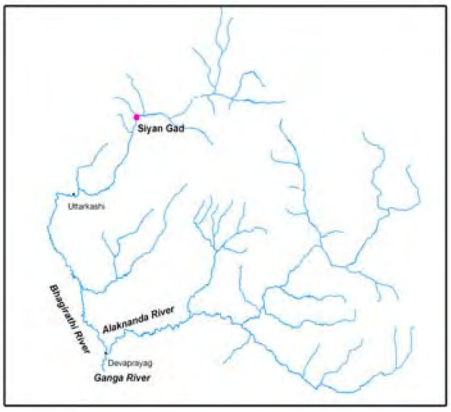
Location:	On way to Harsil
District:	Uttarkashi
Longitude:	78°41’ 28’’E
Latitude:	30°55’ 31’’N
Catchment area:	14.75 km^2
Developer:	UJVNL
River:	Kalpganga
Tributary of:	Bhagirathi
Up stream \Downstream HEP projects:	Lohari nag pala/ Palamaneri HEP
Diverted river length:	
Type:	Run of the River
Height/ length of the Dam/ Barrage:	??
Full Reservoir level (FRL):	2377
Head Race Tunnel:	?
Power House:	Surface
Installed Capacity:	3.5 mw
Annual generation:	20.6MU
Status:	Under various stages of development

SUWARI GAD HYDRO ELECTRIC PROJECT



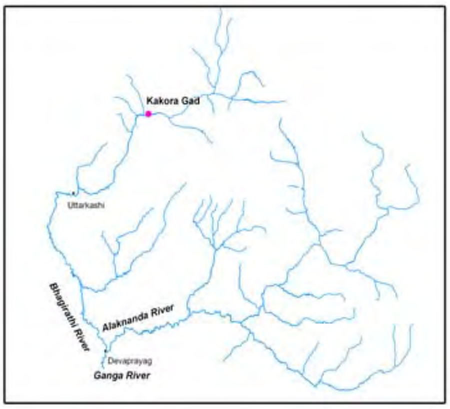
Location:	On way to Harsil
District:	Uttarkashi
Longitude:	78°37’ 0’’E
Latitude:	30°51’ 0’’N
Catchment area:	35.67 km^2
Developer:	UJVNL
River:	Suwari gad
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	Palamaneri / Maneri Bhali HEP
Type:	Run of the River
Height/ length of the Dam/ Barrage :	
Full Reservoir level (FRL):	1827.563
Head Race Tunnel:	?
Power House:	Surface
Installed Capacity:	2 mw
Annual generation:	11.1MU
Status:	Under various stages of development

SIYANG GAD HYDRO ELECTRIC PROJECT



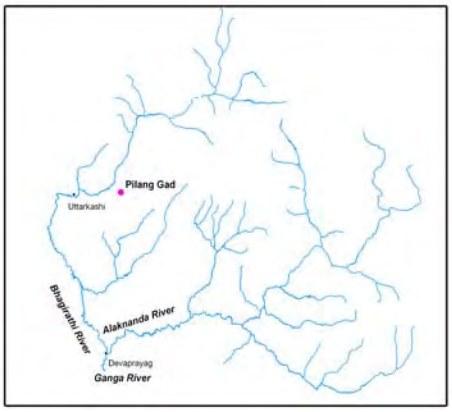
Location:	Near Harsil
District:	Uttarkashi
Longitude:	78°41’ 50’’E
Latitude:	31°30’ 10’’N
Catchment area:	136 km^2
Developer:	UJVNL
River:	Siyan gad
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	------/LohariNagpala HEP
Type:	Run of the River
Height/ length of the Dam/ Barrage:	?
Full Reservoir level (FRL):	2765
Head Race Tunnel:	?
Power House:	Surface
Installed Capacity:	11.5 mw
Annual generation:	53.0 MU
Status:	Under various stages of development

KAKORA GAD HYDRO ELECTRIC PROJECT



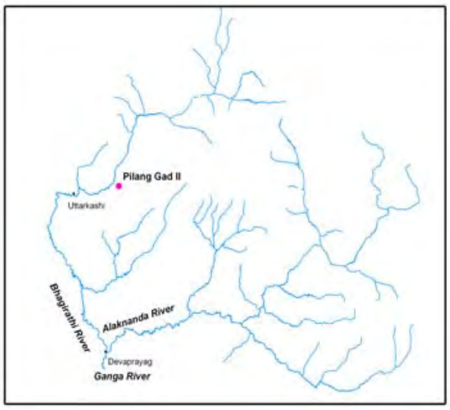
Location:	Near Harsil
District:	Uttarkashi
Longitude:	78°46' 20''E
Latitude:	31°3' 32''N
Catchment area:	86 km^2
Developer:	UJVNL
River:	Kakora gad
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	------/LohariNagpala HEP
Type:	Run of the River
Height/ length of the Dam/ Barrage :	
Full Reservoir level (FRL):	2442
Head Race Tunnel :	?
Power House:	Surface
Installed Capacity :	12.5 mw
Annual generation:	56.5 MU
Status:	Under various stages of development

PILANG GAD HYDRO ELECTRIC PROJECT



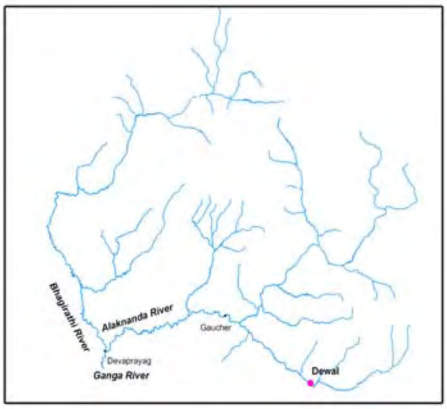
Location:	Near Bhatwari
Teshil:	Bhatwari
District:	Uttarkashi
Longitude:	78°38' 0''E
Latitude:	30°46' 0''N
Catchment area:	252 km^2
Developer:	UJVNL
River:	Pilang gad
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	/Pilang gad II/ Maneri Bhali.
Type:	Run of the River
Height/ length of the Dam/ Barrage :	
Full Reservoir level (FRL):	UA
Head Race Tunnel:	
Power House:	Surface
Installed Capacity:	2.25 mw
Annual generation:	2.75MU
Status:	Under various stages of development

PILANG GAD II HYDRO ELECTRIC PROJECT



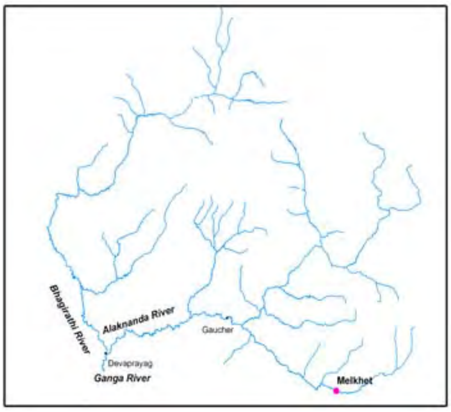
Location:	Near Bhatwari
Teshil:	Bhatwari
District:	Uttarkashi
Longitude:	78°39' 55''E
Latitude:	30°45' 55''N
Catchment area:	140 km^2
Developer:	UJVNL
River:	Pilang Gad
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	/------/Pilang gad
Type:	Run of the River
Height/ length of the Dam/ Barrage :	
Full Reservoir level (FRL):	1985
Head Race Tunnel:	
Power House:	Surface
Installed Capacity:	4mw
Annual generation:	18.7MU
Status:	Under various stages of development

DEBAL HYDRO ELECTRIC PROJECT



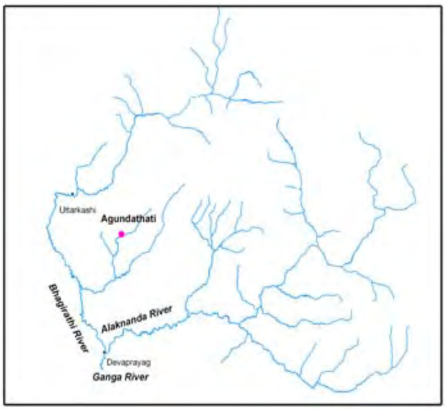
Location:	Debal village
Tehsil:	Tharali
District:	Chamoli
Longitude:	79°33' 10''E
Latitude:	30°3' 0''N
Catchment area:	360 km^2
Developer:	Chamoli Hydro power Pvt. Ltd.
River:	Kail Ganga
Tributary of:	Pi nder
Up stream \Downstream HEP projects:	Melkhet /Devsari
Type:	Run of the River
Height/ length of the Dam/ Barrage : ?	
Full Reservoir level (FRL):	360
Head Race Tunnel:	
Power House:	Surface
Installed Capacity:	5
Annual generation:	34.3 MU
Status:	Under operation Debal Hydro Electric Project

MELKHET HEP



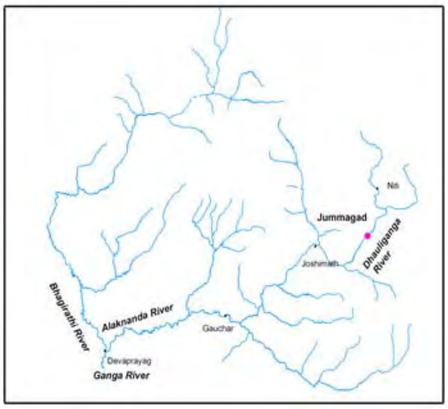
Location:	Melkhet village
Tehsil:	Tharali
District:	Chamoli
Longitude:	79°2' 20''E
Latitude:	30°1' 23''N
Catchment area:	644 km^2
Developer:	Melkhet Hydro power Pvt. Ltd.
River:	Pinder Ganga
Tributary of:	Alaknanda
Up stream \Downstream HEP projects:	-----/Devsari
Diverted river length :	
Type:	Run of the River
Height/ length of the Dam/ Barrage:	?
Full Reservoir level (FRL):	1452.55
Head Race Tunnel:	?
Power House:	Surface
Installed Capacity:	15
Annual generation:	110.2 MU
Status:	under various stages of development

AGUNDA THATI HYDRO-ELECTRIC PROJECT.



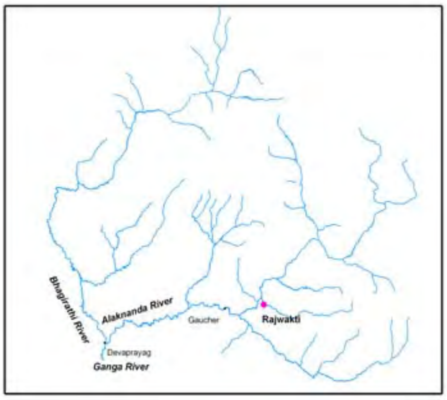
Location:	Bhudha Kedar
Tehsil:	Ghansali
District:	Tehri
Developer:	Gunsola Hydro Power Generation Pvt. Ltd.
Catchment area:	121 Km^2
Latitude:	30°36'6"
Longitude:	78°37'22"
River:	Bhagirathi
Tributary:	Dharamganga
Up stream \Downstream HEP projects:	Jhala koti/ Kot Bhuda Kedar HEP
Diverted river length (M):	2000
Type:	ROR
Height of the Dam:	3.5
Volume content of Dam:	
FRL:	1286.5
Head race Tunnel Type:	Length:
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	3
Firm Power Capacity:	
Annual Power generation (MU):	26.23
Status:	Commissioned

JUMAGAD HYDRO-ELECTRIC PROJECT.



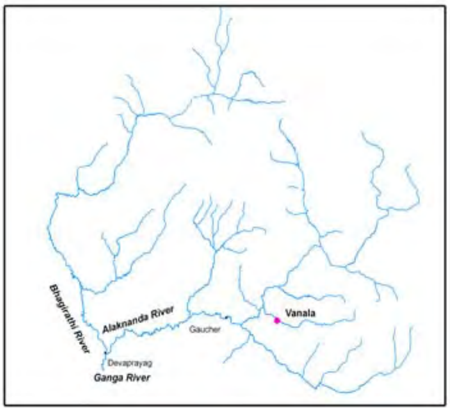
Location:	Jumagad
Tehsil:	Joshimath
District:	Chamoli
Developer:	UJVNL
Catchment area:	27 Km^2
Latitude:	30°40'0"
Longitude:	79°50'0"
River:	Dhauliganga
Tributary:	Jummagad
Up stream \Downstream HEP projects:	None
Diverted river length (M):	2000
Type:	ROR
Height of the Dam:	3.49
Volume content of Dam:	
FRL:	1143.9
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	1.2
Firm Power Capacity:	
Annual Power generation (MU):	10.593
Status:	Commissioned

RAJWAKTI HYDRO-ELECTRIC PROJECT.



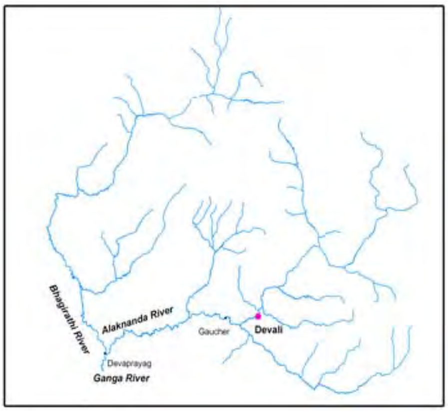
Location:	Rajwakti village
Tehsil:	Ghat
District:	Chamoli
Developer:	Him Urja Private Limited
Catchment area:	545 Km^2
Latitude:	30°18'25"
Longitude:	79°21'0"
River:	Alaknanda
Tributary:	Nandakini
Up stream \Downstream HEP projects:	Vanala / Devali HEP
Diverted river length (M):	2500
Type:	ROR
Height of the Dam:	6.5
Volume content of Dam:	
FRL:	991
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	3.6
Firm Power Capacity:	
Annual Power generation (MU):	27.68
Status:	Commissioned

VANALA HYDRO-ELECTRIC PROJECT.



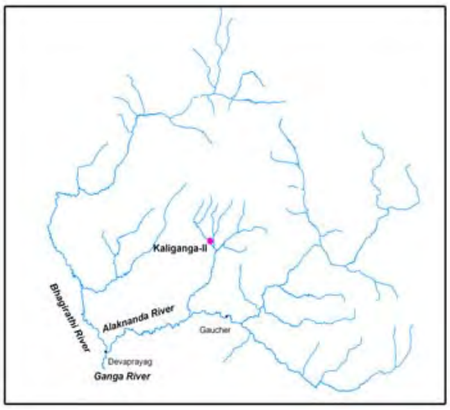
Location:	Vanala village
Tehsil:	Ghat
District:	Chamoli
Developer:	Him Urja Private Limited
Catchment area:	418 Km^2
Latitude:	30°16’0”
Longitude:	79°25’0”
River:	Alaknanda
Tributary:	Nandakini
Up stream \Downstream HEP projects:	Rajwakti HEP (D)
Diverted river length (M):	6500
Type:	ROR
Height of the Dam:	6.2
Volume content of Dam:	
FRL:	1202.5
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	15
Firm Power Capacity:	
Annual Power generation (MU):	81.104
Status: Commissioned	

DEVALI HYDRO-ELECTRIC PROJECT.



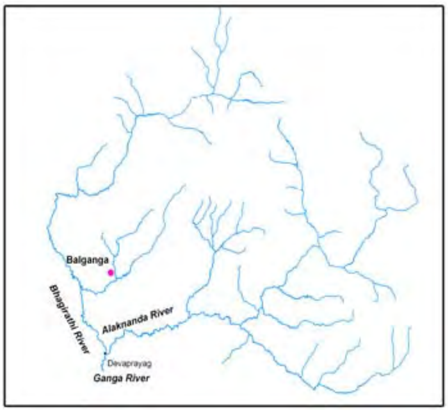
Location:	Vanala village
Tehsil:	Ghat
District:	Chamoli
Developer:	Him Urja Private Limited
Catchment area:	497.5 Km^2
Latitude:	30°18’0”
Longitude:	79°20’0”
River:	Alaknanda
Tributary:	Nandakini
Up stream \Downstream HEP projects:	Rajwakti HEP (U)
Diverted river length (M):	10500
Type:	ROR
Height of the Dam:	6
Volume content of Dam:	
FRL:	939
Head race Tunnel Type Length:	
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	13
Firm Power Capacity:	
Annual Power generation (MU):	69.9
Status:	Under the other stage of development.

KALIGANGA-II HYDRO-ELECTRIC PROJECT.



Location:	Near Jaitala village
Tehsil:	Okhimath
District:	Rudryaprayag
Longitude:	79°5’ 10’’E
Latitude:	30°36’ 40’’N
Catchment area:	182 km^2
Developer:	UJVNL
River:	Kali ganga
Tributary of:	Mandakini
Up stream \Downstream HEP projects:	----/Kali ganga II
Diverted river length:	3000
Type:	Run of the River
Height/ length of the Dam/ Barrage:	6.48
Full Reservoir level (FRL):	1487
Head Race Tunnel:	400 m
Power House:	Surface
Installed Capacity:	6 mw
Annual generation:	40 MU
Status:	Under various stages of development

BALGANGA-II HYDRO-ELECTRIC PROJECT.

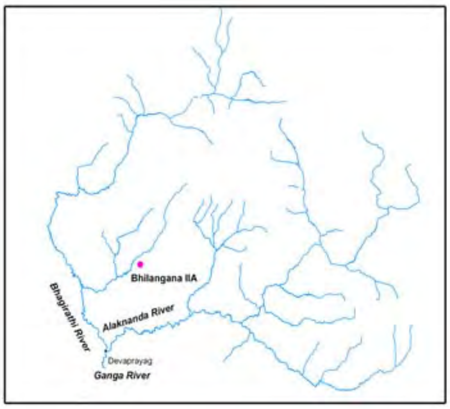


Location:	Vanala village
Tehsil:	Ghansali
District:	Tehri
Developer:	UJVNL
Catchment area (Km^2):	395
Latitude:	30°29’0”
Longitude:	78°37’30”
River:	Bhagirathi
Tributary:	Balganga
Up stream \Downstream HEP projects:	Balganga HEP (U)
Diverted river length (M):	3250
Type:	ROR
Height of the Dam:	5
Volume content of Dam:	
FRL:	1145
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	7
Firm Power Capacity:	
Annual Power generation (MU):	29.98

Status: Under the other stage of development.

BHILANGANA- II A HYDRO-ELECTRIC PROJECT.

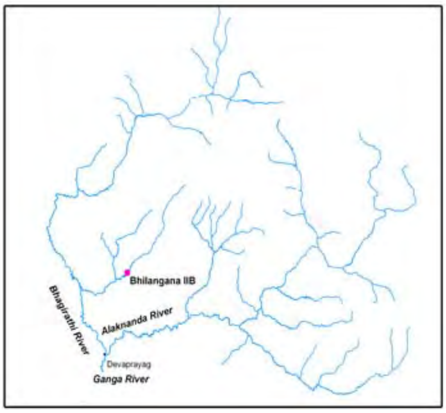
Location:	On the way Budhakedar temple.
Tehsil:	Ghansali
District:	Tehri
Developer:	UJVNL
Catchment area:	457 Km^2
Latitude:	30°31'37"
Longitude:	78°44'52"
River:	Bhagirathi
Tributary:	Bhilangana
Up stream \Downstream HEP projects:	Bhilangana III / Bhilangana II B
Diverted river length (M):	5000
Type:	ROR
Height of the Dam:	9
Volume content of Dam:	
FRL:	1660
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	24
Firm Power Capacity:	
Annual Power generation (MU):	149.56



Status: Under the other stage of development.

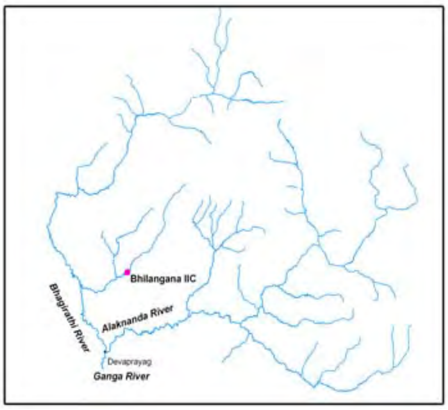
BHILANGANA- II B HEP

Location:	Near Bhilangana II A HEP.
Tehsil:	Ghansali
District:	Tehri
Developer:	UJVNL
Catchment area:	562.3
Latitude:	30°29'30"
Longitude:	78°43'15"
River:	Bhagirathi
Tributary:	Bhilangana
Up stream \Downstream HEP projects:	Bhilangana II A / Bhilangana II C
Diverted river length (M):	4500
Type:	ROR
Height of the Dam:	5
Volume content of Dam:	
FRL:	1410
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	24
Firm Power Capacity:	
Annual Power generation (MU):	163.31



Status: Under the other stage of development.

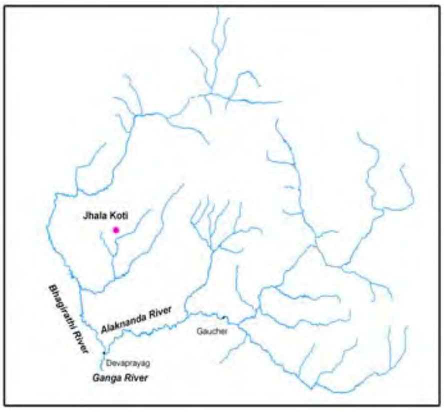
BHILANGANA- II C HYDRO-ELECTRIC PROJECT



Location:	Near Bhilangana II B HEP
Tehsil:	Ghansali
District:	Tehri
Developer:	UJVNL
Catchment area:	570 Km^2
Latitude:	30°23'24"
Longitude:	78°36'36"
River:	Bhagirathi
Tributary:	Bhilangana
Up stream \Downstream HEP projects:	Bhilangana II B / Bhilangana
Diverted river length (M):	6500
Type:	ROR
Height of the Dam:	3.5
Volume content of Dam:	
FRL:	1248.5
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Nubmer and type:	
Power House Size:	
Installed Capacity (MW):	21
Firm Power Capacity:	
Annual Power generation (MU):	149.42

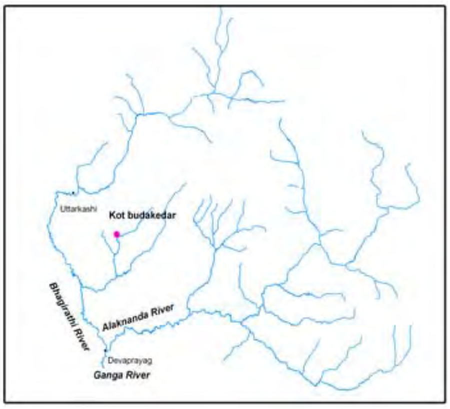
Status: Under the other stage of development.

JHALAKOTI HYDRO-ELECTRIC PROJECT.



Location:	Jhalakoti
Tehsil:	Ghansali
District:	Tehri
Developer:	Gunsola Hydro Power Generation Pvt. Ltd.
Catchment area:	105 Km^2
Latitude:	30°38'53"
Longitude:	78°38'10"
River:	Bhagirathi
Tributary:	Balganga
Up stream \Downstream HEP projects:	Agunda Thati (D)
Diverted river length (M):	4750
Type:	ROR
Height of the Dam:	2.2
Volume content of Dam:	
FRL:	1724.2
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock:	Number and type
Power House Size:	
Installed Capacity (MW):	12.5
Firm Power Capacity:	
Annual Power generation (MU):	59.8
Status:	Under the other stage of development.

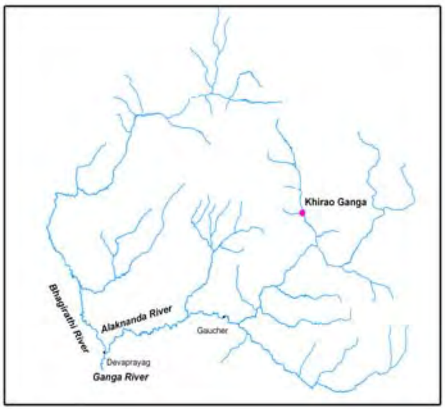
KOT BUDHA KEDAR HYDRO-ELECTRIC PROJECT.



Location:	Bhudha Kedar
Tehsil:	Ghansali
District:	Tehri
Developer:	Gunsola Hydro Power Generation Pvt. Ltd.
Catchment area:	135 Km^2
Latitude:	30°35’13”
Longitude:	78°38’3”
River:	Bhagirathi
Tributary:	Balganga
Up stream \Downstream HEP projects:	Agunda Thati (U)
Diverted river length (M):	4750
Type:	ROR
Height of the Dam:	1
Volume content of Dam:	
FRL:	1577
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Number and type:	
Power House Size:	
Installed Capacity (MW):	6
Firm Power Capacity:	
Annual Power generation (MU):	51.8

Status: Under the other stage of development.

KHIROGANGA HYDRO-ELECTRIC PROJECT.



Location:	Khiron valley
Tehsil:	Joshimath
District:	Chamoli
Developer:	Super Hydro Pvt. Ltd
Catchment area:	145 Km^2
Latitude:	30°41’2.5”
Longitude:	79°29’27”
River:	Alaknanda
Tributary:	Khironganga
Up stream \Downstream HEP projects:	Alaknanda HEP ?
Diverted river length (M):	2750
Type:	ROR
Height of the Dam:	4
Volume content of Dam	
FRL:	2451
Head race Tunnel Type:	Length
Tail Race-Length:	
Penstock- Number and type:	
Power House Size:	
Installed Capacity (MW) - 4	
Firm Power Capacity:	
Annual Power generation (MU) - 19.4	
Status:	Under the other stage of development.

Criteria adopted for developing impact matrix.

	Impact Receptors	RET species	Endemic species	IWPA species	Medicinal Species	Habitat Diversity	Breeding/ Congregation sites	Migratory Sites
Impact Sources								
River Length Affected								
Forest Area loss								

Appendix 5.1

Checklist of plant species found in the Alaknand and Bhagirathi basins

Trees Species recorded in the two basins

S.No.	Name of the Species	Vernacular Name	Ethnobotanical Notes	References
1.	*Abies pindrow* Royle	Raga	M,Ed, Tm, Fl	GMR HE Project Report
2.	*Acacia arabica* (Lam). Willd.	Khair	M , Fd	Kotlibhel EIA Report
3.	*Acacia catechu* (L.F.) Wild.	Khair	M,Fl	Kotlibhel EIA Report, Gangwar *et al.*2011
4.	*Acacia nilotica* L.	Babool	Tm, Fl	Gangwar *et al.* 2011
5.	*Acacia farnesiana* (L.) Willd.)	Vilayati Kikar	Fl, M, Api, Ag.	Kotlibhel EIA Report
6.	*Acer caesium* Wall. ex Brandis		Fd, Fl	Uniyal *et al.* 2002
7.	*Adina cordifolia* Roxb.	Haldu	M	Kotlibhel EIA Report
8.	*Aegle marmelos* L.	Bel	Ed, M , Api	Kotlibhel EIA Report
9.	*Albizia chinensis* (Osb.) Merr.	Siris	Ag.	Gangwar *et al.*2011
10.	*Albizia julibrissin* Durazz.	Bhondir	Tm	Gangwar *et al.*2011
11.	*Albizia lebbek* (L.) Benth.	Siris	M, Fl, Fd	Kotlibhel EIA Report
12.	*Albizia procera* (Roxb.) Benth.	Safed siris	Tm	Gangwar *et al.*2011
13.	*Alnus nepalensis* D. Don	Utis	M, Fl	Gangwar *et al.*2011
14.	*Anogeisus latifolia* (Roxb. ex DC.)	Dhauda	Tm, Ag.	Kotlibhel EIA Report
15.	*Aesculus indica* L.	Pangar	M	Phondani *et al.* 2009
16.	*Azadirachta indica* A.Juss.	Neem	M, Tm	Gangwar *et al.*2011
17.	*Bauhinia purpurea* L.	Guiral	Ed, M , Dye	Kotlibhel EIA Report
18.	*Bauhinia racemosa* Lam.	Jhanjhora	Fl	Gangwar *et al.*2011
19.	*Bauhinia variegata* L.	Kachnar	M, Fd, Fl	Kotlibhel EIA Report
20.	*Betula utilis* D.Don	Bhojpatra	M	Phondani *et al.* 2009
21.	*Boehmeria rugulosa*	Genthi	Fd, M	Kotlibhel EIA Report

	Wedd.			
22.	*Bombex ceiba* L.	Semal	M , Ed	Kotlibhel EIA Report
23.	*Butea monosperma* (Lam.) Kuntze.	Dhak	Fd, M	Kotlibhel EIA Report
24.	*Carica papaya* L.	Papeeta	M	Phondani *et al.* 2009
25.	*Cassia fistula* L.	Amaltas	M, Fd, Fl	Kotlibhel EIA Report
26.	*Cedrus deodara* (Roxb.ex D.Don) G.Don	Deodar	M, Tm	Phondani *et al.* 2009
27.	*Celtis australis* L.	Kharik	Fl, Tm, Fd	Kotlibhel EIA Report
28.	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Kagji Nimbu	M	Phondani *et al.* 2009
29.	*Dalbergia sissoo* L.	Shisham	M, Fd, Fl	Kotlibhel EIA Report
30.	*Delonix regia* Boj.	Gulmohar	Fd, Fl	Kotlibhel EIA Report
31.	*Dyospyros montana* Roxb.	NA	M, Ag.	Kotlibhel EIA Report
32.	*Erythrina variegata* L.	Dhaul Dhak	M	Kotlibhel EIA Report
33.	*Eucalyptus camaldulensis* Dehnh.	Safeda	M, Fl, Fd	Kotlibhel EIA Report
34.	*Ougenia oojeinensis* Benth.	Sandan	M, Tm, Fl, Fd	Kotlibhel EIA Report
35.	*Ficus hispida* L.f.	Gobla	Fd	Gangwar *et al.*2011
36.	*Ficus palmata* Forsk.	Bedu	M, Fd,Ed	Kotlibhel EIA Report
37.	*Ficus racemosa* L.	Gular	Fd	Gangwar *et al.*2011
38.	*Ficus religiosa* L.	Peepal	M, Fd, Fl	Kotlibhel EIA Report
39.	*Ficus roxburgii* Wall.	Timal	Tm	Gangwar *et al.*2011
40.	*Ficus semicordata* Buch -Ham. ex Smith	Khina	M, Fd,Fb, Ed	Kotlibhel EIA Report
41.	*Ficus benghalensis* L.	Bargad	M, Fd	Kotlibhel EIA Report
42.	*Grevillea robusta* A. Cunn.	Silver aak	Tm	Gangwar *et al.*2011
43.	*Grewia optiva* Drummond ex Burret	Bheemal	M, Fb, Fd, Ed	Kotlibhel EIA Report
44.	*Hippophae rhamnoides* L.	NA	M	GMR HE Project Report
45.	*Hippophae salicifolia* D.Don	Amesh	M	Phondani *et al.* 2009

46.	*Jacaranda mimosifolia* D.Don	Padeli		Kotlibhel EIA Report
47.	*Juglans regia* L.	Akhrot	M,Fd.	Phondani *et al.* 2009, Uniyal *et al.* 2002
48.	*Kydia calycina* Roxb.	Pula	M, Fl, Fb	Uniyal *et al.* 2002
49.	*Lagerstroemia parviflora* Rox.	Dhaudi	Tm	Gangwar *et al.*2011
50.	*Lannea coromandelica* (D.Don) Houttuym	Kalmina	Tn,Fl,Fd	Kotlibhel EIA Report
51.	*Leucaena leucocephala* (Lam.) Wit.	Subabul	Sc.	Kotlibhel EIA Report
52.	*Lyonia ovalifolia* Wall.	Anyar	M	Uniyal *et al.* 2002
53.	*Mallotus phillipensis* (Lam.) Muell-Arg.	Ruina	Ml, Fl, Api, Dy, Rit.	Kotlibhel EIA Report, Uniyal *et al.* 2002
54.	*Mangifera indica* L.	Aam	Ed, Tm, M	Kotlibhel EIA Report
55.	*Melia azedarach* L.	Daikan	Fd, Ag, M	Kotlibhel EIA Report, Uniyal *et al.* 2002
56.	*Moringa oleifera* Lamk.	Sunara	Ed, M	Kotlibhel EIA Report
57.	*Morus alba* L.	Tatri	Ed, Fl	Gangwar *et al.*2011
58.	*Myrica esculenta* Buch-Ham ex D.Don	Kafal	M,Ed, Fd,	Phondani *et al.* 2009, Uniyal *et al.* 2002
59.	*Phoenix humilis* Royle	Khajoor	Fb, Ed	Kotlibhel EIA Report
60.	*Phyllanthus emblica* L.	Anowla	M,Ed, Fd,	Phondani *et al.* 2009
61.	*Picea smithiana* (Wall.) Boiss.	Roi	Fl	Gangwar *et al.*2011
62.	*Pinus roxburghii* Sargent	Chir	Tm, M, Fl.	Kotlibhel EIA Report, Uniyal *et al.* 2002
63.	*Pinus wallichiana* Jacks.	Kail	M,Fl	Phondani *et al.* 2009, Uniyal *et al.* 2002
64.	*Pistacia integrerrima* Stewart ex Brandis	Kaker singhee	M	Phondani *et al.* 2009
65.	*Populus ciliata* Wall. ex Royle.	Ban Pipal	M,Fd.Tm	GMR HE Project Report, Uniyal *et al.* 2002
66.	*Premna barbata* Wall. ex Schauer	NA	Fd, M, Fl	Kotlibhel EIA Report

67.	*Prunus cerasoides* D Don	Paiyan	M, Rit.	Kotlibhel EIA Report
68.	*Prunus persica* (L.) Batsch	Aaru	M, Ed, Fd	Phondani *et al.* 2009
69.	*Psidium guajava* L.	Amrood	Ed	Kotlibhel EIA Report
70.	*Punica granatum* L.	Darim	Ed, M	Gangwar *et al.*2011
71.	*Pyrus pashia* Buch - Ham ex D.Don	Melu	Fd, Sc, Ed, M, Api.	Kotlibhel EIA Report, Uniyal *et al.* 2002
72.	*Quercus leucotricophora* A.	Banj	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
73.	*Quercus semecarpifolia* Sm.		Fd, Fl	Uniyal *et al.* 2002
74.	*Rhamnus virgatus* Roxb.	Cholu	M	Phondani *et al.* 2009
75.	*Rhododendron arboreum* Sm.	Burans	M, Ed, Fl	Uniyal *et al.* 2002
76.	*Rhus wallichii* Hook. f.		Fl	Uniyal *et al.* 2002
77.	*Salix disperma* Roxb. ex D.Don	Jalmala, laila	M	GMR HE Project Report
78.	*Sapindus mukorossi* Gaertner	Reetha	M.	Kotlibhel EIA Report
79.	*Spondias pinnata* (L.f.) Kurz.	Amra	M, Ed,Fl.	Phondani *et al.* 2009
80.	*Syzygium cumini* (L.) Skeels	Jamun	Ed, Tm, M, Dy, Tm	Kotlibhel EIA Report
81.	*Taxus baccata* (L.)	Thuner	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
82.	*Terminalia alata* Heyne ex Roth	Sain	Tm	Gangwar *et al.* 2011
83.	*Terminalia arjuna* Roxb. Ex. Dc.	Arjuna	M	Phondani *et al.* 2009
84.	*Terminalia bellerica* Roxb.	Bahera	M	Phondani *et al.* 2009
85.	*Terminalia chebula* Retzr.	Haira	M	Phondani *et al.* 2009
86.	*Toona ciliata* (Wall. ex Roxb.) Rom.	Pahari - Tun	Tm, Dy, Api, Soc, Fl	Kotlibhel EIA Report
87.	*Wrightia tomentosa* Roem.	Dudhali	Tm	Gangwar *et al.* 2011

Shrub and undershrub species recorded in the two basins

S.No.	Name of the Species	Vernacular Name	Ethnobotanical Notes	References
1.	*Abutilon indicum* L	Kanghi	M, Fl	Gangwar *et al.* 2011
2.	*Adhatoda zeylanica* Medikus	Baisingu	M, Ed	Gangwar *et al.* 2011, Uniyal *et al.* 2002
3.	*Aerva sanguinolenta* (L.) Blume	Safedphulia	M, Ed	Kotlibhel EIA Report.
4.	*Agave americana* L.	Ram Baans	Fb, M, Sc	Kotlibhel EIA Report, Gangwar *et al.* 2011
5.	*Ardisia solanacea* Roxb.	Bhatmal	M	Gangwar *et al.* 2011
6.	*Artemisia nilagirica* (C.B.Clarke) Pamp.	Kunja	M	Uniyal *et al.* 2002
7.	*Artemisia roxburghiana* Wall. ex Besser	Kunja	M, Rit	Kotlibhel EIA Report
8.	*Asparagus officinalis* L.	Satavar	M	NHPC Pipalkoti HE project, Uniyal *et al.* 2002
9.	*Asparagus adscendens* Buch - Ham. ex Roxb.	Jhimi	Ed, M	Kotlibhel EIA Report
10.	*Barleria cristata* L.	Saundi	M, Sc.	Kotlibhel EIA Report, Uniyal *et al.* 2002
11.	*Berberis aristata* DC.	Chatru	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
12.	*Berberis asiatica* DC.	Kirmod	M	Kotlibhel EIA Report, Uniyal *et al.* 2002
13.	*Berberis lycium* Royle	Kirmor	M, Sc, Ed.	Kotlibhel EIA Report, Uniyal *et al.* 2002
14.	*Bergenia ciliata* (Haw.) Strnb.	Pathar chata, Pashan bhed	M	Uniyal *et al.* 2002
15.	*Brugmansia suaveolens* (Humb. & Bonpl. Ex Willd.) Berch. & Presl.	NA	M.	Kotlibhel EIA Report
16.	*Buddleja asiatica* Lours.	Bhati	M.	Kotlibhel EIA Report, Gangwar *et al.* 2011
17.	*Buddleja paniculata* Wall.	Sendroi	Fl	Gangwar *et al.* 2011
18.	*Cajanus mollis* (Benth.) Maess.	ban sem	Fd,Sc	Kotlibhel EIA Report
19.	*Calicarpa macrophylla Vahl.*	Daya	M	NHPC Pipalkoti HE project, Uniyal *et al.* 2002
20.	*Calotropis procera* (Air.) R.Br	Aak	M	Gangwar *et al.* 2011

21.	*Calotropis gigantea* (L.) Dryander	Mudar	M	Gangwar *et al.* 2011
22.	*Cannabis sativa* L.	Bhang	M, Fb, Ed	Kotlibhel EIA Report, Uniyal *et al.* 2002
23.	*Carissa opaca* Stapf. ex Haines	Karonda	Fd, Sc	Kotlibhel EIA Report
24.	*Caryopteris odorata* (D.Don) Robinson	NA		Kotlibhel EIA Report
25.	*Cassia tora* L.	Chakunda	M.	Kotlibhel EIA Report
26.	*Cestrum nocturnum* L.	Rat ki rani	M.Api	Kotlibhel EIA Report
27.	*Cinnamomum tamala* Nees	Tejpat	M	NHPC Pipalkoti HE project
28.	*Clerodendrom viscosum* Vent.	Bhant	M.	Gangwar *et al.* 2011
29.	*Clerodendrom serratum* Spreng	Banbahri	M.	Gangwar *et al.* 2011
30.	*Clematis gouriana* Roxb. ex DC.	NA	M, Api.	Kotlibhel EIA Report, Uniyal *et al.* 2002
31.	*Colebrookia oppositifolia* Smith	Binda	M, Sc.	Kotlibhel EIA Report
32.	*Cotoneaster microphyllus* Wall. ex Lindl.	NA	M	GMR HE Project Report
33.	*Debregeasia longifolia* (Burm. f.) Wedd.	Syanru	Fd, Fb, M	Kotlibhel EIA Report
34.	*Desmodium gangeticum* (L.) DC.	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
35.	*Desmodium velutinum* (Willd.) DC.	NA	Fi, M, Sc	Kotlibhel EIA Report
36.	*Desmodium laxiflorum* DC.	NA	M,Fd	Kotlibhel EIA Report, Uniyal *et al.* 2002
37.	*Dodonaea angustifolia* L.f.	Sinatha		Kotlibhel EIA Report
38.	*Elsholtzia fruticosa* (D.Don) Rehder	Pothi	M	GMR HE Project Report
39.	*Embelia robusta* Roxb.	Gaia	M	Gangwar *et al.* 2011
40.	*Ephedra gerardiana* Wall. ex Stapf.	Som lata	M	GMR HE project Area
41.	*Eupatorium perfoliatum* L.	Bashya	M	Phondani *et al.* 2009
42.	*Eupatorium adenophorum* Sprengel	Kharnabakura	Fd,M	Kotlibhel EIA Report, Uniyal *et al.* 2002
43.	*Euphorbia royleana* Boissier	Sulla	M, Sc.	Kotlibhel EIA Report
44.	*Ficus sarmentosa* Buch - Ham. ex Smith.	NA	Fd, Ed.	Kotlibhel EIA Report

45.	*Flacourtia indica* (Burm.f.) Merrill.	NA	Fd, Ed, M.	Kotlibhel EIA Report
46.	*Gerardinia diversifolia* (Link) Friis	Bichchhu	M.	Gangwar *et al.* 2011
47.	*Helictreres isora* L.	Bhendu	Fb, M	Kotlibhel EIA Report
48.	*Holmskioldia sanguinea* Retz.	NA	M	Kotlibhel EIA Report
49.	*Indigofera astragalina* DC.	Sakina	M, F.	Kotlibhel EIA Report
50.	*Jatropha curcas* L.	Pahari Arand	Fl, M.	Kotlibhel EIA Report, Gangwar *et al.* 2011
51.	*Juniperus communis* L.	Junipers	M	GMR HE Project Report, Uniyal *et al.* 2002
52.	*Juniperus indica* Bertol.	Dhupi	M	GMR HE project Area
53.	*Juniperus squamata* Buch.-Ham. ex D. Don	Thelu	Fl	Gangwar *et al.* 2011
54.	*Lagerostroemia indica* L.	Dhatura		Kotlibhel EIA Report
55.	*Lantana camara* L.	Kuri - ghas	Fl, M, Sc.	Kotlibhel EIA Report
56.	*Leea aspera* M. Laws.	Kunwai	M.	Gangwar *et al.* 2011
57.	*Mimosa himalayana* Gamble	Alay	M	Gangwar *et al.* 2011
58.	*Murraya koenigii*. (L.) Sprengel.	Kadi patta	M	Kotlibhel EIA Report
59.	*Nerium oleander* L.	Kaner		Kotlibhel EIA Report
60.	*Opuntia elatior* Miller	Nagfani	Ed	Kotlibhel EIA Report
61.	*Pelargonium graveolense* L.Herit.	Geranium	M.	NHPC Pipalkoti HE project
62.	*Plumbago zeylanica* L.	Chitrak	M.	Kotlibhel EIA Report
63.	*Phoenix sylvestris* Roxb.	Khajur	M.	Gangwar *et al.* 2011
64.	*Pogostemon benghalense* (Burm.f.) Kuntze	NA	Api	Kotlibhel EIA Report
65.	*Prinsepia utilis* Royle.	Bhekal	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
66.	*Pteracanthus angustifrons* (Clarke) Bremek.	Pathora	M.	Kotlibhel EIA Report
67.	*Pupalia lappacea* (L.) Juss.	Nagdaminee	M	Kotlibhel EIA Report
68.	*Rauwolfia serpentina* (L.) Benth.	Sarpgandha	M	Gangwar *et al.* 2011
69.	*Pyracantha crenulata* (D. Don) M. Roemer	Ghangharu	M	Gangwar *et al.* 2011

70.	*Rhamnus virgatus* Roxb.	Chentuli		Kotlibhel EIA Report
71.	*Rhododendron anthopogon* D.Don	Awon	M	Phondani *et al.* 2009
72.	*Rhododendron campanulatum* D.Don	Simru	M	GMR HE Project Report
73.	*Rhus parviflora* Roxb.	Tungla	Ed, Fl, M.	Kotlibhel EIA Report, Uniyal *et al.* 2002
74.	*Ricinus communis* L.	Arandi	M, Sc.	Kotlibhel EIA Report
75.	*Rosa moschata* Herm.	Kunj pani	M	GMR HE Project Report
76.	*Rosa sinensis* L.	Gulab	M	Phondani *et al.* 2009
77.				
78.	*Roylea cinerea* (D.Don) Baillon.	Karui	Ed	Kotlibhel EIA Report
79.	*Rubus ellipticus* Smith.	Hinsalu	M, Sc.	Kotlibhel EIA Report
80.	*Rubus foliolosus* D.Don	Kala hisar	Ed	Kotlibhel EIA Report
81.	*Rubus niveus* Thunb.	Bhera	M	Gangwar *et al.* 2011
82.	*Salix denticulata* Anderss.	bashal,chhoti bashroi	Fl,Fd	GMR HE Project Report
83.	*Scurrula cordifolia* (Wallich) G.Don	NA		Kotlibhel EIA Report
84.	*Sida cardifolia* L.	Balu	Fb, M.	Kotlibhel EIA Report
85.	*Skimmia laureola* (DC.) Seibold & Zucc. Ex walp.	Nairpat	Fd,Ed, M	GMR HE Project Report, Uniyal *et al.* 2002
86.	Solanum anguivi L.	Barhanta	M,	Gangwar *et al.* 2011
87.	*Solanum indicum* L.	Bhut-Kataia	M.	Gangwar *et al.* 2011
88.	*Solanum surratense* Burm. f.	Kantakari	M.	Gangwar *et al.* 2011
89.	*Solanum virginianum* L.		M.	Gangwar *et al.* 2011
90.	*Sorbia tomentosa* (Lindl.) Rehder.	Bakhree jhar	M,Fd	GMR HE Project Report
91.	*Tamarix dioica* Roxb.ex Roth.	NA		Kotlibhel EIA Report
92.	*Tephrosia candida* (Roxb.)DC.	Ban tor	Fd.	Kotlibhel EIA Report
93.	*Thespesia lampas* Dalz. & Gibs.	Ban kapasi	Fl	Gangwar *et al.* 2011
94.	*Thymus linearis* Benth.	Ban ajwain	M	NHPC Pipalkoti HE project

95.	*Urtica dioica* L.	Kandali	Fb, M.	Kotlibhel EIA Report
96.	*Viburnum cotonifolium* D. Don	Bhatyanu	M.	Gangwar *et al.* 2011
97.	*Viburnum grandiflorum* wall. ex DC.	Thallana	Fl	GMR HE Project Report
98.	*Vitex negundo* L.	NA		Kotlibhel EIA Report
99.	*Woodfordia fruticosa* (L.) Kurz	Dhola	M, Dy, Sc.	Kotlibhel EIA Report, Uniyal *et al.* 2002
100.	*Xanthium indicum* Koening.	Kuru		Kotlibhel EIA Report
101.	*Zanthoxylum armatum* DC.	Timru	M, Rit.	Phondani *et al.* 2009, Uniyal *et al.* 2002
102.	*Zizyphus oenoplia* (Linn.)Mill	Makoy	M, Fl	Gangwar *et al.* 2011
103.	*Ziziphus mauritiana* Lamk.	Ber	M, Ed.	Kotlibhel EIA Report, Uniyal *et al.* 2002
104.	*Zizyphus nummularia* (Burm. f.) W. & A.	Jharber	Fl, Fd	Gangwar *et al.* 2011
105.	*Zizyphus oxyphylla* Edgew.		M.	

Herbaceous plants and grasses recorded in the two basins

S.No.	Name of the Species	Vernacular Name	Ethnobotanical Notes	References
1.	*Aconitum heterophyllum* Wall.	Atis	M	Phondani *et al.* 2009
2.	*Achyranthes aspera* L.	NA	M.	Kotlibhel EIA Report
3.	*Aconitum balfourii* Stapf.	Mithabish	M	Phondani *et al.* 2009
4.	*Acorus calamus* L.	Bach	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
5.	*Aerva lanata* (L.) Juss. Ex Schult.	Chaya	Fd	Gangwar *et al.* 2011
6.	*Ageratum conyzoides* L.	Kansura	M	Kotlibhel EIA Report
7.	*Ageratum houstonianum* Mill.	Gundhry	M	Kotlibhel EIA Report
8.	*Ajuga bracteosa* Wall. ex Benth.	Neelkanthi	M	Kotlibhel EIA Report, Uniyal *et al.* 2002
9.	*Ajuga macrosperma* Wall. ex Benth.	NA	M	Kotlibhel EIA Report
10.	*Allium ampeloprasum* L.	Lahsun jangli	M	NHPC Pipalkoti HE project
11.	*Allium humile* Kunth	Jamu faran	M	Phondani *et al.* 2009
12.	*Alternanthera sessilis* (L.) R.Br. ex DC	Gudrisag	M.	Gangwar *et al.* 2011
13.	*Aloe barbadensis* Mill.	Ghritkumari	M	NHPC Pipalkoti HE project
14.	*Aloe vera* (L.) Burm. f.	NA	M.	Kotlibhel EIA Report
15.	*Alternanthera pungens* Homb, Bonpl & Kunth	NA		Kotlibhel EIA Report
16.	*Alternanthera pungens* Humb.	NA		Kotlibhel EIA Report
17.	*Alysicarpus vaginalis* (L.) DC.	NA		Kotlibhel EIA Report
18.	*Amaranthus spinosus* Linn.	Kanta-Chaulai	M.	Gangwar *et al.* 2011

19.	*Amaranthus viridis* L.	NA	M.	Kotlibhel EIA Report, Uniyal *et al.* 2002
20.	*Ammi majus* L.	Visnasa	M	NHPC Pipalkoti HE project
21.	*Anagallis arvensis* L.	NA		Kotlibhel EIA Report
22.	*Anaphalis triplinervis* (Sims.) Clarke.	Bugla	Sc.	GMR HE Project report, Uniyal *et al.* 2002
23.	*Anaphalis adnata* Wall. ex. DC.	NA		Kotlibhel EIA Report
24.	*Androsace sarmentosa* Wall.	Rock jasmine	M	GMR HE Project report.
25.	*Androsace umbellata* (Lour.) Merrill	NA	Api	Kotlibhel EIA Report
26.	*Angelica glauca* Edgew.	Choru	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
27.	*Anisomeles indica* (L.) Kuntze	Goplya	M.	Gangwar *et al.* 2011
28.	*Apluda mutica* L.	NA	Fd.	Kotlibhel EIA Report, Uniyal *et al.* 2002
29.	*Arenaria serpyllifolia* L.	NA		Kotlibhel EIA Report
30.	*Argemone ochroleuca* Sweet	NA	M	Kotlibhel EIA Report
31.	*Argemone mexicana* L.	Pili kateli	M.	Kotlibhel EIA Report
32.	*Arisaema tortousom* (Wall.) Schott	NA		Kotlibhel EIA Report
33.	*Arnebia benthami* (Wall ex D.Don) Jhonston.	Balchari	M	Phondani *et al.* 2009
34.	*Artemisia nilagarica* (Clarke) Pamp.	Pati	M.	NHPC Pipalkoti HE project, Uniyal *et al.* 2002
35.	*Artemisia capillaris* Thunb.	Marwa jhirun	M.	Kotlibhel EIA Report
36.	*Arthraxon hispidus* (Thunb.) Makino.	NA	M	GMR HE Project report.

37.	*Arundinella nepalensis* Trinius	NA	Fd	Kotlibhel EIA Report
38.	*Aster peduncularis* Wallich ex Nees	Phulyan	M	Kotlibhel EIA Report
39.	*Avena fatua* L.	Jawatu	Fd.	Kotlibhel EIA Report
40.	*Baliospermum montanum* (Wild.) Muell.-Arg.	NA	M	Kotlibhel EIA Report
41.	*Barleria prionitis* L.	Peela-bansa	M.	Gangwar *et al.* 2011
42.	*Bergenia ciliata* (Haw.) Sternb.	Silphori	M.	Phondani *et al.* 2009
43.	*Bidens pilosa* L.	Kumur	M.	Kotlibhel EIA Report, Uniyal *et al.* 2002
44.	*Bidens biternata* (Lour.) Merrill & Sherff	Kura	M.	Kotlibhel EIA Report
45.	*Blumea lacera* (Burm. F.) DC	Kukronda	M.	Gangwar *et al.* 2011
46.	*Boerhavia diffusa* L.	NA	M	Kotlibhel EIA Report
47.	*Brachiaria ramosa* (L)	NA	Fd.	Kotlibhel EIA Report
48.	*Brachypodium sylvaticum* (Huds.) P. Beaur.	NA	Fd	GMR HE prject report
49.	*Brassica rapa* L.	NA		Kotlibhel EIA Report
50.	*Bupleuram falcatum* L.	NA	M.	Kotlibhel EIA Report
51.	*Calamagrostis emodensis* Griseb.	NA	M	GMR HE project Report.
52.	*Calendula arvensis* L.	Calendula	M	NHPC Pipalkoti HE project
53.	*Callicarpa macrophylla* Vahl.	NA		Kotlibhel EIA Report
54.	*Campanula alsinoides* Hook.f. & Thomsan	Bell flower	Ed.	GMR HE Project report.
55.	*Canabis sativa* L.	Bhang	M	Phondani *et al.* 2009
56.	*Capsella bursa-pastoris* (L.) Medikus	NA		Kotlibhel EIA Report, Uniyal *et*

				al. 2002
57.	*Capsicum annuum* L.	Mirch	M	Phondani *et al.* 2009
58.	*Cardiospermum helicacabum* L.	NA	M.	Kotlibhel EIA Report
59.	*Carex myosurus* Nees.	NA		Kotlibhel EIA Report
60.	*Carum carvi* L.	Kala jeera	M	Phondani *et al.* 2009
61.	*Cassia absus* L.	NA		Kotlibhel EIA Report
62.	*Cassia mimosoides* L.	NA		Kotlibhel EIA Report
63.	*Celosia argentea* L.	Gadrya	Ed; M	Kotlibhel EIA Report
64.	*Cassia occidentalis* Linn.	Chakunda	Fl	Gangwar *et al.* 2011
65.	*Centella asiatica* L.	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
66.	*Chenopodium ambrosioides* Linn.	Bathua	Ed, M	Gangwar *et al.* 2011
67.	*Chenopodium album* L.	Bhettu	Ed, M	Kotlibhel EIA Report, Uniyal *et al.* 2002
68.	*Chloris dolichostachya* Lagasca.	NA	Fl	Kotlibhel EIA Report
69.	*Chlorophytum tuberosum* (Roxb.) Baker.	Safed musli	M.	Phondani *et al.* 2009
70.	*Cirsium arvense* (L.) Scop.	Kardra	M.	Gangwar *et al.* 2011
71.	*Cirsium wallichii* DC	NA	M.	GMR HE Project report.
72.	*Cleome viscosa* Linn	Hurhur	M.	Gangwar *et al.* 2011
73.	*Colocasia elculenta* (L.) Schott.	NA	Ed.	Kotlibhel EIA Report
74.	*Commelina benghalensis* L.	Kansura	M.	Kotlibhel EIA Report
75.	*Conyza stricta* Willd.	NA		Kotlibhel EIA Report

76.	*Conyza japonica* (Thumb.) Lessing	NA	Ed.	Kotlibhel EIA Report
77.	*Cotula anthemoides* L.	NA		Kotlibhel EIA Report
78.	*Crepis mulitcaulis* Ledebour.	NA	M.	Kotlibhel EIA Report
79.	*Crotalaria medicaginea* Lam.	Van methi	M.	Kotlibhel EIA Report
80.	*Cucumis hardwickii* Royle.	Elaroo	M.	Phondani *et al.* 2009
81.	*Curculigo orchioides* Gaertn.	Kali musli	M.	NHPC Pipalkoti HE project
82.	*Cyathocline purpurea* (D.Don)	NA		Kotlibhel EIA Report
83.	*Cymbopogon citratratus* (D.C.) Stapf	Lemon grass	M.	NHPC Pipalkoti HE project
84.	*Cymbopogon winterianus* Jowitt.	Citronela grass	M.	NHPC Pipalkoti HE project
85.	*Cymbopogon martini* (Roxb.) Wat.	Mirchya ghas	M.	Phondani *et al.* 2009
86.	*Cynodon dactylon* (L.) Persoon	Doob		Kotlibhel EIA Report, Uniyal *et al.* 2002
87.	*Cynoglossum glochidiatum* Wall. ex Benth	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
88.	*Cyperus corymbosus* Rottboell	NA		Kotlibhel EIA Report
89.	*Cyperus niveus* Retz.	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
90.	*Cyperus rotundu*s Linn.	Motha	M	Gangwar *et al.* 2011
91.	*Cyperus compressus* L.	NA		Kotlibhel EIA Report
92.	*Datura stramonium* L.	NA		Kotlibhel EIA Report
93.	*Dactylorhizia hatagirea* D.Don	Hatajari	M.	Phondani *et al.* 2009
94.	*Delphinium denudatum* Wall. ex Hook. F.	Nirbisi	M.	GMR HE project Area, Uniyal *et al.*

				2002
95.	*Desmodium triflorum* (L.) DC.	Kudaliya	Fd.	Kotlibhel EIA Report
96.	*Dicliptera bupleuroides* Nees.	NA		Kotlibhel EIA Report
97.	*Digitalis purpurea* L.	Digitalis	M	NHPC Pipalkoti HE project
98.	*Digitaria ciliaris* (Retz.) Koeler	NA		Kotlibhel EIA Report
99.	*Drymaria cordata* (L.) Wild ex Romer	Pit papera	M,. Fd	Kotlibhel EIA Report
100.	*Echinops cornigerus* DC.	Kantela	Ed, M.	Kotlibhel EIA Report
101.	*Elettaria cardomomum* (L.) Maton.	Badi elachi	M	Phondani *et al.* 2009
102.	*Eleusine coracona* (L.) Gaertn.	Koda		Kotlibhel EIA Report
103.	*Eclipta alba L.*	Bhangaru	M.	Gangwar *et al.* 2011
104.	*Eclipta prostrata* (Linn.)Linn	Keshraj	M.	Gangwar *et al.* 2011
105.	*Emilia sonchifolia* (L.) DC.	NA		Kotlibhel EIA Report
106.	*Epilobium latifolium* L.		M	GMR HE project Area
107.	*Epilobium brevifolium* D.Don	NA		Kotlibhel EIA Report
108.	*Eragrostis minor* Host.	NA		Kotlibhel EIA Report
109.	*Eriophorum comosum* (Wall.) Wall. ex Nees	NA	Fb.	Kotlibhel EIA Report
110.	*Euphorbia chamaesyce* L.	NA		Kotlibhel EIA Report
111.	*Euphorbia hirta* L.	. Dudhi	M.	Kotlibhel EIA Report
112.	*Evolvulus alsinoides* (L.)	Sankhpuspi	M.	Kotlibhel EIA Report
113.	*Filago hurdwarica* Wall. ex DC.	NA		Kotlibhel EIA Report
114.	*Fragaria indica* Andrews	Gand khaphal	M. Ed	Kotlibhel EIA

				Report
115.	*Fumaria indica* (Haussk.) Pugsley	Pit papera	M	Kotlibhel EIA Report
116.	*Galinsoga parviflora* Cav.	NA		Kotlibhel EIA Report
117.	*Galium aparine* L.	Lesskuri	M	GMR HE project Area, Uniyal *et al.* 2002
118.	*Gnaphalium leuto album* L.	Bal-raksha	M	Gangwar *et al.* 2011
119.	*Gentiana capitata*. Buch. –Ham. ex D.Don	Chiratu	M	Kotlibhel EIA Report
120.	*Geranium nepalense* Sw.	Phori	M.	Gangwar *et al.* 2011
121.	*Geranium roberttianum* L.	NA	Orn, M	GMR HE project Area
122.	*Geranium ocellatum* Cambess.	Kaphlya	M	Kotlibhel EIA Report, Uniyal *et al.* 2002
123.	*Gerbera gossypina* (Royle) G. Beauv.	Kapasi	M	Kotlibhel EIA Report
124.	*Hedychium spicatum* Var.acuminatum (Rosc) Wall.	Van Haldi	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
125.	*Heliotropium strigosum* Willd.	NA	M	Kotlibhel EIA Report
126.	*Heteropogon contortus* (L.) Beauv. ex Romer & Schultes	NA		Kotlibhel EIA Report
127.	*Hypoxis aurea* Lour.	NA	M	Kotlibhel EIA Report
128.	*Impatiens balsamina* L.	NA		Kotlibhel EIA Report
129.	*Kalanchoe integra* (Medikus) Kuntze	Bis kapra		Kotlibhel EIA Report
130.	*Lamium amplexicaulis* L.	NA	Fd.	Kotlibhel EIA Report
131.	*Lathyrus sativus* L.	NA	Fd.	Kotlibhel EIA Report
132.	*Lathyrus sphaericus* Retz.	NA	Fd.	Kotlibhel EIA Report

133.	*Lathyrus aphaca* L.	Kureheli	Fd.	Kotlibhel EIA Report
134.	*Launaea asplenifolia* (Willd.) Hook. F.	NA		Kotlibhel EIA Report
135.	*Launnea procumbens*	Van-gobhi	Fd.	Gangwar *et al.* 2011
136.	*Lepidum sativum* L.	Chdrasur	M, Ed, Fd	Kotlibhel EIA Report
137.	*Leucas cephalotus* (Roth.) Sprengel	Gumba		Kotlibhel EIA Report
138.	*Leucas lanata* Benth.	NA	M	Kotlibhel EIA Report
139.	*Lobelia heyneana* Roemer & Schultes	NA		Kotlibhel EIA Report
140.	*Lotus corniculata* L.	NA		Kotlibhel EIA Report
141.	*Macrotyloma uniflorum* (Lam.) Verdc.	Cheerkaguli	M	Phondani *et al.* 2009
142.	*Malva sylvestris* L.	Gurchanti	M	Kotlibhel EIA Report
143.	*Malvastrum coromendalianum* (L.) Garcke	Suchi		Kotlibhel EIA Report
144.	*Mazus pumilus* (Burm. f.) Van Steenis	Mastura	M.	Kotlibhel EIA Report
145.	*Medicago sativa* L.	NA		Kotlibhel EIA Report
146.	*Megacarpea polyandra* Benth.	Bermula	M	Phondani *et al.* 2009
147.	*Merremia tridentata* (Linn.)Hall. F.	Prasarini	M	Gangwar *et al.* 2011
148.	*Micromeria biflora* (Buch.-Ham.ex D.Don	Gorakhopan	M	Kotlibhel EIA Report
149.	*Microstylis muscifera* (Lindl.) Ridl.	Reebjak	M	Phondani *et al.* 2009
150.	*Miscanthus nepalensis* (Trin.) Hack.	Feyari ghass	Fd	GMR HE project Area
151.	*Morina longifolia* Wall.	Biskandru	M	GMR HE project Area
152.	*Musa paradisiaca* L.	Kela	Ed, Fb, M, Ri.	Phondani *et al.* 2009

153.	*Nardostachyas grandiflora* DC.	Jatamansi	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
154.	*Nepeta hindostana* (Roth.) Haines.	NA		Kotlibhel EIA Report
155.	*Notholirion thomsonianum* (Royle) Stapf	NA		Kotlibhel EIA Report
156.	*Ocimum basilicium* L.	Kali tulsi	M	NHPC Pipalkoti HE project
157.	*Ocimum kilimandscharicum* Guerke.	Kapoor tulsi	M	NHPC Pipalkoti HE project
158.	*Ocimum sanctum* L.	Tulsi	M	Kotlibhel EIA Report
159.	*Origanum vulgare* L.	Ban Tulsi	M, Rit.	Kotlibhel EIA Report
160.	*Oryza sativa* L.	NA	Ed.	Kotlibhel EIA Report
161.	*Oxalis corniculata* L.	Chilmori	M; Ed.	Kotlibhel EIA Report, Uniyal *et al.* 2002
162.	*Paeonia emodi* Wall. ex Royle.	Chandra	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
163.	*Panicum milialaceum* L.	Cheena	M	Phondani *et al.* 2009
164.	*Perilla frutescens* (L.) Britton	Bhangjeera	M.Ed. Api.	Kotlibhel EIA Report
165.	*Phragmitis karka* Trin.	Narkul	M.	Gangwar *et al.* 2011
166.	*Physalis divaricata* D.Don.	Damphu	Ed; M.	Kotlibhel EIA Report
167.	*Picrorhiza kurrooa* Royle ex Benth.	Kutki	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
168.	*Pilea umbrosa* wedd.	NA	M	GMR HE project Area
169.	*Plantago ovata* Forsk.	Isabgol	M	Phondani *et al.* 2009
170.	*Podophyllum hexandrum* Royle.	Bankakri	M	Phondani *et al.* 2009, Uniyal *et al.* 2002

171.	*Polygonum hydropiper* L	NA	M	Gangwar *et al.* 2011
172.	*Polygomum plebeium* R. Br. Dondya	Dondya	M.	Kotlibhel EIA Report
173.	*Polygonatum verticillatum* (L.) All.	Salam misri	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
174.	*Portulaca oleracea* Linn.	Badinoni	M	Gangwar *et al.* 2011
175.	*Potentilla fulgens* wall. ex Lehm.	Bajaradanti	M	Phondani *et al.* 2009
176.	*Potentilla supina* L.	NA		Kotlibhel EIA Report
177.	*Ranunculus muricatus* L.	NA	M	Kotlibhel EIA Report
178.	*Ranunculus laetus* Wall. ex D.Don	NA	M	Kotlibhel EIA Report
179.	*Rauwolfia serpentina* (L.) Benth. ex Kurz.	Sharpgandha	M	Phondani *et al.* 2009
180.	*Reinwardtia indica* Dumort.	Phiunli	M	Phondani *et al.* 2009
181.	*Rheum australe* D.Don	Dolu	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
182.	*Ribes orientale* Desf.	Darbag	M.	Gangwar *et al.* 2011
183.	*Rosularia adenotricha* (Wallich ex Edgew.)	Looniya	M.	Gangwar *et al.* 2011
184.	*Rosularia rosulata* (Edgew.) Ohba	NA	M	Kotlibhel EIA Report
185.	*Rumex hastatus* D. Don	Almora	M, Ed.	Kotlibhel EIA Report, Uniyal *et al.* 2002
186.	*Rungia pectinata* (L.) Nees	Pindikunda	M.	Gangwar *et al.* 2011
187.	*Saccharum spontaneum* L.	wild sugar cane	Fodder	GMR HE project Area
188.	*Salvia plebeia* R. Br.	Sathi, Samundarsok	M	Gangwar *et al.* 2011
189.	*Salvia coccinia* Buch' hoz ex Etlinger	NA		Kotlibhel EIA Report

190.	*Saussurea costus* (Falc.) Lipsch.	Kuth	M	Phondani *et al.* 2009
191.	*Saussurea obvallata* (DC) Edgew	Brahm kamal	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
192.	*Saussurea heteromalla* (D Don) Hand.	NA		Kotlibhel EIA Report
193.	*Scutellaria linearis* Benth.	NA	M.	Kotlibhel EIA Report
194.	*Scutellaria scandens* Buch. –Ham. ex D.Don	kutlaphul	M. Api	Kotlibhel EIA Report
195.	*Sedum motanum* Wall. ex Edgew.	NA	Ed,M.	GMR HE project Area
196.	*Sedum multicaule* Wallich ex Lindley	cane	M	Kotlibhel EIA Report
197.	*Selinum tenuifolium* wall.	Bhutkeshi	M	Phondani *et al.* 2009
198.	*Sesamum orientale* L.	Til	M	Phondani *et al.* 2009
199.	*Sida rhombifolia* L.	NA		Kotlibhel EIA Report
200.	*Sida cordata* (Burm. f.) Borss. Waalk.	Bhiyli	M	Kotlibhel EIA Report
201.	*Solanum nigrum* L.	NA		Kotlibhel EIA Report
202.	*Solanum viarum* Dunal.	NA		Kotlibhel EIA Report
203.	*Solanum erianthum* D.Don	NA		Kotlibhel EIA Report
204.	*Sonchus asper* (L.) Hill.	NA		Kotlibhel EIA Report
205.	*Sonchus oleraceus*	Dudhi	M., Fd	Gangwar *et al.* 2011
206.	*Stellaria media* (L.)Villars.	Badalau	M, Ed.	Kotlibhel EIA Report
207.	*Swertia chirayita* (Roxb. ex Fleming)	Cheriata	M	Phondani *et al.* 2009, Uniyal *et al.* 2002
208.	*Tagetes erecta* L.	NA		Kotlibhel EIA Report

209.	*Taraxacum officinale* Weber.	NA	M	GMR and Kotlibhel HE. Project Report
210.	*Thalictrum foliolosum* DC	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
211.	*Thalictrum javanicum* Blume.	Peeli jari	M	Phondani *et al.* 2009
212.	*Themeda triandra* Forssk.	Red grass	Orn	GMR HE project Area
213.	*Tridax procumbens* L.	Keshraj	M.	Gangwar *et al.* 2011
214.	*Trigonella corniculata* L.	Van mathi		Kotlibhel EIA Report
215.	*Trigonella foenum-graecum* L.	Methi	M	Phondani *et al.* 2009
216.	*Trigonella polycerata* L.	NA		Kotlibhel EIA Report
217.	*Triticum aestivum* L.	NA		Kotlibhel EIA Report
218.	*Urena lobata* Linn.	Ungoo	M	Gangwar *et al.* 2011
219.	*Urginea indica* (Roxb.) Kunth	NA	M	Gangwar *et al.* 2011
220.	*Valeriana hardwickii* Wall.	Tagar	M	Phondani *et al.* 2009
221.	*Verbascum chinense* (L.) Santapau.	NA		Kotlibhel EIA Report
222.	*Verbascum thapsus* L.	NA		Kotlibhel EIA Report, Uniyal *et al.* 2002
223.	*Vicia sativa* L.	NA		Kotlibhel EIA Report
224.	*Vicia faba* L.	NA		Kotlibhel EIA Report
225.	*Vigna radiate* (L.) R. Wilczek.	Mung		Kotlibhel EIA Report
226.	*Vigna ungiculata* (L.) Walp.	Sunte		Kotlibhel EIA Report
227.	*Viola canescens* Wall.	NA		Kotlibhel EIA Report

228.	*Withania somnifera* (L.) Dunal.	Ashwagandha	M	Phondani *et al.* 2009
229.	*Xanthium strumarium* L.	Chota-dhatura	M.	Gangwar *et al.* 2011

Cultigens recorded in the two basins

S.No.	Name of the Species	Vernacular Name	Ethnobotanical Notes	References
1.	*Allium cepa* L.	Pyaz	M	Phondani *et al.* 2010
2.	*Allium sativum* L.	Lashun	M	Phondani *et al*. 2010
3.	*Amaranthus cruentus* Sieber ex C. Presl.	Marsu	M	Kala, 2005
4.	*Arisaema tortuosum* (Wall.) schott	Bag-mungri.	M	Phondani *et al.* 2010
5.	*Brassica campestris* L.	Sarso	M	Phondani *et al*. 2010
6.	*Brassica juncea* (L.) Czern.	Rai	M	Phondani *et al.* 2010
7.	*Capsicum annuum* L.	Mirch	M	Phondani *et al.* 2010
8.	*Coriandrum sativum* L.	Dhaniya	M.	Phondani *et al.* 2010
9.	*Cucumis sativus* L.	Kakree	M	Phondani *et al.* 2010
10.	*Curcuma longa* L.	Haldi	M	Phondani *et al.* 2010
11.	*Daucus carota* L.	Gajar	M.	Phondani *et al.* 2010
12.	*Echinochloa frumentacea* Link.	Jhangora.	M	Phondani *et al.* 2010
13.	*Glycine max* (L.) Merr.	Kala bhat.	M	Phondani *et al.* 2010
14.	*Hordeum vulgare* L.	Jau.	M	Phondani *et al.* 2010
15.	*Macrotyloma uniflorum* (Lam.) Verdc.	Gaheth.	M	Phondani *et al.* 2010
16.	*Mentha arvensis* L.	Podina	M	Phondani *et al.* 2010

17.	*Momordica charantia L.*	Karela	M	Tiwari *et al.* 2010
18.	*Raphanus sativus* L.	Muli	M	Phondani *et al.* 2010
19.	*Sesamum orientale* wild. ex Roxb.	Til	M	Kala, 2005
20.	*Trigonella foenum-graecum* L.	Methi	M	Kala, 2005
21.	*Vigna mungo* (L.) Hepper.	Kali dal	M	Phondani *et al.* 2010
22.	*Zingiber officinale* Roscoe	Adrak	M	Phondani *et al.* 2010

Climbers recorded in the two basins

S.No.	Name of the Species	Vernacular Name	Ethnobotanical Notes	References
1.	*Abrus pulchellus* Wall.		M.	Kotlibhel EIA Report
2.	*Argyreia nervosa* (Burm.f.) Boj.	Ghav bel	M	Gangwar *et al.* 2011
3.	*Bauhinia vahlii* W. & A.	Maljhan	Fd	Gangwar *et al.* 2011
4.	*Caesalpinia bonducella* (L.) Roxb.	Kath Karanj	M	Gangwar *et al.* 2011
5.	*Capparis zeylanica* Linn.	Hins	M	Gangwar *et al.* 2011
6.	*Clematis gouriana* Roxb. ex DC.	NA	M, Api.	Kotlibhel EIA Report
7.	*Cryptolepis buchananii* Roem. & Schult.	Medha-singhi	M	Gangwar *et al.* 2011
8.	*Ficus hederacea* Roxb.	Beduli	Fd	Kotlibhel EIA Report
9.	*Ipomoea hederifolia* L.	NA		Kotlibhel EIA Report
10.	*Ipomoea nil* L.	Guj	Fd	Gangwar *et al.* 2011
11.	*Ipomoea pes tigris* L.	Panch patri	Fd	Gangwar *et al.* 2011
12.	*Millettia auriculata* Baker	Gauj	Fd	Gangwar *et al.* 2011
13.	*Mucuna prurita* Hook.	Kaircha	M	Gangwar *et al.* 2011
14.	*Pergularia daemia* (Forsk) Chioaenda.	Utraun		Kotlibhel EIA Report

15.	*Rosa brunoii* Lindley	NA	M, Sc, Api.	Uniyal *et al.* 2002
16.	*Smilax aspera* L.	NA		Kotlibhel EIA Report
17.	*Tinospora cordifolia (*Willd.) Hook. f. & Thomson	Giali	M	Phondani *et al.* 2009
18.	*Vallaris heynei* Spreng	Dudhi-bel	Fd	Gangwar *et al.* 2011

[M = Medicinal, Ed = Wild Edible; Fd =Fodder, Tm = Timber, Fl = Fuelwood, Fb = Fiber, Api = Apiculture, Ag = Agricultural Implements, Dy = Dye, Rit =Ritual, Sc. = Soil Conservation.]

Appendix 5.2

RET/Endemic species of plants recorded in the Bhagirathi and Alaknanda basins.

S.N	RET species	Family	Basin
1.	*Acer caesium* Wall. ex Brandis	Aceraceae.	Alk & Bhag.
2.	*Aconitum balfourii* Stapf.	Ranunculaceae	Alk.
3.	*Aconitum falconeri* Stapf var. falconeri	Ranunculaceae	Alk.
4.	*Aconitum hetrophyllum* Wall.	Ranunculaceae	Alk & Bhag.
5.	*Aconitum violaceum* Jacquem. ex Stapf.	Ranunculaceae	Alk.
6.	*Acorus calamus* L.	Araceae	Alk.
7.	*Agrostis tungnathii* Bhattach. & Jain	Poaceae	Alk.
8.	*Allium humile* Kunth	Alliaceae	Alk.
9.	*Allium stacheyi* Baker	Alliaceae	Alk & Bhag.
10.	*Androsace garhwalicum* Balodi & Singh	Primulaceae	Alk.
11.	*Anemone raui* Goel & Bhattach.	Ranunculaceae	Bhag.
12.	*Angelica glauca* Edgrew.	Apiaceae	Alk & Bhag.
13.	*Arenaria curvifolia* Majumdar	Caryophyllaceae	Alk.
14.	*Arenaria ferruginea* Duthie ex F. Williams	Caryophyllaceae	Alk.
15.	*Arnebia benthamii* (Wall. ex D. Don) Johnston	Boraginaceae	Alk & Bhag.
16.	*Berberis osmastonii* Dunn.	Berberidaceae	Alk.
17.	*Berberis petiolaris* Wall. ex G.Don	Berberidaceae	Alk.
18.	*Bergenia ligulata* (Wall.) Engl.	Saxifragaceae.	Alk.
19.	*Calamogrostis garhwalensis*	Asteraceae	Alk.
20.	*Caragana sukiensis* Schn.	Fabaceae	Bhag.
21.	*Carex nandadeviensis* Ghildyal, et al.	Cyperaceae	Alk.
22.	*Catamixis baccharoides* Thoms.	Asteraceae	Alk.
23.	*Coleus barbatus* (Andr.) Benth.	Lamiaceae	Alk & Bhag.
24.	*Cyananthus integer* Wall. ex Benth.	Campanulaceae	Alk.
25.	*Cyathea spinulosa* Wall.	Cyatheaceae	Alk.
26.	*Dactylorhiza hatagirea* (D.Don) Soo.	Orchideaceae.	Alk.
27.	*Datisca cannabina* L.	Datiscaceae	Alk & Bhag.
28.	*Delphinium brunonianum* Royle.	Ranunculaceae	Alk.
29.	*Dilophia purii* Rawat, Dangwal & R.D. Gaur	Brassicaceae	Alk.
30.	*Dioscorea deltoidea* Wall. ex Griseb.	Dioscoreaceae	Alk.
31.	*Epilobium latifolium* L.	Onagraceae	Alk.
32.	*Epipogium aphyllum* (Schm.) Swartz	Orchideaceae.	Bhag.
33.	*Euphorbia sharmae* U.C. Bhattach	Euphorbiaceae	Alk.
34.	*Festuca nandadevica* Hajra	Poaceae	Alk.
35.	*Fritillaria roylei* Hook.	Liliaceae	Alk.
36.	*Gentiana saginoides* Burkill	Gentianaceae	Alk.
37.	*Gentiana tetrasepala* Biswas	Gentianaceae	Alk.
38.	*Hedychium spicatum* Lodd.	Zingiberaceae	Alk.

39.	*Hedysarum microcalyx* Baker	Fabaceae	Alk.
40.	*Lilium polyphyllum* D. Don ex Royle	Liliaceae	Bhag.
41.	*Listera nandadeviensis* Hajra	Orchidaceae	Alk.
42.	*Meconopsis aculeate* Royle.	Papaveraceae	Alk.
43.	*Microschoenus duthiei* Clarke	Cyperaceae	Bhag.
44.	*Nardostachys grandiflora* DC.	Valerianaceae	Alk & Bhag.
45.	*Picrorhiza kurrooa* Royle ex Benth.	Scrophulariaceae	Alk & Bhag.
46.	*Podophyllum hexandrum* Royle.	Berberidaceae	Alk & Bhag.
47.	*Polygonatum multiflorum* Kunth.	Convallariaceae	Alk.
48.	*Ranunculus uttaranchalensis* Pusalkar & Singh	Ranunculaceae	Bhag.
49.	*Rheum austral* D.Don	Polygonaceae	Alk & Bhag.
50.	*Rheum webbianum* Royle.	Polygonaceae	Alk.
51.	*Saussurea sudhanshui* Hajra	Asteraceae	Alk.
52.	*Silene gangotriana* Pusalkar et al.	Caryophyllaceae	Bhag.
53.	*Trachyspermum falconeri* (Clarke) H. Wolff	Apiaceae	Alk & Bhag.
54.	*Trillidium govanianum* (D. Don) Kunth.	Liliaceae	Alk.
55.	*Viola kunawarensis* Royle	Violaceae	Alk.

Alk = Alaknanda basin, Bhag = Bhagirathi basin.

Appendix 5.3

Description of RET plant species found in the two basins.

Name:	*Acer caesium* Wall. ex Brandis.	
Family:	Aceraceae	
Vern/ Common name:	Kanchula	
Distribution:	India, Western Himalaya from Kashmir to Kumaon.	
Description	Large deciduous broad-leaved trees dormant flower buds large and prominent. Leaves 8-18 x 10-20 cm, palmately 5-lobed, upper surface green, lower surface characteristically caesio-pruinose, base deeply cordate, 5-nerved, leaf lobes caudate-acuminate, petioles 6-15 cm long, reddish. Inflorescence corymbose-panicle, erect, terminal, puberulous, appearing after the leaves. Flowers pale greenish-yellow to yellow. Sepals longer than petals. Stamens 8, inserted into the disc, exserted. Ovary pubescent , style 2, connate half way up. Fruit a two winged samara.	
Habitat and Ecology	It is the largest maple in the western Himalayas between t 2130-3050 m asl. It is characteristic of the moist temperate deciduous forests, commonly associated with *Corylus colurna, Aesculus indica, Prunus cornuta, Ulmus wallichiana, Carpinus viminea, Betula utilis* and the lauraceous genera such as *Lindera* and *Machilus*. In Upper west Himalayan temperate forest the species is in association with *Quercus semicarpifolia, Q. dilatata* and *Abies pindrow*.	
Uses	Wood is frequently used for making agricultural implements, wooden utensils and also as fuel wood. The knots on the stem are highly prized for making wooden bowels by certain ethnic communities in hills.	
Source : Nayar & Sastry 1987. Red Data Book of Indian Plants, Vol-I: 5		

Name:	*Aconitum heterophyllum* Wall.	
Family:	Ranunculaceae	
Vern/ Common name:	Atees	
Status:	Threatened	
Distribution	Temperate and Alpine zone of Western & Central Himalaya 2000-4000 m.	
Description	An erect, leafy herb having biennial, paired, tuberous roots. Stem upto 1 m tall with broad, ovate or orbicular, cordate, lobed and toothed, shortly stalked or sessile, amplexicaule leaves. Flowers bright-blue to yellow greenish blue with purple veins in long, many flowered peduncles. Fruit, a 5 celled capsule.	
Habitat and Ecology	An erect herb found in forested blanks and alpine meadows above 3000 m.	
Uses	Used in Ayurvedic as a well as Unani system of medicine for the preparation of various formulations. It is also used locally as a popular household medicine for the treatment of fever and stomachache.	
Source: Nayar & Sastry 1987. Red Data Book of Indian Plants		

Name:	*Acorus calamus* L.	
Family:	Araceae	
Vern/ Common name:	*Baodh, Bauj, Baj, Bach,;*	
Status:	Threatened	
Distribution	Widely distributed in temperate belt of northern Hemisphere including Himalaya. [Mondal, Pindar valley, Akash kamini, Phata].	
Description	An erect, semi-aquatic herb. Root stock rhizomatous, creeping and aromatic. Leaves fascicled, 3-4 from a tiller, 35 – 50 cm long and 8 – 15 cm wide, shining green. Inflorescence compact spadix borne on basal parts of upper leaves. Flowers minute, yellowish green, inconspicuous.	
Habitat and Ecology	A typical species of hill valley wetlands and marshes.	
Uses	Sweet flag is used medicinally for a wide variety of ailments since centuries. The aromatic oil extracted from its rhizomes are valued in the perfume industry.	
Source: Pl. 324, 1753; Hook. *f.* Fl. Brit. India. 6: 555. 1893, Naithani, Fl. Chamoli – II, 150, 1984; Gaur, Fl. Garhwal 604, 1999.		

Name:	*Allium stracheyi* Baker	
Family:	Alliaceae	
Vern/ Common name:	Faran, Jambu	
Status:	Vulnerable	
Distribution	Western Himalaya: From Pakistan to Uttrakhand , Nepal.Endemic to Himalaya.	
Description	Small bulbous herb, 8-20 cm tall, bulbs 3.5-5 cm long, elongate-ovoid with parallel fibrous scales. Leaves 2-4, 11-30 cm X 1-2 mm, linear, longer than scapes. Flowers purple or pink in colour, 4-5 mm long, oblong-campanulate, on 3-7 mm long pedicel, many, heads sub- globose or hemispherical, 1.5-2.5 cm in diameter. Stamens and pistil longer and exserted. Capsules ca 4x3 mm, globose, oblong, thin papery, with 6 black seeds.	
Habitat and Ecology	Found on open grassy slopes and alpine meadows between 2400-4000 m. Cultivated in some parts of Dhauliganga Valley.	
Uses	Used for seasoning vegetables locally and also used to cure physical injuries and joint pains.	
Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-III: 9.		

Name:	*Allium humile* Kunth	
Family:	Alliaceae	
Vern/ Common name:	*Jimboo; Faran*	
Status:	Not assessed	
Distribution	Sporadically distributed along the sub-alpine and alpine moist valleys mainly in Western Himalaya. In Uttarakhand the species is found in upper catchments of Yamuna, Bhagirathi and Alaknanda rivers.	
Description	Perennial, tufted and bulbous herbs. Aerial parts withering during winter. Leaves strongly aromatic, 4-7, linear, 4-5 mm wide, flat, fleshy. Flowers white, star shaped, in a rather lax umbel 2.5-4 cm across, born on a leafy stem.	
Habitat and Ecology	Alpine moist slopes at altitudes of 3000-4000 m.	
Uses	Leaves are used in culinary purposes locally as in case of *Allium stracheyi*. It is also known to be used in the treatment of minor ailments such as stomach diseases, jaundice, cold and cough.	
Source: Kunth, Naithani, Fl. Chamoli – II, 647, 1984.		

Name:	*Arnebia benthamii* (Wall. ex D. Don) Johnston	
Family:	Boraginaceae	
Vern/ Common name:	Ratan Jot; Balchhad	
Status:	Vulnerable	
Distribution	Alpine moist pastures, especially in the Western Himalaya between 3000–3900 m asl.	
Description	A perennial, erect, hoary herb. Stem stout up to 50 cm high. Leaves linear, alternate. Inflorescences a dense shaggy-haired cylindrical spike. Flowers reddish-purple.	
Habitat and Ecology	Open slopes and shrubberies between 3500 - 4200 m asl.	
Uses	The species is a major ingredient of the commercial drug available under the name Gaozaban, which has antibacterial, antifungal, anti-inflammatory and wound-healing properties. Roots yield purplish red dye when soaked in mustard oil and used locally as a hair tonic.	
Source: (Wall. ex G. Don) I.M. Johnson in Journ. Arn. Arb. 35:36, 1954; Raizada and Saxena, Fl. Mussoorie, 567, 1978.		

Name:	*Berberis osmastonii* Dunn.	
Family:	Berberidaceae.	
Vern/ Common name:	NA	
Status:	Rare	
Distribution	Endemic to Uttarakhand in Pindar Valley and Pithoragarh District.	
Description	Subprostrate shrubs. Stems terete or subterete, mature shoots purplish red. Spines 3-fid, slender, 1-3 cm. leaves 10-20 x 2-3 mm, lonear-oblong or very narrowly elliptic, margins entire revolute. Flower solitary. Outer sepals 3.5 X 1mm, entire, glands orbicular, stamens 5 mm, produced, apiculate. Berries ovoid, stylose.	
Habitat and Ecology	Patchily distributed on open dry, hill slopes at higher altitudes (1800 – 2200 m asl).	
Uses	Not known.	
Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-I: 100.		

Name:	*Caragana sukiensis* Schn.	
Family:	Leguminosae	
Vern/ Common name:	NA	
Status:	Not assessed	
Distribution	Near Endemic. Known to occur in few patches of Western Uttarakhand and Western Nepal. In Uttarakhand few patches have been located near Sukhi and Harshi Villages.	
Description	A spiny, tufted shrub up to 2 m tall. Leaves crowded, pinnate with 8-10 leaflets. Stipule not connate behind. Flowers yellow,fading to orange or brown. Pods 4-6 cm long, turgid.	
Habitat and Ecology	Sparsely distributed along dry, boulder slopes and sandy riverbanks. An excellent soil binder and helps in reclamation of soil owing to its nodular roots and nitrogen fixing properties.	
Uses	Important fuel wood and valuable for soil reclamation.	
Source: C.K. Schneid in Bull. Herb. Boiss. Ser. 2, 7: 313. 1907; Naithani, Fl. Chamoli - I 150, 1984. *C. hoplites I Dunn. In Kew Bull.* 338.		

Name:	*Catamixis baccharoides* Thoms.	
Family:	Asteraceae	
Vern/ Common name:	NA	
Status:	Vulnerable	
Distribution	Endemic to the Siwalik belt and outer Himalaya. Sporadically distributed along Dehra Dun Shiwaliks between Yamuna and Ganges. Few patches have been located in dry slopes near Kotlibhel in Tehri district.	
Description	A low hanging shrub, 1.0-1.5 m high. Stems with silky pubescence. Leaves alternate, shortly petiolate, semi-amplexicaule, obovate or obovate-spathulate, 5.0-7.5 X 2.0-3.7 cm, crenate or crenate serrate. Inflorescence in heads, ligulate, 7.5 mm long, in terminal corymbs. Involucral bracts few to many seriate, much shorter than flowers. Florets all ligulate, purplish white. Achenes silky-villous. Pappus hairy,white.	
Habitat and Ecology	The species is found on steep calcareous and sand stone rocks between 500 – 1200 m asl.	
Uses	Not known	
Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-1: 78.		

Name:	*Coleus barbatus* (Andr.) Benth.	
Family:	Lamiaceae or Labiatae	
Vern/ Common name:	Patthar Chud, Fiwai. English : Indian coleus, False boldo.	
Status:	Not Assessed	
Distribution	Sub-montane and warm temperate belt of Himalaya between 1000 – 2000 m. In Uttarakhand it can be seen sporadically distributed along lower parts of Bhagirathi and Alaknanda valleys. Also reported from hilly tracts of Central India and Western Ghats.	
Description	Perennial herbs, 30- 60 cm high. Roots fleshy, fibrous. Stem decumbent, cylindrical and hairy. Leaves ovate to obovate, petiolated. Flowers in whorls of 6 -8, pale- blue. Calyx and corolla 2 lipped.	
Habitat and Ecology	Coleus is a hardy plant species growing on the dry slopes of the lower Himalaya, often along the edges of fallow fields and pine forests.	
Uses	An important source of Colenol, this species is exploited heavily by various Ayurvedic industries.	
Source: (Andr.) Benth. Hook. *f* Fl. Brit. India.4: 625.1885. Naithani, Fl. Chamoli -II. 504, 1984s.		

Name:	*Cyananthus integer* Wall. ex Benth.	
Family:	Campanulaceae	
Vern/ Common name:	NA	
Status:	Rare	
Distribution	Endemic to Uttarakhand	
Description	Dwarf, decumbent branched, glabrous to puberulous herbs. Leaves alternate or opposite, petiolate, ovate to ovate-lanceolate, dentate or sub-entire, pubescent on the upper surface and villous on the lower surface, 1.2-7.6 x 0.5-4.6 cm. Flowers purplish blue. Corolla broadly cylindric or campanulate, cleft for less than ½ the length, 9-11.5 mm. Capsules subglobose, 8.5-11.5 mm long and 9-12 mm broad.	
Habitat and Ecology	Moist alpine slopes and rocks in alpine areas between 3000-3800m.	
Uses	Not known	

Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-II: 81.

Name:	*Datisca cannabina* L.	
Family:	Datiscaceae	
Vern/ Common name:	Bajra Bhang	
Status:	Not Assessed	
Distribution	Sparsely and patchily distributed in dry temperate belt of Western Himalaya and extends up to Mediterranean zone. Garhwal Himalaya a few patches have been located near Harsil, Tharali, Khetaswami, Chirbatiya, and Narayan Bagarh.	
Description	An erect shrub up to 2.5 m tall. Stem slender, cylindrical, branching only in the terminal parts. Leaves pinnate. Pinnae resemble the leaflets of hemp. Flowers small, greenish, unisexual, male and female plants borne on different plants, in terminal racemes.	
Habitat and Ecology	The species is peculiar in its habitat, largely colonizing banks of seasonal streams especially on steep slopes.	
Uses	Roots are known to be an importance source of dye.	

Source: Hook. *f* Fl. Brit. India.2: 656. 1879. Naithani, Fl. Chamoli -I. 249, 1984.

Name:	*Dioscorea deltoidea* Wall. ex Kunth.
Family:	Dioscoreaceae
Vern/ Common name:	Ghanjir
Status:	Vulnerable due to the over exploitation.
Distribution	Widely distributed in temperate and sub-alpine zone of Himalaya, from Kashmir to Arunachal Pradesh, South-West China.
Description	Glabrous, herbaceous climber with tuberous roots. Leaves alternate, 5-13 cm long, ovate, acuminate, base deeply cordate, lobes rounded, sometimes dilated outwards petiole as long as the blade. Male spikes solitary, rarely in pairs, 8-35 cm long, very slender, perianth segments broadly oblong, flower in small, distinct cluster, stamen 6. Female spikes 8-16 cm long, usually broader than long, solitary, flower few, distinct. Capsule 1.5-2.5 X 2.5-5 cm, variable in shape. Seeds round, winged.
Habitat and Ecology	Temperate belt in open areas and forest edges between 1000-3500 m altitudes.
Uses	Tuberous roots are used for extracting steroidal saponin, diosgenin. Diosgenin is a precursor of cortisone, hydro-cartisone, sex hormone & antifertility drug largely used in modern medicine.
Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-II: 104.	

Name:	*Epipogium aphyllum* (Schmidt) Sw.
Family:	Orchideaceae
Vern/ Common name:	N.A.
Status:	Not Assessed
Distribution	Sparsely distributed in the temperate and sub-alpine zone of Western and Central Himalaya. Only two populations of this species were located in Garhwal – one in Bhyundar Valley and other near Gangotri (3200m).
Description	A slender, leafless ground orchid. Root stock creeping. Leaves reduced to scales. Flowering stem 10-20 cm long, pale brown, smooth. Lowers white to pale yellow, 4-5 in a simple raceme.
Habitat and Ecology	The species likes to grow in shady moist areas as an understory of forested habitats in especially along riverine areas between 2500 – 3000 m.
Uses	The species is of botanical interest. Local uses are not known.
Source: Veget. Scand. 32. 1814. *Orchis aphylla* Schmidt in May Sammal. Phys. Aufs. 1:240. 1791. Non frossk. 1775; Hook. *f*. Fl. Brit Ind. 6: 124.1890; Naithani, Fl. Chamoli – II, 616, 1984.	

Name:	*Lilium polyphyllum* D.Don ex Royle	
Family:	Liliaceae	
Vern/ Common name:	Kakoli, Kshir Kakoli	
Status:	Vulnerable	
Distribution	Sparsely distributed in the temperate belt of Western Himalaya between 2000 – 3300 m asl, from Kashmir to Garhwal. In the survey area a few populations were located near Kanol Sitale and Gangotri (3200m asl).	
Description	Perennial, erect herbs upto 50 cm tall. Bulbs up to 5 cm across. Leaves sessile, alternate or nearly opposite or whorled, narrowly lanceolate or linear, 8-12 x 1- 2 cm. Bracts leaf-like, often whorled. Flowers whorled and with long stalk. Perianth 5- 8 cm long, greenish white with purple dots inside, segments obtuse, recurved when fully expanded.	
Habitat and Ecology	This species is found primarily as and understory of deodar and fir between 2400 – 3300 m asl.	
Uses	The species has a great potential as horticultural crop. Its medicinal properties are yet to be explored.	
Source: Don in Royle, Ill. Bot. Himal. 388. 1840; Hook. *f* Fl. Brit. India. 6:351. 1892; Naithani, Fl. Chamoli – II, 652, 1984.		

Name:	*Nardostachys jatamansi* DC.	
Family:	Valerianaceae	
Vern/ Common name:	Mansi, Jatamansi	
Status:	Vulnerable	
Distribution	Sparsely distributed in the moist alpine areas of Greater Himalaya from Eastern Himachal Pradesh to Sikkim.	
Description	An aromatic, decumbent herb, 10-30cm high. Basal parts of stem rhizomatous, fibrous covered with tail like brown fibers left over from the withered leaves towards the stem, while the root continuous to penetrate deep in the soil. Leaves are radical in nature long, narrow and the flower are creamy white, often rosy or pale pink in appearance arising in terminal corymbose cymes. Market drug consists of a short portion of rhizome, as thick as little finger, dark grey, covered by a tuft of fine, reddish brown fibers and gives an appearance of a tail. Fibers are malted together as a network. It has a heavy aromatic odour and tastes bitter.	
Habitat and Ecology	Usually found on rocky slopes in the alpine areas above 3500 m.	
Uses	It is used in Ayurvedic system of medicine and perfumery. Local people use as incense. Market drug consists of a short portion of rhizome.	
	Source: Nayar & Sastry 1987. Red Data Book of Indian Plants.	

Name:	*Picrorhiza kurrooa* Royle ex Benth.	
Family:	Scrophulariaceae	
Vern/ Common name:	Kutki, Karui	
Status:	Vulnerable	
Distribution	Himalaya: From Kashmir to Sikkim.	
Description	A rhizomatous, perennial herb with bitter taste. Leaves 5-10 cm, coriaceous, trip rounded, base narrowed into a winged sheating petiole. Flowering stock ascending, longer than the leaves, with or without bracts below the inflorescence. Spike 5-10 cm long, obtuse, many flowered, sub- hirsute, bracts oblong or lanceolate, as long as calyx. Sepals 5, lanceolate, 4-5 mm long, ciliate. Corolla 5-8 mm long, lobes ovate, acuminate, ciliata. Capsule 1-1.5 cm long, ovoid, turgid, acute.	
Habitat and Ecology	The species is found sporadically on moist skeletal alpine valleys and stream courses between 3300-4500 m altitudes.	
Uses	Used locally to cure stomach ache. Commercially exploited across the Himalaya for preparation of various formulations especially to cure liver diseases.	
Source: Nayar,M.P. & Sastry,A.R.K. 1987. Red Data Book of Indian Plants, vol-I: 350.		

Name:	*Trillidium govanianum* (D. Don) Kunth	
Family:	Liliaceae	
Vern/ Common name:	Satwa	
Status:	Not Assessed	
Distribution	Sparsely but widely distributed throughout the Himalayan region between 3000 – 4000 m asl. In the survey area this species was recorded in upper parts of Bhagirathi and Alaknanda valleys.	
Description	A tuberous herb often up to 30 cm tall, growing frequently in forest shades with three leaves in one whorl at the summit of the stem and solitary, purple flower in the centre. Leaves are broadly ovate, ovate and conspicuously stalked, 3.5 – 10 cm long. Flowers brown purple with narrow, spreading petals, the outer three narrowly lanceolate, the inner 3, linear. Anthers large, yellow, style 3, long and conspicuous. Fruit is a red, globular berry, 1-2 cm in diameter.	
Habitat and Ecology	Shady moist forests among boulders often under the birch-rhododendron forests.	
Uses	The cortico-steroid hormone isolated from the plant is used in various preparations like sex hormones, cortisone and allied preparations used in the treatment of rheumatism, birth control, regulation of menstrual flow and the like. It is an important source of diosgenin.	
Source: Kunth. Nayar & Sastry 1987. Red Data Book of Indian Plants. Trillium govanianum Wall. Cat. 812,		

Annexure 5.4

Checklist of fishes found in the ZoIs of hydroelectric projects in Alaknanda and Bhagirathi basins

SL. NO	Name of the Fish Species	Agunda thati	Badrinath	Bhilangana	Dewal	Jumma gad	Maneri bhali I	Maneri bhali II	Pilangad	Rajwakti	Tehri stage-I	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	-	-	-	+	-	+	-	+	-	-	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	+	-	-	-	-	-	+	+	EN
4	*Tor putitora* (Ham.)	-	-	+	+	-	+	+	-	+	+	EN
5	*Tor chelinoides* (McClell.)	-	-	-	-	-	-	-	-	-	+	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	-	-	-	-	-	+	
7	*Labeo dyocheilus* (McClell.)	-	-	-	+	-	-	+	-	+	+	
8	*Labeo dero* (Ham.)	-	-	+	+	-	+	+	-	+	+	
9	*Labeo boga* (Ham.)	-	-	-	-	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	-	+	-	-	-	-	-	-	+	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	+	-	+	+	-	+	+	+	+	+	
19	*Barilius shacra* (Ham.)	-	-	+	+	-	-	+	-	+	+	
20	*Barilius barna* (Ham.)	+	-	+	+	-	+	+	-	+	+	
21	*Barilius barila* (Ham.)	+	-	+	+	-	-	+	-	+	+	
22	*Barilius vagra* (Ham.)	+	-	+	+	-	+	+	-	+	+	
23	*Raiamas bola* (Ham.)	-	-	-	-	-	-	-	-	-	+	

24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	+	-	+	+	-	+	+	+	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	-	+	+	-	-	-	-	+	-	
31	*Schizothorax progastus* (McClell.)	-	-	-	+	-	-	-	-	-	-	
32	*Schizothorax esocinus* Heckel	-	-	-	-	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	-	+	+	-	-	-	-	+	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	-	+	-	-	-	-	-	+	-	
35	*Schizothoraichthys curvifrons* (Heckel)	-	-	+	+	-	-	-	-	+	-	
36	*Schizothoraichthys planifrons* (Heckely)	-	-	+	+	-	-	+	-	+	+	
37	*Garra gotyla gotyla* (Gray)	-	-	+	-	-	+	+	+	-	+	VU
38	*Garra lamta* (Ham.)	-	-	+	-	-	-	+	-	-	+	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	+	-	-	-	-	-	-	+	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	-	-	-	-	-	+	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	-	-	-	-	-	+	VU
44	*Botia almorhe* Gray	-	-	-	-	-	-	-	-	-	+	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	-	-	+	-	-	+	+	+	-	+	
47	*Paraschistura montanus* (McClell.)	-	-	+	-	-	+	+	-	-	+	
48	*Schistura beavani* Gunther	-	-	+	-	-	+	+	-	-	+	
49	*Schistura savona* (Ham.)	-	-	+	-	-	-	-	-	-	+	

50	*Schistura denisonii* (Jerdon.)	-	-	+	-	-	-	-	-	-	+	
51	*Nemacheilus multifasciatus* Day	-	-	+	-	-	-	-	-	-	+	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	
55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	-	+	-	-	-	-	-	-	+	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	-	+	-	-	-	-	-	-	+	
60	*Glyptothorax madraspatanum* (Day)	-	-	-	-	-	-	-	-	-	+	
61	*Glyptothorax pectinopterus* (McClell.)	-	-	+	+	-	+	+	+	+	+	
62	*Glyptothorax telchitta* (Ham.)	-	-	+	+	-	-	+	-	+	+	VU
63	*Glyptothorax conirostris* (Steind.)	-	-	+	+	-	-	-	-	+	+	
64	*Glyptothorax cavia* (Ham.)	-	-	+	+	-	-	-	-	+	+	EN
65	*Glyptothorax trilineatis* Blyth	-	-	+	+	-	+	+	-	+	+	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	-	-	-	-	-	+	
67	*Glyptothorax brevipinnis* Hora	-	-	+	+	-	-	+	-	+	+	
68	*Pseudecheneis sulcatus* (McClell.)	-	-	+	+	-	-	-	-	+	+	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	-	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	+	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	+	

SL. NO	Name of the Fish Species	Urgam	Vanala	Vishnu prayag	Bhilangana -III	Birahi Ganga	Kail ganga	Kaliganga -I	Kaliganga -II	Koteshwar	Lohari Nagpala	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	-	-	-	-	-	+	-	-	-	+	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
4	*Tor putitora* (Ham.)	-	+	-	+	-	+	-	-	+	+	EN
5	*Tor chelinoides* (McClell.)	-	-	-	-	-	-	-	-	+	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	+	-	-	-	-	-	-	-	+	
8	*Labeo dero* (Ham.)	-	+	-	-	-	-	-	-	+	+	
9	*Labeo boga* (Ham.)	-	-	-	-	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	-	+	-	-	-	+	-	-	+	+	
19	*Barilius shacra* (Ham.)	-	+	-	-	-	-	-	-	+	-	
20	*Barilius barna* (Ham.)	-	+	-	-	-	+	-	-	+	-	
21	*Barilius barila* (Ham.)	-	+	-	-	-	+	-	-	+	-	
22	*Barilius vagra* (Ham.)	-	+	-	-	-	-	-	-	+	-	
23	*Raiamas bola* (Ham.)	-	-	-	-	-	-	-	-	+	-	
24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	

27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	-	+	-	+	+	+	-	-	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	+	-	-	+	+	-	-	-	-	
31	*Schizothorax progastus* (McClell.)	-	+	-	-	-	+	-	-	-	+	
32	*Schizothorax esocinus* Heckel	-	-	-	-	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	+	-	-	-	-	-	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	-	-	-	-	-	-	-	-	-	
35	*Schizothoraichthys curvifrons* (Heckel)	-	+	-	-	-	-	-	-	-	-	
36	*Schizothoraichthys planifrons* (Heckely)	-	+	-	-	+	-	-	-	+	-	
37	*Garra gotyla gotyla* (Gray)	-	-	-	-	-	+	-	-	+	+	VU
38	*Garra lamta* (Ham.)	-	-	-	+	-	-	-	-	+	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	-	-	-	-	+	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
44	*Botia almorhe* Gray	-	-	-	-	-	-	-	-	+	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	-	-	-	-	-	+	-	-	+	-	
47	*Paraschistura montanus* (McClell.)	-	-	-	-	-	-	-	-	+	-	
48	*Schistura beavani* Gunther	-	-	-	-	-	-	-	-	+	-	
49	*Schistura savona* (Ham.)	-	-	-	-	-	+	-	-	+	-	
50	*Schistura denisonii* (Jerdon.)	-	-	-	+	-	-	-	-	-	-	
51	*Nemacheilus multifasciatus* Day	-	-	-	-	-	-	-	-	+	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	

55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	-	-	-	-	-	-	-	+	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	-	-	-	-	-	-	-	+	-	
60	*Glyptothorax madraspatanum* (Day)	-	+	-	+	+	-	-	-	+	-	
61	*Glyptothorax pectinopterus* (McClell.)	-	+	-	+	+	+	-	-	-	-	
62	*Glyptothorax telchitta* (Ham.)	-	+	-	-	+	-	-	-	+	-	VU
63	*Glyptothorax conirostris* (Steind.)	-	+	-	-	+	-	-	-	-	-	
64	*Glyptothorax cavia* (Ham.)	-	+	-	-	+	-	-	-	+	-	EN
65	*Glyptothorax trilineatis* Blyth	-	+	-	-	+	-	-	-	+	-	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	-	-	-	-	+	-	
67	*Glyptothorax brevipinnis* Hora	-	+	-	+	+	-	-	-	+	+	
68	*Pseudecheneis sulcatus* (McClell.)	-	+	-	-	+	-	-	-	-	-	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	-	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	+	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	-	

SL. NO	Name of the Fish Species	Madh mesheshwar	Phata Byung	Rishi Ganga	Singoli Bhatwari	Srinagar	Tapovan Vishnugad	Vishnugad Pipalkoti	Alaknanda -Badrinath	Asiganga -I	Asiganga -II	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	-	-	-	-	-	-	-	-	+	+	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	-	+	+	-	-	-	-	-	EN
4	*Tor putitora* (Ham.)	+	-	-	+	+	-	-	-	-	-	EN
5	*Tor chelinoides* (McClell.)	+	-	-	-	+	-	+	-	-	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	+	-	+	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	-	-	-	+	-	-	-	-	-	
8	*Labeo dero* (Ham.)	+	-	-	-	+	-	-	-	-	-	
9	*Labeo boga* (Ham.)	-	-	-	+	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	-	-	-	+	-	-	-	-	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	+	-	-	+	+	-	-	-	-	-	
19	*Barilius shacra* (Ham.)	+	-	-	-	+	-	-	-	-	-	
20	*Barilius barna* (Ham.)	+	-	-	+	+	-	-	-	-	-	
21	*Barilius barila* (Ham.)	+	-	-	+	+	-	-	-	-	-	
22	*Barilius vagra* (Ham.)	+	-	-	+	+	-	-	-	-	-	
23	*Raiamas bola* (Ham.)	-	-	-	-	+	-	-	-	-	-	
24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	

26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	+	-	-	+	+	-	+	-	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	-	-	+	-	-	+	-	-	-	
31	*Schizothorax progastus* (McClell.)	+	-	-	+	-	-	+	-	-	-	
32	*Schizothorax esocinus* Heckel	-	-	-	-	-	-	+	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	-	-	+	-	-	+	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	-	-	-	-	-	+	-	-	-	
35	*Schizothoraichthys curvifrons* (Heckel)	+	-	-	-	-	-	+	-	-	-	
36	*Schizothoraichthys planifrons* (Heckely)	-	-	-	-	+	-	+	-	-	-	
37	*Garra gotyla gotyla* (Gray)	+	-	-	+	+	-	-	-	-	-	VU
38	*Garra lamta* (Ham.)	+	-	-	+	+	-	-	-	-	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	-	+	+	-	-	-	-	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	+	-	-	-	-	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	+	-	-	-	-	-	VU
44	*Botia almorhe* Gray	-	-	-	-	+	-	-	-	-	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	+	-	-	+	+	-	-	-	-	-	
47	*Paraschistura montanus* (McClell.)	-	-	-	+	+	-	-	-	-	-	
48	*Schistura beavani* Gunther	+	-	-	+	+	-	-	-	-	-	
49	*Schistura savona* (Ham.)	-	-	-	+	+	-	-	-	-	-	
50	*Schistura denisonii* (Jerdon.)	-	-	-	-	+	-	-	-	-	-	

51	*Nemacheilus multifasciatus* Day	-	-	-	-	+	-	-	-	-	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	
55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	-	-	-	+	-	-	-	-	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	-	-	-	+	-	-	-	-	-	
60	*Glyptothorax madraspatanum* (Day)	-	-	-	+	+	-	+	-	-	-	
61	*Glyptothorax pectinopterus* (McClell.)	+	-	-	-	+	-	+	-	-	-	
62	*Glyptothorax telchitta* (Ham.)	-	-	-	-	+	-	+	-	-	-	VU
63	*Glyptothorax conirostris* (Steind.)	-	-	-	+	+	-	+	-	+	+	
64	*Glyptothorax cavia* (Ham.)	-	-	-	+	+	-	+	-	-	-	EN
65	*Glyptothorax trilineatis* Blyth	+	-	-	-	+	-	+	-	-	-	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	+	-	+	-	-	-	
67	*Glyptothorax brevipinnis* Hora	-	-	-	-	+	-	+	-	-	-	
68	*Pseudecheneis sulcatus* (McClell.)	-	-	-	+	+	-	+	-	-	-	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	+	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	-	

SL. NO	Name of the Fish Species	Asiganga -III	Balganga -II	Bharon Ghati (I,II) including Harsil	Bhilangana -IIA	Bhilangana -IIB	Bhilangana -IIC	Bhyunder ganga	Birahi Ganga -I	Birahi Ganga -II	Bowla Nand prayag	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	+	-	+	-	-	-	-	-	-	-	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	+	-	-	-	-	-	-	-	-	EN
4	*Tor putitora* (Ham.)	-	+	-	+	+	+	-	-	-	+	EN
5	*Tor chelinoides* (McClell.)	-	+	-	-	-	-	-	-	-	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	+	-	-	-	-	-	-	-	+	
8	*Labeo dero* (Ham.)	-	+	-	-	-	-	-	-	-	+	
9	*Labeo boga* (Ham.)	-	-	-	-	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	+	-	-	-	-	-	-	-	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	-	+	-	-	-	-	-	-	-	+	
19	*Barilius shacra* (Ham.)	-	+	-	-	-	-	-	-	-	-	
20	*Barilius barna* (Ham.)	-	+	-	-	-	-	-	-	-	+	
21	*Barilius barila* (Ham.)	-	+	-	-	-	-	-	-	-	+	
22	*Barilius vagra* (Ham.)	-	+	-	-	-	-	-	-	-	+	
23	*Raiamas bola* (Ham.)	-	-	-	-	-	-	-	-	-	-	

24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	+	+	+	+	+	+	-	+	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	+	-	+	+	+	-	+	+	+	
31	*Schizothorax progastus* (McClell.)	-	+	-	-	-	-	-	-	-	+	
32	*Schizothorax esocinus* Heckel	-	+	-	-	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	+	-	-	-	-	-	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	+	-	-	-	-	-	-	-	+	
35	*Schizothoraichthys curvifrons* (Heckel)	-	+	-	-	-	-	-	-	-	+	
36	*Schizothoraichthys planifrons* (Heckely)	-	+	-	-	-	-	-	+	+	-	
37	*Garra gotyla gotyla* (Gray)	-	+	-	-	-	-	-	-	-	-	VU
38	*Garra lamta* (Ham.)	-	+	-	+	+	+	-	-	-	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	+	-	-	-	-	-	-	-	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	-	-	-	-	-	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
44	*Botia almorhe* Gray	-	-	-	-	-	-	-	-	-	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	-	+	-	+	+	+	-	-	-	-	
47	*Paraschistura montanus* (McClell.)	-	+	-	+	+	+	-	-	-	-	
48	*Schistura beavani* Gunther	-	+	-	-	-	-	-	-	-	-	
49	*Schistura savona* (Ham.)	-	+	-	+	+	+	-	-	-	-	
50	*Schistura denisonii* (Jerdon.)	-	+	-	+	+	+	-	-	-	-	

51	*Nemacheilus multifasciatus* Day	-	+	-	-	-	-	-	-	-	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	
55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	+	-	-	-	-	-	-	-	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	+	-	-	-	-	-	-	-	-	
60	*Glyptothorax madraspatanum* (Day)	-	+	-	+	+	+	-	+	+	+	
61	*Glyptothorax pectinopterus* (McClell.)	-	+	-	+	+	+	-	+	+	+	
62	*Glyptothorax telchitta* (Ham.)	-	+	-	-	-	-	-	+	+	-	VU
63	*Glyptothorax conirostris* (Steind.)	+	+	-	-	-	-	-	+	+	-	
64	*Glyptothorax cavia* (Ham.)	-	+	-	-	-	-	-	+	+	+	EN
65	*Glyptothorax trilineatis* Blyth	-	+	-	-	-	-	-	+	+	+	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	-	-	-	-	-	-	
67	*Glyptothorax brevipinnis* Hora	-	+	-	+	+	+	-	+	+	+	
68	*Pseudecheneis sulcatus* (McClell.)	-	+	-	-	-	-	-	+	+	+	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	-	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	-	

SL. NO	Name of the Fish Species	Devsari	Devali	Gohana Tal	Jadh Ganga	Jalandharigad	Jelam Tamak	Jhala koti	Kakoragad	Kaldigad	Karmoli	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	+	-	-	-	+	-	-	-	+	-	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
4	*Tor putitora* (Ham.)	+	+	-	-	-	-	-	-	-	-	EN
5	*Tor chelinoides* (McClell.)	+	-	-	-	-	-	-	-	-	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	+	-	-	-	-	-	-	-	-	
8	*Labeo dero* (Ham.)	-	-	-	-	-	-	-	-	-	-	
9	*Labeo boga* (Ham.)	-	-	-	-	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	+	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	+	+	-	-	-	-	-	-	-	-	
19	*Barilius shacra* (Ham.)	-	-	-	-	-	-	-	-	-	-	
20	*Barilius barna* (Ham.)	+	+	-	-	-	-	-	-	-	-	
21	*Barilius barila* (Ham.)	+	-	-	-	-	-	-	-	-	-	
22	*Barilius vagra* (Ham.)	+	+	-	-	+	-	-	-	-	-	
23	*Raiamas bola* (Ham.)	-	-	-	-	-	-	-	-	-	-	
24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	

28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	+	+	+	-	+	-	+	-	-	-	VU
30	*Schizothorax plagiostomus* Heckel	+	+	+	-	-	-	+	-	-	-	
31	*Schizothorax progastus* (McClell.)	+	+	-	-	-	-	-	-	-	-	
32	*Schizothorax esocinus* Heckel	-	-	-	-	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	-	-	-	-	-	-	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	+	-	-	-	-	-	-	-	-	
35	*Schizothoraichthys curvifrons* (Heckel)	-	+	-	-	-	-	-	-	-	-	
36	*Schizothoraichthys planifrons* (Heckely)	-	-	+	-	-	-	-	-	-	-	
37	*Garra gotyla gotyla* (Gray)	+	-	-	-	+	-	+	-	-	-	VU
38	*Garra lamta* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	-	-	-	-	-	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
44	*Botia almorhe* Gray	-	-	-	-	-	-	-	-	-	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	+	-	-	-	-	-	+	-	-	-	
47	*Paraschistura montanus* (McClell.)	-	-	-	-	-	-	+	-	-	-	
48	*Schistura beavani* Gunther	-	-	-	-	+	-	-	-	-	-	
49	*Schistura savona* (Ham.)	-	-	-	-	-	-	-	-	-	-	
50	*Schistura denisonii* (Jerdon.)	-	-	-	-	-	-	-	-	-	-	
51	*Nemacheilus multifasciatus* Day	-	-	-	-	-	-	-	-	-	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	

55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	-	-	-	-	-	-	-	-	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	-	-	-	-	-	-	-	-	-	
60	*Glyptothorax madraspatanum* (Day)	-	-	+	-	-	-	-	-	-	-	
61	*Glyptothorax pectinopterus* (McClell.)	+	+	+	-	-	-	+	-	-	-	
62	*Glyptothorax telchitta* (Ham.)	+	-	+	-	-	-	-	-	-	-	VU
63	*Glyptothorax conirostris* (Steind.)	-	-	+	-	-	-	-	-	-	-	
64	*Glyptothorax cavia* (Ham.)	+	+	+	-	-	-	-	-	-	-	EN
65	*Glyptothorax trilineatis* Blyth	-	+	+	-	-	-	-	-	-	-	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	-	-	-	-	-	-	
67	*Glyptothorax brevipinnis* Hora	-	+	+	-	-	-	-	-	-	-	
68	*Pseudecheneis sulcatus* (McClell.)	-	+	+	-	-	-	-	-	-	-	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	-	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	-	

SL. NO	Name of the Fish Species	Khirao ganga	Kotbudha kedar	Kotlibhel IA (Bhagirathi)	Kotlibhel IB (Alaknanda)	Kotlibhel II	Lata Tapovan	Limchagad	Malari Jelam	Melkhet	Nandprayag Langasu	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	-	-	-	-	-	-	-	-	+	-	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	+	+	+	-	-	-	-	-	EN
4	*Tor putitora* (Ham.)	-	+	+	+	+	-	-	-	+	+	EN
5	*Tor chelinoides* (McClell.)	-	-	+	+	+	-	-	-	+	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	+	+	-	-	-	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	-	+	+	+	-	-	-	-	+	
8	*Labeo dero* (Ham.)	-	-	+	+	+	-	-	-	-	+	
9	*Labeo boga* (Ham.)	-	-	-	+	+	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	+	+	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	+	+	+	+	-	-	-	-	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	+	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	+	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	+	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	+	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	+	-	-	-	+	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	-	+	+	+	+	-	-	-	+	+	
19	*Barilius shacra* (Ham.)	-	+	+	+	-	-	-	-	-	-	
20	*Barilius barna* (Ham.)	-	+	+	+	+	-	-	-	+	+	
21	*Barilius barila* (Ham.)	-	+	+	+	+	-	-	-	+	+	
22	*Barilius vagra* (Ham.)	-	+	+	+	+	-	-	-	+	+	
23	*Raiamas bola* (Ham.)	-	-	+	+	-	-	-	-	-	-	
24	*Danio (Brachydanio) rerio*	-	-	-	-	+	-	-	-	-	-	

	(Ham.)											
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	+	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	+	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	-	+	+	+	+	-	-	-	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	+	+	+	+	-	-	-	+	+	
31	*Schizothorax progastus* (McClell.)	-	-	+	+	+	-	-	-	+	+	
32	*Schizothorax esocinus* Heckel	-	-	+	+	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	-	+	+	-	-	-	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	-	+	+	+	-	-	-	-	+	
35	*Schizothoraichthys curvifrons* (Heckel)	-	-	+	+	+	-	-	-	-	+	
36	*Schizothoraichthys planifrons* (Heckely)	-	+	+	+	-	-	-	-	-	-	
37	*Garra gotyla gotyla* (Gray)	-	+	+	+	+	-	-	-	+	-	VU
38	*Garra lamta* (Ham.)	-	-	+	+	+	-	-	-	-	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	+	+	+	-	-	-	-	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	+	+	+	-	-	-	-	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	+	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	+	+	+	-	-	-	-	-	VU
44	*Botia almorhe* Gray	-	-	+	+	+	-	-	-	-	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	+	-	-	-	-	-	
46	*Schistura rupicola* (McClell.)	-	+	+	+	+	-	-	-	+	-	
47	*Paraschistura montanus*	-	+	+	+	+	-	-	-	-	-	

	(McClell.)											
48	*Schistura beavani* Gunther	-	-	+	+	+	-	-	-	-	-	
49	*Schistura savona* (Ham.)	-	-	+	+	+	-	-	-	-	-	
50	*Schistura denisonii* (Jerdon.)	-	-	+	+	+	-	-	-	-	-	
51	*Nemacheilus multifasciatus* Day	-	+	+	+	+	-	-	-	-	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	+	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	
55	*Rita rita* (Ham.)	-	-	-	-	+	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	+	+	+	+	-	-	-	-	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	+	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	+	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	+	+	+	+	-	-	-	-	-	
60	*Glyptothorax madraspatanum* (Day)	-	+	+	+	+	-	-	-	-	+	
61	*Glyptothorax pectinopterus* (McClell.)	-	+	+	+	+	-	-	-	+	+	
62	*Glyptothorax telchitta* (Ham.)	-	-	+	+	+	-	-	-	+	-	VU
63	*Glyptothorax conirostris* (Steind.)	-	-	+	+	+	-	-	-	-	-	
64	*Glyptothorax cavia* (Ham.)	-	+	+	+	+	-	-	-	+	+	EN
65	*Glyptothorax trilineatis* Blyth	-	+	+	+	+	-	-	-	-	+	
66	*Glyptothorax kashmirensis* Hora	-	-	-	+	+	-	-	-	-	-	
67	*Glyptothorax brevipinnis* Hora	-	-	+	+	+	-	-	-	-	+	
68	*Pseudecheneis sulcatus* (McClell.)	-	+	+	+	+	-	-	-	-	+	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	+	+	-	-	-	-	-	-	
72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	

73	*Glyptothorax alaknandi*	-	-	-	+	+	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	+	+	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	-	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	-	-	

SL. NO	Name of the Fish Species	Pala Maneri	Pilangad -II	Rama bara	Rishiganga I	Rishiganga II	Siyangad	Suwarigad	Tamak Lata	Tehri stage-II	Urgam-II	NBFGR 2009
1	*Salmo trutta fario* Linnaeus	+	+	-	-	-	-	-	-	-	-	
2	*Salmo gairdnerii gairdnerii* Richardson	-	-	-	-	-	-	-	-	-	-	
3	*Tor tor* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
4	*Tor putitora* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
5	*Tor chelinoides* (McClell.)	-	-	-	-	-	-	-	-	+	-	
6	*Neolissochilus hexastrichus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
7	*Labeo dyocheilus* (McClell.)	-	-	-	-	-	-	-	-	+	-	
8	*Labeo dero* (Ham.)	-	-	-	-	-	-	-	-	+	-	
9	*Labeo boga* (Ham.)	-	-	-	-	-	-	-	-	-	-	
10	*Labeo bata* (Ham.)	-	-	-	-	-	-	-	-	-	-	
11	*Chagunius chagunio* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
12	*Puntius ticto* (Ham.)	-	-	-	-	-	-	-	-	-	-	
13	*Puntius conchonius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
14	*Puntius sophoue* (Ham.)	-	-	-	-	-	-	-	-	-	-	
15	*Puntius chola* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
16	*Puntius sarana* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
17	*Puntius phutunio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
18	*Barilius bendelisis* (Ham.)	+	+	-	-	-	-	+	-	+	-	
19	*Barilius shacra* (Ham.)	-	-	-	-	-	-	-	-	+	-	
20	*Barilius barna* (Ham.)	-	-	-	-	-	-	-	-	+	-	

21	*Barilius barila* (Ham.)	-	-	-	-	-	-	-	-	+	-	
22	*Barilius vagra* (Ham.)	-	-	-	-	-	-	-	-	+	-	
23	*Raiamas bola* (Ham.)	-	-	-	-	-	-	-	-	+	-	
24	*Danio (Brachydanio) rerio* (Ham.)	-	-	-	-	-	-	-	-	-	-	
25	*Devario aequipinnatus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
26	*Devario devario* (McClell.)	-	-	-	-	-	-	-	-	-	-	
27	*Esomus danricus* (Ham.)	-	-	-	-	-	-	-	-	-	-	
28	*Rasbora daniconius* (Ham.)	-	-	-	-	-	-	-	-	-	-	
29	*Schizothorax richardsonii* (Gray)	+	+	-	-	-	-	+	-	+	+	VU
30	*Schizothorax plagiostomus* Heckel	-	-	-	-	-	-	-	-	-	-	
31	*Schizothorax progastus* (McClell.)	-	-	-	-	-	-	-	-	-	-	
32	*Schizothorax esocinus* Heckel	-	-	-	-	-	-	-	-	-	-	
33	*Schizothoraichthys micropogon* (Heckel)	-	-	-	-	-	-	-	-	-	-	
34	*Schizothoraichthys longipinnis* (Heckel)	-	-	-	-	-	-	-	-	-	-	
35	*Schizothoraichthys curvifrons* (Heckel)	-	-	-	-	-	-	-	-	-	-	
36	*Schizothoraichthys planifrons* (Heckely)	-	-	-	-	-	-	-	-	+	-	
37	*Garra gotyla gotyla* (Gray)	+	+	-	-	-	-	+	-	+	-	VU
38	*Garra lamta* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
39	*Crossocheilus latius latius* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
40	*Psilorhynchus balitora* (Ham.)	-	-	-	-	-	-	-	-	+	-	
41	*Balitora brucei* Gray	-	-	-	-	-	-	-	-	-	-	
42	*Lepidocephalus guntea* (Ham.)	-	-	-	-	-	-	-	-	-	-	
43	*Botia dario* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
44	*Botia almorhe* Gray	-	-	-	-	-	-	-	-	+	-	
45	*Acanthacobitis botia* (Ham.)	-	-	-	-	-	-	-	-	-	-	

46	*Schistura rupicola* (McClell.)	+	+	-	-	-	-	-	-	+	-	
47	*Paraschistura montanus* (McClell.)	-	-	-	-	-	-	-	-	+	-	
48	*Schistura beavani* Gunther	-	-	-	-	-	-	-	-	+	-	
49	*Schistura savona* (Ham.)	-	-	-	-	-	-	-	-	+	-	
50	*Schistura denisonii* (Jerdon.)	-	-	-	-	-	-	-	-	+	-	
51	*Nemacheilus multifasciatus* Day	-	-	-	-	-	-	-	-	+	-	VU
52	*Nemacheilus scaturigina* (McClell.)	-	-	-	-	-	-	-	-	-	-	
53	*Schistura corica* (Ham.)	-	-	-	-	-	-	-	-	-	-	
54	*Mystus tengara (Ham.)*	-	-	-	-	-	-	-	-	-	-	
55	*Rita rita* (Ham.)	-	-	-	-	-	-	-	-	-	-	
56	*Clupisoma garua* (Ham.)	-	-	-	-	-	-	-	-	+	-	
57	*Amblyceps mangois* (Ham.)	-	-	-	-	-	-	-	-	-	-	EN
58	*Bagarius bagarius* (Ham.)	-	-	-	-	-	-	-	-	-	-	VU
59	*Parachiloganis hodgarti* (Hora)	-	-	-	-	-	-	-	-	+	-	
60	*Glyptothorax madraspatanum* (Day)	-	-	-	-	-	-	-	-	+	-	
61	*Glyptothorax pectinopterus* (McClell.)	+	+	-	-	-	-	-	-	+	-	
62	*Glyptothorax telchitta* (Ham.)	-	-	-	-	-	-	-	-	+	-	VU
63	*Glyptothorax conirostris* (Steind.)	-	-	-	-	-	-	-	-	+	-	
64	*Glyptothorax cavia* (Ham.)	-	-	-	-	-	-	-	-	+	-	EN
65	*Glyptothorax trilineatis* Blyth	-	-	-	-	-	-	-	-	+	-	
66	*Glyptothorax kashmirensis* Hora	-	-	-	-	-	-	-	-	+	-	
67	*Glyptothorax brevipinnis* Hora	-	-	-	-	-	-	-	-	+	-	
68	*Pseudecheneis sulcatus* (McClell.)	-	-	-	-	-	-	-	-	+	-	VU
69	*Xenetodon cancila* (Ham.)	-	-	-	-	-	-	-	-	-	-	
70	*Channa gachna* (Ham.)	-	-	-	-	-	-	-	-	-	-	
71	*Mastacembelus armatus* (Lacep.)	-	-	-	-	-	-	-	-	-	-	

72	*Trichogaster fasciatus* (Schn.)	-	-	-	-	-	-	-	-	-	-	
73	*Glyptothorax alaknandi*	-	-	-	-	-	-	-	-	-	-	
74	*Glyptothorax garhwali*	-	-	-	-	-	-	-	-	-	-	
75	*Cyprinus carpio carpio*	-	-	-	-	-	-	-	-	+	-	
76	*Ctenopharyngodon idella*	-	-	-	-	-	-	-	-	+	-	

Appendix 5.5

Distribution of birds in the sub-basins of Alaknanda and Bhagirathi basins

S.No.	Common Name	***Sub-basins*** / ***Scientific Name***	B-I	B-II	ASI	B-III	B-IV	BHI	BAL	A-I	MAN	A-II	PIN	NAN	BG	RG	DG	BYU	A-III	GAN
1	Black-faced Warbler	*Abroscopus schisticeps*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
2	Shikra	*Accipiter badius*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
3	Goshawk	*Accipiter gentilis*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
4	Eurasian Sparrowhawk	*Accipiter nisus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
5	Crested Goshawk	*Accipiter trivirgatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	Jungle Myna	*Acridotheres fuscus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	Common Myna	*Acridotheres tristis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Black-throated Tit	*Aegithalos concinnus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	White-throated Tit	*Aegithalos niveogularis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
10	Common iroa	*Aegithina tiphia*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
11	Cinereous Vulture	*Aegypius monachus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	Mrs Gould Sunbird	*Aethopyga gouldiae*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
13	Fire-tailed Sunbird	*Aethopyga ignicauda*	0	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
14	Green-tailed Sunbird	*Aethopyga nipalensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Black-throated Sunbird	*Aethopyga saturata*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
16	Crimson Sunbird	*Aethopyga siparaja*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
17	Common Kingfisher	*Alcedo atthis*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
18	White-browed Fulvetta	*Alcippe vinipectus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
19	Northern Pintail	*Anas acuta*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
20	Gadwall	*Anas strepera*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
21	Tawny Pipit	*Anthus campestris*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	Olive-backed Pipit	*Anthus hodgsoni*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	Rosy Pipit	*Anthus roseatus*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
24	Upland Pipit	*Anthus sylvanus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
25	Tree Pipit	*Anthus trivialis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
26	House Swift	*Apus affinis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	Common Swift	*Apus apus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
28	Fork-tailed Swift	*Apus pacificus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	Golden Eagle	*Aquila chrysaetos*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
30	Steppe eagle	*Aquila nipalensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	Hill Partridge	*Arborophila torqueola*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
32	Eurasian Skylark	*Atauda aruensis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	Spotted Owlet	*Athene barma*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
34	Spotted Bush Warbler	*Bradypterus thoracicus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
35	Eurasian Eagle Owl	*Bubo bubo*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
36	Spot-bellied eagle Owl	*Bubo nipalensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
37	Great Hornbill	*Buceros bicornis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

38	White-eyed Buzzard	*Butastur teesa*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
39	Upland Buzzard	*Buteo hemilasius*	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0
40	Longlegged Buzzard	*Buteo rufinus*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
41	Grey-bellied Cuckoo	*Cacomantis passerinus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
42	Sand Lark	*Calandrella raytal*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
43	Red-brown Finch	*Callacanthis burtoni*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
44	Indian Nightjar	*Caprimulgus asiaticus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
45	Large-tailed Nightjar	*Caprimulgus macrurus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
46	Grey Nightjar	*Caprimulugus indicus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
47	European Goldfinch	*Carduelis carduelis*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
48	Yellow-breasted Greenfinch	*Carduelis spinoides*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
49	Common Rose Finch	*Carpodacus erythrinus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	Dark-breasted Rosefinch	*Carpodacus nipalensis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
51	Beautiful Rosefinch	*Carpodacus pulcherrimus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
52	Pink-browed Rosefinch	*Carpodacus rhodochorus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
53	Spot-winged Rosefinch	*Carpodacus rhodopeplus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
54	White-browed Rosefinch	*Carpodacus thura*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
55	Cheer Pheasant	*Catreus wallichii*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	0	0	0
56	Rufous Woodpecker	*Celeus brachyurus*	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	1
57	Greater Coucal	*Centropus sinensis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
58	Fire-capped Tit	*Cephalopyrus flammiceps*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
59	Eurasian Treecreeper	*Certhia familiaris*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
60	Bar-tailed Treecreeper	*Certhia himalayana*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
61	Rusty-flanked Treecreeper	*Certhia nipalensis*	0	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
62	Pied Kingfisher	*Ceryle rudis*	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1
63	Grey-sided Bush Warbler	*Cettia brunnifrons*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
64	Aberrant Bush Warbler	*Cettia flavolivacea*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
65	Chestnut-crowned Bush Warbler	*Cettia major*	0	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
66	White-capped Redstart	*Chaimarrornis leucocephalus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
67	Emerald Dove	*Chalcophaps indica*	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
68	Orange-bellied Leafbird	*Chloropsis hardwickii*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
69	Yellow-eyed Babbler	*Chrysomma sinense*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
70	Brown Dipper	*Cinclus pallasii*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
71	Hen Harrier	*Circus cyaneus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	Red-Billed Blue Magpie	*Cissa erythrorhyncha*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
73	Yellow-billed Blue Magpie	*Cissa flavirostris*	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
74	Pied Cuckoo	*Clamator coromandus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
75	Himalayan Swiftlet	*Collocalia brevirostris*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
76	Speckled Wood Pigeon	*Columba hodgsonii*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
77	Snow Pigeon	*Columba leuconota*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
78	Rock Pigeon	*Columba livia*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
79	Hill Pigeon	*Columba rupestris*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

80	Oriental Magpie Robin	*Copsychus saularis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
81	Indian Roller	*Coracias benghalensis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
82	Large Cuckooshrike	*Coracina macei*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1
83	Black-winged Cuckoo Shrike	*Coracina melaschistos*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
84	Raven	*Corvus corax*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
85	Large-billed Crow	*Corvus macrorhynchos*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
86	House Crow	*Corvus splendens*	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
87	Common Quail	*Coturnix coturnix*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1
88	Eurasian Cuckoo	*Cuculus canorus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
89	Indian Cuckoo	*Cuculus micropterus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
90	Lesser Cuckoo	*Cuculus poliocephalus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
91	Oriental Cuckoo	*Cuculus saturatos*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
92	Large Hawk Cuckoo	*Cuculus sparveroides*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
93	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
94	Blue Throated Flycatcher	*Cyornis rubeculoides*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
95	Asian House Martin	*Delichon dasypus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
96	Nepal House Martin	*Delichon nipalensis*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
97	Northern House Martin	*Delicon urbica*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
98	Grey Treepie	*Dendrocitta formosae*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
99	Indian Treepie	*Dendrocitta vagabunda*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
100	Brown-fronted Woodpecker	*Dendrocopos auriceps*	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
101	Grey Capped Woodpecker	*Dendrocopos canicapillus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
102	Fluvorus-breasted Woodpecker	*Dendrocopos macei*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
103	Yellow crowned Woodpecker	*Dendrocopos mahrattensis*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
104	Himalyan Woodpecker	*Dendrocopus himalayensis*	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
105	Rufous-bellied Woodpecker	*Dendrocopus hyperythrus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
106	Thick-billed Flower pecker	*Dicaeum agile*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
107	Pale-billed Flower pecker	*Dicaeum erythrorhynchos*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
108	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
109	Bronzed Drongo	*Dicrurus aeneus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
110	Spangled Drongo	*Dicrurus hottentottus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
111	Ashy Drongo	*Dicrurus leucophaeus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
112	Black Drongo	*Dicrurus macrocercus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
113	Lesser Racket-tailed Drongo	*Dicrurus remifer*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
114	Himalayan Flameback	*Dinopium shorii*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
115	Tawny -bellied Babbler	*Dumetia hyperythra*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
116	Rock Bunting	*Emberiza cia*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
117	Pine Bunting	*Emberiza leucocephalus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
118	Little Bunting	*Emberiza pusilla*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
119	Reed Bunting	*Emberiza schoeniclus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
120	White-capped Bunting	*Emberiza stewarti*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
121	Black-backed Forktail	*Enicurus immaculatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1

122	Spotted Forktail	*Enicurus maculatus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
123	Slaty-backed Forktail	*Enicurus schistaceus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
124	Little Forktail	*Enicurus scouleri*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
125	Ashy-crowned Sparrow Lark	*Eremopterix grisea*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
126	Asian Koel	*Eudynamys scolopacea*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
127	Verditer Flycatcher	*Eumyias thalassina*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
128	Peregrine Falcon	*Falco peregrinus calidus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
129	Common Kestrel	*Falco tinnunculus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
130	Red-throated Flycatcher	*Ficedula (parva) parva*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
131	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
132	Ultramarine Flycatcher	*Ficedula superciliaris*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
133	Slaty-blue Flycatcher	*Ficedula tricolor*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
134	Black Francolin	*Francolinus francolinus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
135	Chaffinch	*Fringilla coelebs*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
136	Red Spurfowl	*Galloperdix spadicea*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
137	Red Junglefowl	*Gallus gallus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
138	White-throated Laughingthrush	*Garrulax albogularis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
139	Chestnut-crowned Laughingthrush	*Garrulax erythrocephalus*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
140	White crested Laughing Thrush	*Garrulax leucolophus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
141	Streaked Laughingthrush	*Garrulax lineatus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
142	Spotted Laughingthrush	*Garrulax ocellanutus*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
143	Greater-neckalced Laughingthrush	*Garrulax pectoralis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
144	Rufous-gorgeted Laughing Thrush	*Garrulax rufogularis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
145	Striated Laughingthrush	*Garrulax striatus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
146	Variegated Laughingthrush	*Garrulax variegatus*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
147	Eurasian Jay	*Garrulus glandarius*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
148	Black-headed Jay	*Garrulus lanceolatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
149	Asian-barred Owlet	*Glaucidium cuculoides*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
150	Jungle Owlet	*Glaucidium radiatum*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
151	Grandala	*Grandala coelicolor*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1
152	Lammergeier	*Gypaetus barbatus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
153	Indian White-backed Vulture	*Gyps bengalensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
154	Eurasian Griffon	*Gyps fulvus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
155	Himalayan Griffon	*Gyps himalayensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
156	Scarlet Finch	*Haematospiza sipahi*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
157	White-throated Kingfisher	*Halycon smyrnensis*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
158	Crested Treeswift	*Hemiprocne coronata*	0	1	1	0	0	1	1	0	1	1	1	1	1	0	0	0	0	1
159	Bar-winged Flycatcher Shrike	*Hemipus picatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
160	Rufous Sibia	*Heterophasia capistrata*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
161	Booted Hawk Eagle	*Hieraateus bennatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
162	Commom Hawk Cuckoo	*Hierococyx varius*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
163	White Throated Niddletail	*Hirundapus caudacutus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

164	Dusky Crag Martin	*Hirundo concolor*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
165	Red-rumped Swallow	*Hirundo daurica*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
166	Streak Throated Swallow	*Hirundo fluvicola*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
167	Eurasian Crag Martin	*Hirundo rupestris*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
168	Barn Swallow	*Hirundo rustica*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
169	White-bellied Redstart	*Hodgsonius phaenicuroides*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
170	Black Bulbul	*Hypsipetes leucocephalus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
171	Black Eagle	*Ictinaetus malayensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
172	Yellow-rumped Honeyguide	*Indicator xanthonotus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
173	Brown Shrike	*Lanius cristatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
174	Great Grey Shrike	*Lanius excubitor*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
175	Long-tailed Shrike	*Lanius schach*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
176	Red-billed Leiothrix	*Leiothrix lutea*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
177	Snow Partridge	*Lerwa lerwa*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
178	Plain Mountain Finch	*Leucosticte nemoricola*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
179	Black-headed Munia	*Lonchura malacca*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
180	Scaly-breasted Munia	*Lonchura punctulata*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
181	White-rumped Munia	*Lonchura striata*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
182	Himalayan Monal	*Lophophorus impejanus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
183	Kalij Pheasant	*Lophura leucomelanos*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
184	White-tailed Rubby Throat	*Luscinia pectoralis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
185	Crested Kingfisher	*Megaceryle lugubris*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
186	Blue-throated Barbet	*Megalaima asiatica*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
187	Copper-smith Barbet	*Megalaima haemacephala*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
188	Lineated Barbet	*Megalaima lineata*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
189	Great Barbet	*Megalaima virens*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
190	Brown-headed Barbet	*Megalaima zeylanica*	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1
191	Crested Bunting	*Melophus lathami*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
192	Chestnut-headed Bee-eater	*Merops leschenaulti*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
193	Green Bee-eater	*Merops orientalis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
194	Blue tailed Bee-eater	*Merops philippinus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
195	Black Kite	*Milvus migrans*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
196	Bar-throated Minla	*Minla strigula*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
197	Blue-capped Rock Thrush	*Monticola cinclorhynchus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
198	Chestnut-bellied Rock Thrush	*Monticola rufiventris*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
199	White Wagtail	*Motacilla alba*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
200	Grey Wagtail	*Motacilla cinerea*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
201	Yellow Wagtail	*Motacilla flava beema*	1	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
202	Asian brown Flycatcher	*Muscicapa dauurica*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
203	Rusty-tailed Flycatcher	*Muscicapa ruficauda*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
204	Dark-sided Flycatcher	*Muscicapa sibrica*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
205	Collared Grosbeak	*Mycerobas affinis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0

206	White-winged Grosbeak	*Mycerobas carnipes*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
207	Black-and-yellow Grosbeak	*Mycerobas icterioides*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
208	Spot-winged Grosbeak	*Mycerobas melanozanthos*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
209	Blue Whistling Thrush	*Myiophonus caeruleus*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
210	Purple Sunbird	*Nectarinia asiatica*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
211	Egyptian Vulture	*Neophron percnopterus*	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
212	Small Niltava	*Niltava macgrigoriae*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
213	Rufous-bellied Niltava	*Niltava sundara*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
214	Brown Hawk Owl	*Ninox scutulata*	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
215	Spotted Nutcracker	*Nucifraga caryocatactes*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
216	Blue-beared Bee-eater	*Nyctyornis athertoni*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
217	Indian Grey Hornbill	*Ocyceros birostris*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
218	Eurasian Golden Oriole	*Oriolus orilus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
219	Maroon Oriole	*Oriolus traillii*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
220	Black Hooded Oriole	*Oriolus xanthornus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
221	Common Tailorbird	*Orthotomus sutorius*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
222	Collared Scops Owl	*Otus bakkamoena*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
223	Mountain Scops Owl	*Otus spilocephalus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
224	Coal Tit	*Parus ater*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
225	Grey-crested Tit	*Parus dichrous*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
226	Great Tit	*Parus major*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
227	Spot-winged Tit	*Parus melanolophus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
228	Green-backed Tit	*Parus monticolus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
229	Rufous-vented Tit	*Parus rubidiventris*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
230	Rufous-naped Tit	*Parus rufonuchalis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
231	Black-lored Tit	*Parus xanthogenys*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
232	House Sparrow	*Passer domesticus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
233	Eurasian Sparrow	*Passer montanus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
234	Russet Sparrow	*Passer rutilans*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
235	Indian Peafowl	*Pavo cristatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
236	Puff-throated Babbler	*Pellorueum ruficeps*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
237	Jungle Bush Quail	*Perdicula asiatica*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
238	Small Minivet	*Pericrocotus cinnamoneus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
239	Long-tailed Minivet	*Pericrocotus ethologus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
240	Scarlet Minivet	*Pericrocotus flammeus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
241	Oriental Honey-Buzzard	*Pernis ptilorhynchus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
242	Chestnut Shouldered Petronia	*Petronia xanthocollis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
243	Sirkeer Malkoha	*Phaenicophaceus leschenaultii*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
244	Great Cormorant	*Phalacrocorax carbo*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
245	Blue-capped Redstart	*Phoenicurus caeruleocephala*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
246	Blue-fronted Redstart	*Phoenicurus frontalis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
247	Black Redstart	*Phoenicurus ochrurus*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0

248	Tickell's Leaf Warbler	*Phylloscopus affinis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
249	Yellow-vented Warbler	*Phylloscopus cantator*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
250	Common Chiff-chaff	*Phylloscopus collybita*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
251	Sulphur-bellied Warbler	*Phylloscopus griseolus*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
252	Ashy-throated Warbler	*Phylloscopus maculipennis*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
253	Large-billed Leaf Warbler	*Phylloscopus magnirostris*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
254	Plain Leaf Warbler	*Phylloscopus neglectus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
255	Western Crowned Warbler	*Phylloscopus occipitalis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
256	Lemon-rumped Warbler	*Phylloscopus proregulus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
257	Buff-barred Leaf Warbler	*Phylloscopus pulcher*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
258	Blyth's Leaf Warbler	*Phylloscopus reguloides*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
259	Brooks's Leaf Warbler	*Phylloscopus subviridis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
260	Greenish Warbler	*Phylloscopus trochiloides*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
261	Speckled Piculet	*Picumnus innominatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
262	Grey-headed Woodpecker	*Picus canus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
263	Lesser Yellownape	*Picus chlorolophus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
264	Greater Yellownape	*Picus flavinucha*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
265	Scaly-bellied Woodpecker	*Picus squamatus*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
266	Streak-throated Woodpecker	*Picus xanthopygaeus*	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1
267	Indian Pita	*Pitta brachyura*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
268	Scaly-breasted Wren Babbler	*Pnoepyga albiventer*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
269	Baya Beaver	*Polceusphilippinus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
270	Rusty-cheeked Scimitar Babbler	*Pomatorhinus erythrogenys*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
271	White-browned Scimilta Babbler	*Pomatorhinus schisticeps*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
272	Grey-cromed Prinia	*Prinia cinereocapilla*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
273	Brown-hill warbler	*Prinia ciniger*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
274	Grey Breasted Prinia	*Prinia hodgsonii*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
275	Ashy Prinia	*Prinia socialis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
276	Plain Prinia	*Prinia subflava*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
277	Jungle Prinia	*Prinia sylvatica*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
278	Alpine Accentor	*Prunella collaris*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
279	Altai Accentor	*Prunella himalayana*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
280	Robin accentor	*Prunella ruberculoides*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
281	Rufous-breasted Accentor	*Prunella strophiata*	1	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
282	Plum-headed Parakeet	*Psittacula cyanocephala*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
283	Alexandrine Parakeet	*Psittacula eupatria*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
284	Slaty-headed Parakeet	*Psittacula himalayana*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
285	Rose-ringed Parakeet	*Psittacula krameri*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
286	Black-headed Shrike-Babbler	*Pteruthius rufiventer*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
287	Koklass Pheasant	*Pucrasia macrolopha*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
288	Red-vented Bulbul	*Pycnonotus cafer*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
289	Red-whiskered Bulbul	*Pycnonotus jocosus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

290	Himalayan Bulbul	*Pycnonotus leucogenys*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
291	Black-crested Bulbul	*Pycnonotus melanicterus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
292	Yellow-billed Chough	*Pyrrhocorax graculus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
293	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	1	0	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
294	Red-headed Bullfinch	*Pyrrhula erythrocephala*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
295	White-throated Fintail	*Rhipidura albicollis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
296	Yellow-bellied Fantail	*Rhipidura hypoxantha*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
297	Plain Martin	*Riparia paludicola*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
298	Sand Martin	*Riparia riparia*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
299	Red-headed Vulture	*Sarcogyps calvus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
300	Spot-winged Starling	*Saroglossa spiloptera*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
301	Pied Bushchat	*Saxicola caprata*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
302	Grey Bushchat	*Saxicola ferreus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
303	Common Stonechat	*Saxicola torquatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
304	Eurasian Woodcock	*Scolopax rusticola*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
305	White-spectacled Warbler	*Seicercus affinis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
306	Golden-spectacled Warbler	*Seicercus burkii*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
307	Grey-hooded Warbler	*Seicercus xanthoschistos*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
308	Fire-fronted Serin	*Serinus pusilus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
309	Chestnut-bellied Nuthatch	*Sitta castanea*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
310	Velvet-fronted Nuthatch	*Sitta frontalis*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
311	White-tailed Nuthatch	*Sitta himalayensis*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
312	White-cheeked Nuthatch	*Sitta leucopsis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
313	Crested Serpent-Eagle	*Spilornis klossi*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
314	Changeable Hawk Eagle	*Spizaetus cirrhatus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
315	Mountain Hawk Eagle	*Spizaetus nipalensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
316	Black-chinned Babbler	*Stachyris pyrrhops*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
317	Spotted Dove	*Streptopelia chinensis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
318	Eurasian Collared Dove	*Streptopelia dacaocto*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
319	Oriental Turtle Dove	*Streptopelia orientalis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
320	Laughing Dove	*Streptopelia senegalensis*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
321	Red-collared Dove	*Streptopelia tranquebarica*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
322	Tawny Owl	*Strix aluco*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
323	Asian Pied Starling	*Sturnus contra*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
324	Chestnut -tailed Starling	*Sturnus malabaricus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
325	Brahminy Starling	*Sturnus pagodarum*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
326	Common Starling	*Sturnus vulgaris*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
327	Drongo Cuckoo	*Surniculus lugubris*	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1
328	Yellow-browed Tit	*Sylviparus modestus*	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
329	Alpine Swift	*Tachymarptis melba*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
330	Golden Bush Robin	*Tarsiger chrysaeus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
331	Orange-flanked Bush Robin	*Tarsiger cyanurus*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0

332	White-browed Bush Robin	*Tarsiger indicus*	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
333	Asian Paradise-Flycatcher	*Terpsiphone paradisi*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
334	Chestnut-headed Tesia	*Tesia castaneocoronata*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
335	Himalayan Snowcock	*Tetraogallus himalayensis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
336	Wallcreeper	*Tichodroma muraria*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
337	Western Tragopan	*Tragopan melanocephalus*	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
338	Pin-tailed Green Pigeon	*Treron apicauda*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
339	Yellow-footed Green Pigeon	*Treron phoenicoptera*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
340	Wedge-tailed Green pigeon	*Treron sphenura*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
341	Winter Wren	*Trogolodytes trogolodytes*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
342	Common babbler	*Turdoides caudarus*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
343	Large Grey Babbler	*Turdoides malcohni*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
344	Jungle Babbler	*Turdoides striatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
345	White-collared Blackbird	*Turdus albocinctus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
346	Grey-winged Blackbird	*Turdus boulboul*	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
347	Eurasian Blackbird	*Turdus merula*	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
348	Chestnut Thrush	*Turdus rubrocanus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
349	Dark-throated Thrush	*Turdus ruficollis atrogularis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
350	Tickell's Thrush	*Turdus unicolor*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
351	Mistle Thrush	*Turdus viscivorus*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
352	Yellow-legged Button Quail	*Turnix tanki*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
353	Common Hoopoe	*Upupa epops*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
354	Red-wattled Lapwing	*Vanellus cinerus*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
355	River Lapwing	*Vanellus duvaucelii*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
356	Whiskered Yuhina	*Yuhina flavicollis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
357	Stripe-throated Yuhina	*Yuhina gularis*	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
358	Black-chinned Yuhina	*Yuhina nigrimenta*	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
359	White-bellied Yuhina	*Yuhina zantholeuca*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
360	Small-billed Mountain Thrush	*Zoothera dauma*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
361	Plain-backed Thrush	*Zoothera mollissima*	1	1	0	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
362	Long-billed Thrush	*Zoothera monticola*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
363	Pied Thrush	*Zoothera wardii*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
364	Oriental White-eye	*Zosterops palpebrosus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Abb: B-I: Bhagirathi I; **B-II:** Bhagirathi II; **ASI:** Asiganga; **B-III:** Bhagirathi III; **B-IV:** Bhagirathi IV; **BHI:** Bhilangana; **BAL:** Balganga; **A-I:** Alaknanda I; **MAN:** Mandakini; **A-II** Alaknanda II; **PIN:** Pindar; **NAN:** Nandakini; **BG:** Birahi Ganga; **RG:** Rishi Ganga; **DG:** Dhauli Ganga; **BYU:** Bhyundar Ganga; **A-III:** Alaknanda III; and **GAN:** Ganga Basin.

Distribution of mammals in the sub-basins of Alaknanda and Bhagirathi basins

S.no	MAMMAALS	B-I	B-II	ASI	B-III	B-IV	BHI	BAL	A-I	MAN	A-II	PIN	NAN	BG	RG	DG	BYU	A-III	GAN
1	Hodgson's brown-toothed shrew	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
2	Himalayan white-toothed shrew	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	White toothed shrew	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	Rhesus macaque	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	Common langur	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	Golden jackal	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
7	Red fox	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
8	Asiatic black bear	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0
9	Himalayan brown bear	1	0	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	0
10	Himalayan Weasal	1	1	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
11	Himalayan yellow throated marten	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	Beech marten	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
13	Large Indian Civet	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	Small Indian Civet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Himalayan masked palm civet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	Leopard cat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	Jungle cat	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	Common leopard	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	Snow leopard	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0
20	Wild pig	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
21	Himalayan musk deer	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
22	Barking deer	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	Sambar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	Himalayan goral	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	Serow	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
26	Himalayan tahr	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
27	Red giant flying squirrel	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0

Distribution of mammals in the sub-basins of Alaknanda and Bhagirathi basins

28	Parti-coloured Flying squirrel	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
29	Royle's mountain vole	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
30	Wood mouse	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
31	Crested porcupine	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0
32	Himalayan mouse hare	1	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	0
33	Smooth-coated Otter	0	?	?	?	?	?	?	1	?	?	?	?	?	0	0	0	0	?
34	Blue Sheep	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
35	Tibetan wolf	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0

Abb: B-I: Bhagirathi I; **B-II:** Bhagirathi II; **ASI:** Asiganga; **B-III:** Bhagirathi III; **B-IV:** Bhagirathi IV; **BHI:** Bhilangana; **BAL:** Balganga; **A-I:** Alaknanda I; **MAN:** Mandakini; **A-II** Alaknanda II; **PIN:** Pindar; **NAN:** Nandakini; **BG:** Birahi Ganga; **RG:** Rishi Ganga; **DG:** Dhauli Ganga; **BYU:** Bhyundar Ganga; **A-III:** Alaknanda III; and **GAN:** Ganga Basin.

Appendix 5.7

Distribution of mammals in the zones of influence of hydroelectric projects of Alaknanda and Bhagirathi basins

SNO	NAME_OF_PR	HBTS	HWTS	WTS	RM	CL	GJ	RF	ABB	HBB	HW	YTM	BM	LIC	SIC	MPC	LC	JC	CL	SL	WP	HMD	BD	SM	HG	SE	HT	GFS	PFS	RMV	WM	CP	HMH	SCO	BS	TW
1	Alaknanda	√	√	√		√			√	√	√	√	√			√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
2	Alaknanda-II	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
3	Bhyundar ganga	√	√	√	√	√			√			√	√		√	√	√	√	√		√		√	√	√	√	√	√				√				√
4	Birahi Ganga		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
5	Birahi Ganga-I		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√									
6	Birahi Ganga-II		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
7	Bowla Nandprayag		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√		√							?		
8	Debal		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√							?		
9	Devali		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
10	Devsari		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√							?		
11	Gangani		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
12	Gohan tal		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
13	Jelam Tamak	√	√	√		√			√	√	√	√	√			√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
14	Jummagad		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√											
15	Kakoragad	√	√	√		√			√		√	√	√			√	√		√		√	√	√	√	√	√	√	√	√	√	√	√	√			
16	Kaliganaga		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√									
17	Kaliganga-I									√									√			√					√									√
18	Kaliganga-II							√		√									√			√					√									√
19	Khirao ganga	√				√		√	√	√	√	√	√						√	√		√		√	√	√	√	√	√	√	√	√			√	√
20	Kotli Bhel 1 B		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
21	Kotli Bhel 2		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									√		
22	Lata Tapovan	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√	√	√	√				√				√
23	Madhmaheshwar		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√		√									
24	Malari Jelam	√	√	√		√			√	√	√	√	√			√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√
25	Melkhet		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√									
26	Nandprayag Langasu		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
27	Phata Byung		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
28	Rajwakti		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
29	Rambara	√	√	√		√			√	√	√	√	√			√	√		√		√	√	√	√	√	√	√	√	√	√	√	√	√			√
30	Rishiganga I	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√	√	√	√				√				√
31	Rishiganga II	√	√	√	√	√			√			√	√		√	√	√		√		√		√	√	√	√	√	√				√				√
32	Singoli Bhatwari		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
33	Srinagar		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									√		
34	Tamak Lata	√	√	√		√			√		√	√	√		√	√	√		√		√	√	√	√	√	√	√	√				√				√
35	Tapovan Vishnugad	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
36	Urgam		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√									
37	Urgam-II		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√		√					√				
38	Vanala		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√											

39	Vishnugad Pipalkoti		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√											
40	Vishnuprayag	√	√	√	√	√			√			√	√		√	√	√		√		√		√	√	√	√	√	√				√				
41	Agunda Thati		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
42	Asiganga I		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√											
43	Asiganga II		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√		√									
44	Asiganga III		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√		√									
45	Balganga II		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√											
46	Bharoghati	√	√	√		√			√		√	√	√		√	√	√		√		√	√	√	√	√	√	√	√				√	√			
47	Bhilangana		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
48	Bhilangana II A		√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
49	Bhilangana II B		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√		√							?		
50	Bhilangana II C		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√									?		
51	Bhilangana III		√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√			√				√				
52	Jalandharigad	√	√	√	√	√			√			√	√		√	√	√		√		√		√	√	√	√	√	√				√				
53	Jhalakoti		√	√	√	√			√			√	√	√	√	√	√	√	√		√	√	√	√	√		√	√				√				
54	Kaldigad	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
55	Karmoli					√		√	√	√	√	√	√						√	√		√		√	√	√	√	√	√	√	√	√	√		√	√
56	Kot budhakedar		√	√	√	√	√		√			√	√	√	√	√	√	√	√		√		√	√	√									?		
57	Koteshwar		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
58	Kotli Bhel 1A		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
59	Limchagad	√	√	√		√			√		√	√	√		√	√	√		√		√	√	√	√	√	√	√	√				√				
60	Lohari nagpala	√	√	√		√			√			√	√	√	√	√	√	√	√		√		√	√	√	√	√	√				√				
61	Maneri Bhali I		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√											
62	Maneri bhali II		√	√	√	√	√		√			√		√	√	√	√	√	√		√		√	√	√											
63	Jadhganga	√	√	√		√			√	√	√	√	√				√		√	√	√	√		√	√	√	√	√	√	√	√	√	√		√	√
64	Pala Maneri		√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√			√				√				
65	Pilangad		√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√											
66	Pilangad-II	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√		√	√				√				
67	Siyangad	√	√	√		√			√	√	√	√	√				√		√		√	√	√	√	√	√	√	√	√	√	√	√	√			
68	Suwari gad	√	√	√	√	√			√			√	√	√	√	√	√	√	√		√		√	√	√	√	√	√				√				
69	Tehri stage I		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		
70	Tehri stage II		√	√	√	√	√					√		√	√	√	√	√	√		√		√	√	√									?		

Abb: HBTS: Hodgson's brown-toothed shrew; **HWTS:** Himalayan white-toothed shrew; **WTS:** White toothed shrew; **RM:** Rhesus macaque; **CL:** Common langur; **GJ:** Golden jackal; **RF:** Red fox; **ABB:** Asiatic black bear; **HBB:** Himalayan brown bear; **HW:** Himalayan Weasal; **YTM:** Himalayan yellow throated marten; **BM:** Beech marten; **LIC:** Large Indian Civet; **SIC:** Small Indian Civet; **MPC:** Himalayan masked palm civet; **LC:** Leopard cat; **JC:** Jungle cat; **CL:** Common leopard; **SL:** Snow leopard; **WP:** Wild pig; **HMD:** Himalayan musk deer; **BD:** Barking deer; **SM:** Sambar; **HG:** Himalayan goral; **SE:** Serow; **HT:** Himalayan tahr; **GFS:** Red giant flying squirrel; **PFS:** Parti-coloured Flying squirrel; **RMV: Royle's** mountain vole; **WM:** Wood mouse; **CP:** Crested porcupine; **HMH:** Himalayan mouse hare; **SCO:** Smooth-coated Otter; **BS:** Blue Sheep; and **TW:** Tibetan wolf.

Appendix. 5.8

Floristic composition of all HEP sites in the Alaknanda & Bhagirathi basins.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
1	Kotlibhel IA HE Project	30^{0}10’12”	78^{0}35’40”	Himalayan subtropical scrub	*Acacia catechu* (L.f.) Willd., *Anogeissus latifolia* (Roxb. Ex Dc) Wallich ex Guill. & Perr., *Holoptelea integrifolia* (Roxb.) Planch., *Lannea coromandelica* (Houtt.) Merr., *Pinus roxburghii* Sarg. (L.f.) Willd.		*Acacia catechu* (L.f.) Willd., *Mallotus phillippensis* (Lam.) muell., *Syzygium cumini* (L.) Skeels., *Diospyros montana* Roxb., *Aegle marmelos* (L.) Corr., *Adhatoda zeylanica* Smith, *Asparagus adscendens* (L.) Corr., *Cannabis sativa* L., *Colebrookia oppositifolia* J.E. Smith., *Murraya koenigii* (L.) Spreng., *Woodfordia fruticosa* (L.) Kurz.
2	Kotlibhel IB HE Project	30^{0}11’1.2”	78^{0}37’39”	Himalayan subtropical scrub	*Acacia catechu* (L.f.) Willd, *Aegle marmelos* (L.) Corr., *Anogeisus latifolia* (Roxb. Ex Dc) Wallich ex Guill. & Perr. *Dalbergia sissoo* Roxb., *Diospyros montana* Roxb., *Haldina cordifolia* (Roxb.) Rid sdale., *Mallotus philippensis* (Lam.) muell.		*Terminalia chebula* Retz., *Terminalia bellirica* (Gaertn.) Roxb., *Terminalia alata* Heyhecx Roth., *Aegle marmelos* (L.) Corr, *Haldina cordifolia* (Roxb.) Rid sdale., *Bidens pilosa* L., *Chenopodium album* L.
3	Kotlibhel II HE Project	30^{0}3’52”	78^{0}29’59”	Moist Siwalik sal forests	*Shorea robusta* Gaertn. *Tectona grandis* L.f., *Holoptelea integrifolia* (Roxb.) Planch., *Lannea coromandelica* (Houtt.) Merr., *Mallotus phillippensis* (Lam.) muell. *& Pinus roxburghii* Sarg. (L.f.) Willd etc.	*Catamixis baccharoides* Thomson.	*Diospyros montana* Roxb., *Adhatoda vasica* Nees., *Cassia tora* L., *Desmodium laxiflorum* DC., *Pogostemon benghalense* (Burm.f.) Kuntz., *Reinwardtia indica* Dumert., *Ageratum conyzoides* L., *Amaranthus viridis* L., *Bupleurum falcatum* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
4	Visnugad Pipalkoti HE Project	$30^0$30'50"	$79^0$29'30"	Banj oak forests	*Albizia lebbeck* (L.) Benth., *Alnus nepalensis* D.Don, *Bombax ceiba* L., *Cupressus torulosa* D.Don, Ficus *palmata* Forssk, *Pinus roxburghii* Sarg. (L.f.) Willd, *Populus ciliata* Wallich ex Royle, *Quercus leucotrichophora* Cams.	*Bergenia ligulata* (Wallich) Engl., *Hedychium spicatum* Buch-Ham ex J.E.Sm., *Thalictrum foliolosum* DC.	*Aegle marmelos* (L.) Corr., *Digitalis purpurea* L., *Emblica officinalis* Gaertn., *Ficus palmata* Forrsk., *Sapindus mukorossi* Gaerth., *Ocimum basilicum* L., *Adhatoda vasica* Nees. *Bergenia ciliata* (Wallich) Engl., *Hedychium spicatum* Buch-Ham. Ex J.E Sm., *Centella asiatica* (L.) Urban.
5	Alaknanda HE Poject.	$30^0$43'24"	$79^0$29'42"	Western mixed conifer forests	*Populus ciliata* Wallich ex Royle., *Salix disperma* Roxb. ex D.Don, *Abies pindrow* Royle., *Hippophae salicifolia* L.,*Cedrus deodara* (Roxb. ex Lambert.) G,Don., *Pinus wallichiana* A.B. Jackson., *Taxus baccata* L., *Betula alnoides* Buch.-Ham ex D.Don	*Allium stracheyi* Baker., *Hedysarum microcalyx* Baker., *Aconitum heterophyllum* Wallich., *Carum carvi* L.,*Epilobium latifolium* L., *Dactylorhiza hatagirea* (D.Don) Soo.	*Aconitum heterophyllum* Wallich., *Asparagus filicinus* Buch-Ham ex D.Don., *Berberis aristata* DC., *Carum carvi* L., *Delphinium denudatum* Wallich ex Hook.f., *Hedychium spicatum* Buch-Ham Ex J.Esm., *Juniperus indica* Bertol.,*Prinsepia utilis* Royle, *Viola biflora* L.
6	Srinagar HE Project.	$30^0$14'0"	$78^0$50'0"	Himalayan Chir Pine Forests	*Aegle marmelos* (L.) Corr, *Lannea cormondelica* (Houtt.) Merr, *Mallotus philippensis* (Lam.) muell, *Syzygium cumini* (L.) Skeels, *Dalbergia sissoo* Roxb.. *Bauhinia purpurea* L., *Acacia catechu* (L.P.)Willd.		*Azadirachta indica* A. Juss., *Cassia fistula* L., *Mallotus philippensis* (Lam) Muell., *Sapindus mukorossi* Gaertn., *Terminalia bellirica* (Gaertn) Roxb., *Terminalia alata* Heyne ex Roth. , *Terminalia chebula* Retz., *Asparagus adscendens* Roxb., *Berberis asiatica* Roxb. ex DC., *Sida cordifolia* L., *Ageratum conyzoides* L., *Ajuga bracteosa* Wallich ex Benth., *Argemone mexicana* L.,

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
							Datura stramonium L, *Ocimum sanctum* L, *Solanum nigrum* L, *Verbascum thapsus* L.
7	Devsari HE project.	$30^0$2'35"	$79^0$34'17"	Himalayan Chir Pine Forests	*Pinus roxburghii* Sarg. (L.f.) Willd., *Quercus leucotrichophora* A.camus., *Toona ciliata* M.Roem., *Terminalia alata*, *Lyonia ovalifolia* (Wallich) Drude., *Alnus nepalensis* D.Don, *Rhus wallichii* Hook.f.	*Datisca cannabina* L.	*Buddleia asiatica* Lour., *Cinnamomum tamala* Nees., *Mallotus philippensis* (Lam) Muell. *Spondias pinnata* (L.f.) Kurz., *Artemisia nilagirica* (C.B.Clarke), *Aspargus adscendens* Roxb., *Berberis asiatica* Roxb ex DC., , *Indigofera cassioides* Rottl. ex DC., *Juniperus communis* L., *Woodfordia fruticosa* (L.) Kurz., *Xanthoxylum armatum* DC., *Anaphalis adnata* DC., *Conyza aegyptiaca* (L.) Aiton., *Verbascum thapus* L.
8	Nandprayag HE project.	$30^0$19'30"	$79^0$18'20"	Himalayan Chir Pine Forests	*Pinus roxburghii* Sarg. (L.f.) Willd., *Sapium insigne* (Royle) Kurz., *Sygium cumini* (L.) Skeels, *Melia azederach* L., *Albizia lebbeck* (L.) Benth.		*Agave americana* L., *Adhatoda zeylanica* J.E. Smith, *Artemisia niligirica* (C.B.Clarke) Pamp., *Verbascum thapus* L., *Bergenia ciliata* (Haw.) Sternb., *Cannabis sativa* L., *Rubus ellipticus* Smith.
9.	Jhelum – Tamak HE Project.	$30^0$38'45"	$79^0$49'57"	Low-level blue pine forest	*Populus ciliata Wall. ex Royle*, *Pinus wallichiana* A.B Jackson, *Cupressus torulosa* D.Don, *Prunus nepalensis* (Ser.) Stend., *Pyrus malus* L., *Salix wallichiana* Roxb. ex D.Don, *Cedrus deodara* (Roxb. ex Lambert) G.Don.	*Allium stracheyi* Baker., *Acer caesium* Wall. ex D.Don, *Arenaria curvifolia* Majumdar, *Saussurea costus* (Falc.) Lipch., *Taxus baccata* L., *Arenaria ferruginea* Duthie	*Aconitum heterophyllum* Wall., *Aconitum balfouri* Stapf., *Berberis aristata* DC., *Echinops cornigerus* DC., *Fagopyrum ecsulentum* Monech., *Jasminum humile* L., *Rosa macrophylla* Lindl., *Hippophae salicifolia*., *Viola*

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
						ex Williams., *Berberis petiolaris* Wall. ex G.Don., *Calamagrostis garhwalensis* C.E Hubb. & Bor., *Carex nandadeviensis* Ghildyal.	*betonicifolia* L., *Picrorhiza kurrooa* Royle,
10.	Malari-Jhelum HE Project.	30^{0}40'54"	79^{0}53'4.5"	Low-level blue pine forest	*Abies pindrow* Royle, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Pinus wallichiana* A.B Jackson, *Taxus baccata* L., *Picea smithiana* Wall.	*Allium stracheyi* Baker., *Acer caesium* Wall. ex D.Don, *Arenaria curvifolia* Majumdar, *Saussurea costus* (Falc.) Lipch., *Taxus baccata* L., *Arenaria ferruginea* Duthie ex Williams. , *Berberis petiolaris* Wallich ex G.Don., *Calamagrostis garhwalensis* C.E Hubb. & Bor., *Carex nandadeviensis* Ghildyal	*Aconitum heterophyllum* Wall. *Aconitum balfouri* Stapf., *Allium humile* Kunth., *Bergenia ciliata* (Haw.) Sternb. *Carum carvi* L., *Centella asiatica* (L.) Urban., *Picrorhiza kurrooa* Royle., *Nardostachys grandiflora* DC.
11	Pala Maneri HE project	30^{0}54'50"	78^{0}40'50"	Dry temperate conifer forests	*Alnus nepalensis* D.Don., *Betula alnoides* Buch.-Ham.ex D.Don., *Cedrus deodara* (Roxb. ex lambert.) G.Don., *Cuppresus torulosa* D.Don., *Dalbergia sericea* G.Don., *Juglans regia* L., *Lyonia ovalifolia* (Wall.) Drude. *Pinus roxburghii* Sarg. (L.P.) Willd, *Populus ciliata* Wall. ex Royle, *Prunus cerasoides* D.Don., *Quercus leucotrichophora* A.Camus., *Rhododendron*	*Caragana sukiensis* Schn., *Datisca cannabina* L., *Picrorhiza kurrooa* Royle ex Benth.	*Celtis australis* L., *Flacourtia indica* (Burm.P.) Merr., *Rhus chinensis* Mill., *Toona ciliata* M.Roem., *Artemisia nilagirica* (C.B.Clarke) Pamp., *Berberis asiatica* Roxb. ex DC., *Berbesis aristata* DC., *Urtica dioica* L., *Bidens pilosa* Guet. Hon Linn., *Dicliptera roxburghiana* Nees., *Geranium nepalense* Sweet., *Oxalis corniculata* L., *Rumex nepalensis* Spreng., *Viola pilosa* Blume.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					arboreum Smith., *Rhus wallichii Hook. F., Toona serrata.*(Royle) M.Roen.		
12	Singoli- Bhatwari HE Project.	30⁰30'17"	79⁰5'22"	Moist temperate deciduous forests	*Alnus nepalensis* D.Don., *Albizia chinensis* (Osbeck) Merr., *Bombax ceiba* L., *Casearia greveolens* Dalz., *Malotus philippensis* (Lam.) muell., *Neolitsea pallens* (D.Don) Momyyama & Hara., *Rhus wallichii* Hook. F., *Salix disperma* Roxb. ex D.Don., *Sapium insigne* (Royle) Kurz.	*Acorus calamus* L.	*Achyranthes aspera* L., *Acorus calamus* L., *Bauhinia variegata* L., *Bergenia ciliata* (Haw) Sternb., *BerberIs aristata* DC., *Centella asiatica* (L.) Urban., *Cinnamomum zeylanicum* Nees., *Cissampelos pariera* L., *Cuscuta reflexa* Roxb., *Dioscorea deltoidea* Wall. ex Griseb., *Ficus relegiosa* L., *Lyonia ovalifolia* (Wall.) Drude., *Mallotus philippensis* (Lam.) muell.
13	Assiganga I HE project	30⁰48'37"	78⁰27'5"	Banj oak forests	*Pinus roxburghii* Sarg. (L.P.) Willd., *Rhododendron arboreum* Smith., *Quercus leocotrichophora* A.Camus., *Eupatorium adenophorum* Spreng., *Anaphalis adnata* DC., *Sonchus asper* (L.) Hill, *Berberis aristata* DC., *Colebrookia oppositifolia* J.E.Smith., *Arachne cordifolia* (Decne.) Hurus., *Parthenium hysterophorus* L., *Girardinia diversifolia* (Link) Friis, *Cannabis sativa* L., *Carissa opaca* Stapf ex Haines, *Desmodium microphyllum* (Thunb.) DC.	*Acer caesium* Wallich ex D.Don, *Aconitum hetrophyllum* Wallich., *Allium stacheyi* Baker., *Picrorhiza kurrooa* Royle., *Arnebia benthamii* (Wall. ex D. Don)	*Pyrus pashia* Buch-Ham ex D.Don, *Anaphalus adnata* DC., *Asparagus adscendens* Roxb., *Barleria cristata* L., *Berberis lycium* Royle., *Berberis aristata* DC., *Cannabis sativa* L., *Rhamnus virgatus* Roxb., *Indigofera atropurpurea* Buch.-Ham. ex Homem., *Prinsepia utilis* Royle, *Asparagus racemosa* Willd., *Desmodium microphyllum* (Thunb.) DC., *Geranium ocellatum* Cambess., *Ajuga bracteosa* Maxim., *Ageratum haustonianum* Mill., *Viola canascens* Wall.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
14	Assiganga II	$30^0$47'40"	$78^0$26'40"	Banj oak forests	*Pinus roxburghii* Sarg. (L.P.) Willd., *Quercus leocotrichophora* A.Camus., *Celtis australis* L., *Juglans regia* L., *Toona ciliata* M.Roem, , *Cannabis sativa* L., *Colebrookia oppositifolia* J.E.Smith., *Rubus ellipticus* Smith, *Prinsepia utilis* Royle., *Cotoneaster bacillaris* Wall. ex Lindl.	*Acer caesium* Wall. ex D.Don, *Aconitum hetrophyllum* Wall., *Allium stacheyi* Baker. *Picrorhiza kurrooa* Royle. *Arnebia benthamii* (Wall. ex D. Don)	*Asparagus adscendens* Roxb., *Barleria cristata* L., *Desmodium elegans* DC., *Euphorbia hirta*L.,,*Geranium ocellatum* Cambess.,,*Anaphalis adnata* DC., *Bidens pilosa* L., *Viola canescens* Wallich., *Reinwardtia indica* Dumort.
15	Assiganga III	$30^0$46'56"	$78^0$27'12"	Banj oak forests	*Pinus roxburghii* Sarg. (L.P.) Willd., *Rhododendron arboreum* Smith, *Quercus leocotrichophora* A.Camus., *Eupatorium adoratum* L., *Anaphalis adnata* DC., *Sonchus asper* (L.) Hill., *Berberis aristata* DC., *Colebrookia oppositifolia* J.E.Smith., *Cynodon dactylon* (L.) Pers., *Arachne cardifolia* (Decne.) Hurus., *Parthenium hysterophorus* L., *Girardinia diversifolia* (Link) Friis, *Cannabis sativa* L.	*Acer caesium* Wall. ex D.Don, *Aconitum hetrophyllum* Wall., *Allium stacheyi* Baker. *Picrorhiza kurrooa* Royle. *Arnebia benthamii* (Wall. ex D. Don)	*Colebrookia oppositifolia* J.E.Smith., *Cannabis sativa* L., *Berberis aristata* DC., *Rhamnus virgatus* Roxb., *Prinsepia utilis* Royle, *Inula cuspidata* (DC.) Clarke. *Asparagus racemosa* Willd. *Geranium ocellatum* Cambess. *Bidens pilosa* L., *Ajuga bracteosa* Wall. ex Benth., *Sonchus asper* (L.) Hill., *Rumex hastatus* D.Don.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
16	Kaldigad HEP	30^{0}50’27	78^{0}2839”	Western mixed conifer forests	*Cedrus deodara* (Roxb. ex lambert.) G.Don, *Pinus roxburghii* Sarg. (L.P.) Willd., *Picea smithiana* Wall., *Pinus wallichiana* A.B Jackson, *Prunus cerasoides* D.Don., *Rhododendrum arboreum* Smith, *Juniperus communis* L., *Quercus semicarpifolia* Smith, *Abies pindrow* Royle.	*Acer caesium* Wall. ex D.Don, *Aconitum hetrophyllum* Wall., *Allium stacheyi* Baker., *Picrorhiza kurrooa* Royle., *Arnebia benthamii* (Wall. ex D. Don)	*Anaphalis adnata* DC., *Asparagus adscendens* Roxb., *Barleria cristata* L., *Origanum vulgare* L., *Geranium ocellatum* Cambess, *Rumex hastatus* D.Don, *Sonchus asper* (L.) Hill., *Viola canescens* Wall.
17	Maneri Bhali I	30^{0}44’16”	78^{0}32’22”	Himlayan Chir Pine forets	*Pinus roxburghii* Sarg. (L.P.) Willd., *Toona ciliata* M.Roem., *Celtis australis* L., *Grewia optiva* JR. Drumm ex Burrett., *Alnus nepalensis* D.Don, *Populus ciliata* Wallich ex Royle.	*Datisca cannabina* L.	*Casia fistula* L., *Sapindus mukorossi* Garten, *Terminalia chebula* Retz., *Hippophae salicifolia* D.Don, *Juglanse regia* L., *Pyrus pashia* Buch-Ham ex D.Don.
18	Maneri Bhali II	30^{0}42’36”	78^{0}24’7”	Himlayan Chir Pine forets	*Lannea cormendelica* (Houtt.) Merr., *Toona serata* (Royle.) M.Roem, *Bauhinia variegata* L., *Mallotus philippiensis* (Lam.) muell., *Ficus palmta* Forrsk., *Murraya koenigii* (L.) Spreng.		*Haldina cordifolia* (Roxb.) Hook.f. ex Brandis., *Diospyros montana* Roxb., *Erythrina variegata* L., *Ficus palmata* Forrsk., *Mallotus philippensis* (Lam) Muell., *Moringa oleifera* Lam.
19	Phata-Byung HE Project	30^{0}37’35”	79^{0}0’28”	Banj oak forests	*Alnus nepalensis* D.Don, *Ilex dipyrena* Wall., *Neolitsea pallens* (D.Don) Momiyama & Hara., *Quercus leucotrichophora* A.Camus., *Lyonia ovalifolia* (Wallich) Drude., *Pyrus pashia* Buch-Ham. Ex D.Don., *Sapium insigne* (Royle) Kurz., *Berberis aristata* DC., *Desmodium triflorum*	*Acorus calamus* L.	*Achyranthes aspera* L., *Bauhinia variegata* L., *Bergenia ciliatae* (Haw.) Sternb., *Berberis chitria* Edwards., *Centella asiatica* (L.) Urban., *Cissampelos pariera* L., *Cuscuta reflexa* Roxb., *Cirsium wallichii* DC., *Geranium wallichianum* D.Don ex Sweet., *Lyonia ovalifolia* (Wallich) Drude.,

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					(L.) DC., *Rhamnus purpura* Edgew.		*Oxalis corniculata* L., *Zanthoxylum aramatum* DC.
20	Bhilangana HEP	$30^0$26'7"	$78^0$39'30"	Himlayana Chir Pine forests	*Acacia catechu* (L.F.) Willd., *Albizia lebbeck* (L.) Benth, *Toona ciliata* M.Roem., *Ficus palmata* Forrsk., *Grewia optiva* JR. Drumm ex Burrett., *Mallotus phillippensis* (Lam.) muell., *Pinus roxburghii* Sarg. (L.P.) Willd. *Salix wallichiana* Andersson, *Sapium insigne* (Royle) Kurz., *Syzygium cumini* (L.) Skeels, *Woodfordia fruticosa* (L.) Kurz. *Ricinus communis* L., *Rhus parviflora* Roxb., *Euphorbia royleana* Boiss.		*Swertia chirayita* (Roxb.) H.Karst., *Pyrus pashia* Buch-Ham ex D.Don, *Centella asiatica* (L.) Urban,*Berberis aristata* DC.,.,*Zanthoxylum armatum* DC., *Emblica officinalis* Gaertn, *Calotropis procera* (Ait) R.Br., *Juglans regia* L.,
21	Bhilangana III HEP	$30^0$33'7"	$78^0$48'26"	Himlayana Chir Pine forests	*Acacia catechu* (L.P.) Willd, *Aegle marmelos* (L.) Corr., *Bombex ceiba* L., *Dalbergia sissoo* Roxb., *Ficus palmata* L., *Grewia optiva* J.R. Drumm. Ex Burrett., *Lannea coromendelica* (Houtt.) Merr., *Mallotus phillippensis* (Lam.) muell., *Melia azedarach* L., *Pinus roxburghii* Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Syzium cumini* (L.) Skeels.		*Litsea glutinosa* (Lour) Robins. *Berberis aristata* DC., *Carrisa opaca*,,*Zanthoxylum armatum* L.,*Clematis montana* Buch.-Ham ex DC. , *Emblica officinalis* Gaertn, *Calotropis procera* (Ait.) R.Br., *Juglans regia* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
22.	Lohari –Nagpala HEP	$30^0$58'16"	$78^0$42'0"	Western mixed conifer forests	*Pinus wallichiana* A.B Jackson, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Taxus baccata* L., *Alnus nepalensis* D.Don, *Quercus leucotricophora, Ilex dipyrena* (Wallich) Hook.f., *Myrica esculenta* Buch.-Ham ex D.Don, *Sapium insigne* (Royle) Kurz.	*Caragana sukiensis* Schn., *Lilium polyphyllum* D. Don ex Royle.	*Berberis aristata* DC., *Pyrus pashia* Buch-Ham ex D.Don, *Berberis asiatica, Prinsepia utilis* Royle,*Viola biflora* L., *Asparagus filicinus* Buch-Ham ex D.Don., *Juglans regia* L.
23	Tehri Stage I	$30^0$23'20"	$78^0$28'51"	Himalayan subtropical scrub	*Pinus roxburghii* Sarg. (L.P.) Willd., *Toona ciliata* M. Roem, *Delbergia sissoo* Roxb.,, *Bombax ceiba* L., *Lannea coromandelica* (Houtt.) Merr., *Mallotus philippensis* (Lam.) muell., *Mangifera indica, Sapium insigne* (Royle) Kurz., *Syzygium cumini* (L.) Skeels.		*Swertia chirayita* (Roxb.) H.Karst., *Berberis lycium* Royle., *Zanthoxylum armatum* DC.,*Acacia catechu* (L.f.) Willd., *Calotropis procera* (Ait) R.Br., *Pyrus pashia* Buch-Ham ex D.Don, *Prunus persica* (L.) Batsch.,
24	Tehri Stage II	$30^0$23'20"	$78^0$28'51"	Himalayan subtropical scrub	*Pinus roxburghii* Sarg. (L.P.) Willd., *Cedrela toona* Rottler, *Delbergia sissoo* Roxb., *Bombex ceiba* L., *Lannea coromandelica* (Houtt.) Merr., *Grevillea robusta, Mallotus philippensis* (Lam.) muell., *Mangifera indica, Sapium insign* (Royle) Kurz., *Syzium cumini* (L.) Skeels *etc*		*Apluda mutica* L., *Swertia chirayita* (Roxb.) H.Karst., *Lawsonia inermis* L., *Berberis lyceum* Royle., *Zanthoxylum armatum* DC., *Acacia catechu* (L.f.) Willd., *Calotropis procera* (Ait) R.Br., *Pyrus pashia* Buch-Ham ex D.Don, *Prunus persica* (L.) Batsch., *Lantana camera* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
25	Koteshwar	30^{0}16’0”	78^{0}30’0”	Himalayan subtropical scrub	*Acacia catechu* (L.f.) Willd., *Mallotus philippensis* (Lam.) muell., *Celtis australis* L., *Lannea coromendelica* (Houtt.) Merr., *Moringa oleifera* Lam., *Pinus roxburghii* Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Syzygium cumini* (L.) Skeels, *Ficus benghalensis* L., *Ficus religiosa* L., *Ficus palmata* Forssk., *Delbergia sissoo* Roxb., *Bombax ceiba* L.		*Litsea glutinosa* (Lour) Robins., *Acacia catechu* (L.f.) Willd., *Berberis chitria* Edwards., *Ricinus communis* L., *Calotropis procera* (Ait) R.Br., *Murraya koenigii* (L.) Spreng.
26	Bhaironghati HEP	31^{0}1’2”	78^{0}42’52”	Deodar forests	*Pinus roxburghii* Sarg. (L.P.) Willd., *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Prunus cornuta* (Wall ex Royle.) Steud., *Abies pindrow* Royle., *Picea smithiana* Wallich, *Betula utilis* D.Don.	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wall.	*Aconitum heterophyllum* Wall., *Rheum webbianun* Royle., *Swertia chirayita* (Roxb.ex Fleming.), *Berberis asiatica* Roxb. ex DC., *Prinsepia utilis* Royle, *Viola biflora* L., *Aspargus filicinus* Buch.-Ham. ex Roxb.
27	Badrinath II	30^{0}43’91”	79^{0}29’48”	Himalayan temperate parkland	*Populus ciliate* Wall ex Royle, *Salix disperma* Roxb. ex D.Don, *Abies pindrow* Royle., *Hippophae salicifolia* L.,*Cedrus deodara* (Roxb. ex lambert.) G.Don, *Pinus wallichiana* A.B Jackson, *Taxus baccata* L., *Betula alnoides* Buch.-Ham ex D.Don.	*Allium stracheyi* Baker, *Hedysarum microcalyx* Baker, *Aconitum heterophyllum* Wall., *Carum carvi* L., *Epilobium latifolium* L.	*Aconitum heterophyllum* Wall., *Aspargus filicinus* Buch.-Ham. ex Roxb, *Berberis aristata* DC.,*Carum carvi* L., *Delphinum denudatum* Wall. ex Hook.f., *Hedychium spicatum* Buch.-Ham ex J.E.Sm., *Prinsepia utilis* Royle.,*Viola biflora* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
28	Vishnuprayag HEP	30^{0}32'0"	79^{0}28'0"	Western mixed conifer forests	*Asculus indica* (Wall. ex camb.) Hook., *Alnus nepalensis* D.Don, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Celtis australis* L., *Lyonia ovalifolia* (Wall.) Drude., *Pinus wallichiana*, *Populus ciliata* Wall. ex Royle, *Pyrus pashia* Buch-Ham ex D.Don, *Quercus semicarpifolia* Smith., *Salix wallichiana* Anderss., *Pyrus malus* L.	*Acer caesium* Wall. ex Brandis, *Allium stacheyi* Baker, *Picrorhiza kurrooa* Royle ex Benth.	*Adenocaulon himalaicum* Edgew. , *Agave Americana* L., *Agrimonia pilosa* Ledeb. *Anaphalis contrata* (D.Don) Hook.f., *Anemone vitifolia* Buch.-Ham. ex DC., *Aquilegia pubiflora* Wall. ex Royle., *Arctium lapa* L., *Arisaema concinnum* Schott. , *Barleria crista* L., *Bergenia ciliata* (Haw.)Sternb., *Bupleurum falcatum* L., *Circium verutum* (D.Don) Spreng., *Cynoglossum lanceolatum* Forssk., *Delphinium danudatum* Wall. ex Hook.f., *Dioscorea deltoidea* Wall. ex Griseb., *Girardiana diversifolia* (Link) Friis., *Jasminum humile* L., *Mentha longifolia* (L.) Huds, *Selinum vaginatum* (Edgew) C.B.Clarke., *Swertia angustifolia* Buch.-Ham. ex D.Don, *Thymus linearis* Benth, *Verbascum thapus L.*, *Zanthoxylum armatum* DC.
29.	Lata Tapovan HEP	30^{0}31'30"	79^{0}43'30"	Banj oak forests	*Querícus leucotricophora* A.Camus, *Betula alnoides* Buch.-Ham ex D.Don, *Carpinus viminea* Lindl., *Lindera pulcherrima* (Nees) Benth ex Hook.f., *Lyonia ovalifolia* (Wall.) Drude., *Rhododendron arboreum* Smith, *Cotoneaster obtusus* Wall. ex Lindl., *Myrsine africana* Linn. , *Hedera nepalensis*	*Aconitum heterophyllum* Wallich., *Picrorhiza kurrooa* Royle., *Allium humile* Kunth.	*Aconitum heterophyllum* Wall., *Swertia chirayita* (Roxb.ex Fleming.), *Picrorhiza kurrooa* Royle., *Angelica glauca* Edgew, *Rheum webbianum* Royle., *Dactylorhiza hatagirea* (D.Don) Soo., *Rheum australe* D.Don, *Allium humile* kunth, *Nardostachys grandiflora* DC., *Bergenia ciliata*

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					K.Koch., *Vitis lanata* Roxb., *Taxillus vestitus* (Wall.) Danser, *Pyrus malus* L.		(Haw.) Sternb., *Megacarpaea polyandra* Benth., *Aconitum balfourii* Stapf., *Hippophae salicifolia* L., *Arnebia benthamii* (Wallich ex D.Don) Jonston, *Zanthoxylum armatum* DC., *Carum carvi* L., *Centella asiatica* (L.) Urban., *Asparagus racemosus* Willd.
30	Tapovan vishnugad HEP	$30^0$29'30"	$79^0$37'30"	Banj oak forets	*Quericus leucotricophora* A.Camus, *Betula alnoides* Buch.-Ham ex D.Don, *Carpinus viminea* Lindl., *Lindera pulcherrima* (Nees) Benth ex Hook.f., *Lyonia ovalifolia* (Wall.) Drude., *Rhododendron arboreum* Smith, *Cotoneaster obtusus* Wall. ex Lindl., *Myrsine africana* Linn. , *Hedera nepalensis* K.Koch., *Vitis lanata* Roxb., *Taxillus vestitus* (Wallich) Danser,*Pyrus malus* L.	*Aconitum heterophyllum* Wall., *Arnebia benthamii* (Wallich ex D.Don) Jhonston *Picrorhiza kurrooa* Royle., *Allium humile* Kunth.	*Aconitum heterophyllum* Wall., *Swertia chirayita* (Roxb.ex Fleming.), *Picrorhiza kurrooa* Royle., *Angelica glauca* Edgew, , *Rheum webbianum* Royle., *Dactylorhiza hatagirea* (D.Don) Soo., *Rheum australe* D.Don, *Allium humile* kunth, *Nardostachys grandiflora* DC., *Bergenia ciliata* (Haw.) Sternb., *Megacarpaea polyandra* Benth., *Aconitum balfourii* Stapf., *Hippophae salicifolia* D.Don., *Berberis lycium* Royle., *Arnebia benthamii* (Wallich ex D.Don) Jhonston, *Zanthoxylum armatum* DC., *Carum carvi* L., *Centella asiatica* (L.) Urban., *Asparagus racemosus* Willd.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
31	Ram Bara HEP	30⁰41'42"	79⁰3'20"	Banj oak forests	*Alnus nepalensis* D.Don, *Quercus leucotrichophora* A.Camus., *Carpinus viminea* Lindl., *Ilex dipyrena* Wall., *Litsea monopetala* (Roxb.) Pers., *Neolitsea pallens* (D.Don) momiyama & Hara., *Lyonia ovalifolia* (Wall.) Drude., *Myrica esculenta* Buch.-Ham. ex D.Don.	*Aconitum heterophyllum* Wallich., *Allium stracheyi* Baker, *Picrorhiza kurrooa* Royle.	*Aconitum heterophyllum* Wall., *Allium stracheyi* Baker, *Dactylorrhiza hatagirea* (D.Don) Soo., *Nardostachys jatamansi* DC., *Picrorhiza kurrooa* Royle., *Podophyllum hexandrum* Royle., *Swertia chirayita* (Roxb.ex Fleming.), *Bergenia ciliata* (Haw.) Sternb., *Geranium wallichianum* D.Don ex Sweet., *etc.*
32	Bowla Nandprayag HEP	30⁰24'24"	79⁰22'48"	Himalayan Chir pine forests	*Alnus nepalensis* D.Don, *Pinus roxburghii* Sarg. (L.P.) Willd., *Quercus semecarpifolia* Smith., *Salix wallichiana* Anderss., *Aesculus indica* (Wall. ex camb.) Hook., *Celtis australis* L. , *Lyonia ovalifolia* (Wall.) Drude., *Pyrus pashia* Buch-Ham. Ex D.Don, *Mallotus phillippensis* (Lam.) muell.		*Agrimonia pilosa* Ledeb., *Anaphalis contorta* (D.Don) Hook.f., *Bergenia ciliata* (Haw.) Sternb., *Bupleurum falcatum* L., *Cirsium verutum* (D.Don) spreng., *Delphinium denudatum* Wall. ex Hook.f., *Dioscorea deltoidea* Wall. ex Griseb., *Girardinia diversifolia* (Link)Friis., *Jasminum humile* L., *Mentha longifolia* (L.) Huds., *Thymus linearis* Benth., *Verbascum thapus* L., *Zanthoxylum armatum* DC.
33	Agundathati HEP	30⁰36'6"	78⁰37'22"	Himlaayan Chir pine forests	*Acacia catechu* (L.P.)Willd , *Aegle marmelos* (L.) Corr. , *Bombex ceiba* L., *Dalbergia sissoo* Roxb., *Ficus palmata* L. ,*Grewia optiva* J.R. Drumm. Ex Burrett., *Lannea coromendelica* (Houtt.) Merr., *Mallotus philipinensis* (Lam.) muell., *Melia azedarach* L., *Pinus*		*Potentilla fulgens* Wall. ex Hook., *Datura stramonium* L., *Solanum nigrum* L., *Sanicula europaea* L., *Pimpinella diversifolia* DC., *Galium rotundifolium* L., *Artemisia parviflora* D.Don, *Anaphalis triplinervis* Sims ex clarke, *Colebrookea oppositifolia* Sm., *Leucas lanata* Wall. ex

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					roxburghii Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Syzium cumini* (L.) Skeels.		Benth., *Achryanthes aspera* L., *Cautleya spicata* (Sm.) Baker.
34	Debal HEP	30^{0}3'0"	79^{0}33'0"	Himalayan chir pine forests	*Pinus roxburghii* Sarg., *Celtis australis* L., *Bombax ceiba* L., *Quercus leucotricophora* A.Camus, *Juglans regia* L., *Toona ciliata* M. Roem, *Bauhinia variegata* L., *Pyrus pashia* Buch-Ham ex D.Don., *Rhus wallichii* Hook.f.	*Datisca cannabina* L.	*Artemisia absinthium* L., *Berberis asiatica* Roxb.ex DC, *Rumex hastatus* D.Don, *Buddleia asiatica*, *Cinnamomum tamala* (Buch-ham) T.Nees & Ebrrm., *Mallotus philippensis* (Lam.) muell, *Spondias pinnata* L.f.Kurz., *Artemisia nilagirica* L., *Asparagus adscendens* Roxb., *Eupatorium adenophorum* Hort.Berol ex Kunth., *Juniperus communis* L., *Woodfordia fruticosa* (L.) Kurz., *Zanthoxylum armatum* DC., *Anaphalis adnata* (D.Don) Hook.f., *Verbascum thapus* L.
35	Jummagad HEP	30^{0}40'0"	79^{0}50'0"	Western mixed conifer forests	*Quericus leucotricophora* A.Camus, *Betula alnoides* Buch-Ham ex D.Don. *Carpinus viminea* Wall. ex Lindl., *Lindera pulcherrima* (Nees) Hook.f., *Lyonia ovalifolia* (Wall.) Drude, *Rhododendron arboreum* Sm., *Taxillus vestitus* (Wall.) Danser, *Populus ciliata* Wall. ex Royle, *Pinus wallichiana* A.B.Jack, *Cupressus torulosa* D.Don, *Prunus nepalensis* Ser., *Pyrus malus* L., *Cedrus deodara* (Roxb.ex Lamb.) G.Don	*Allium stracheyi* Baker, *Allium humile* Kunth, *Nardostachys grandiflora* DC, *Arenaria curvifolia* Majumdar, *Arenaria ferruginea* Duthie ex Williams, *Calamagrostis garhwalensis* C.E. Hubb ex Bor.	*Aconitum heterophyllum* Wall., *Swertia chirayita* (Roxb.) H.Karst., *Picrorhiza kurrooa* Royle, *Angelica glauca* Edgew, *Rheum webbianum* Royle, *Dactylorhiza hatagirea* (D.Don) Soo, *Rheum australe* D.Don., *Allium humile* Kunth, *Saussurea costus* (Falc.) Lipsch, *Nardostachys grandiflora* DC. , *Bergenia ciliata* (Haw.) Sternb., *Megacarpaea polyandra* Benth ex Madden, *Aconitum balfourii* Stapf, *Hippophae*

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
							salicifolia D.Don, *Arnebia benthamii* (Wallich ex D.Don) Jonston, , *Zanthoxylum armatum* DC., *Carum carvi* L., *Centella asiatica* (L.) Urban. *Asparagus racemosus* Willd. *Berberis aristata* DC, *Echinops cornigerus* DC., *Fagopyrum esculentum* Moench, *Jasminum humile* L., *Rosa macrophylla* Lindl.
36	Pilang Gad HEP	$30^0$46'0"	$78^0$38'0"	Himalayan Chir forests	*Pinus roxburghii Sarg.*, *Toona ciliata* M.Roem., *Celtis australis* L., *Grewia optiva* JR. Drumm ex Burrett., *Alnus nepalensis* D.Don, *Populus ciliata* Wallich ex Royle, *Rhododendron companulatum* D. Don	*Datisca cannabina* L.	*Achyranthus aspera* Linn, *Centella asiatica* (Linn.) Urban., *Artemisia nilagirica* (Clarke) Pamp., *Berberis asiatica* Roxb.ex DC, *Viburnum cotinifolium* D. Don, *Eupatorium odoratum* L., *Casia fistula* L., *Sapindus mukorossi* Garten, *Terminalia chebula* Retz., *Hippophae salicifolia* D.Don, *Juglanse regia* L., *Geranium nepalense* Sw., *Leucas aspera* (Willd) Link.
37	Rajwakti HEP	$30^0$18'25"	$79^0$21'0"	Himalayan Chir Pine forests	*Pinus roxburghii Sarg.*, *Toona ciliata* M.Roem., *Celtis australis* L., *Grewia optiva* JR. Drumm ex Burrett, *Mallotus phillippensis* (Lam.) muell, *Bombax ceiba* L., *Dalbergia sissoo* DC., *Bauhinia varigata* L., *Sapium insigne* (Royle) Trimen, *Syzygium cumini* (L.) Skeels., *Melia azederach* L.,		*Agave Americana* L., *Colebrookia oppositifolia* D.Don, *Adhatoda zeylanica* Medik, *Artemisia nilagirica* (Clarke) Pamp, *Verbascum thapus* L., *Bergenia ciliata* (Haw.) Sternb., *Cannabis sativa* L., *Rubus ellipticus* Sm., *Eupatorium adenophorum* Hort.Berol ex Kunth.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					Albizia lebbeck (L.) Benth.		
38	Urgam HEP	30⁰34’30”	79⁰30’7”	Banj oak forests	*Alnus nepalensis* D.Don, *Lyonia ovalifolia* (Wall.) Drude, *Juglans regia* L., *Pinus roxburghii* Sarg. (L.P.) Willd., *Quercus leucotricophora* A.Camus, *Celtis australis* L., *Moringa oleifera* Lam., *Pyrus pashia* Buch-Ham ex D.Don., *Prunus persica, Ficus roxburghii, Toona ciliata* M.Roem, *Rhus wallichii* Hook.f., *Cupressus torulosa* D.Don, *Rhododendron arboreum* D.Don	*Picrorhiza kurrooa* Royle.	*Artemisia nilagirica* (Clarke) Pamp., *Berberis asiatica* Roxb. ex DC., *Rumex hastatus* D.Don, *Cinnamomum tamala* (Buch-ham) T.Nees & Ebrrm., *Mallotus philippensis* (Lam.) muell, *Spondias pinnata* L.f.Kurz., *Artemisia nilagirica* L., *Asparagus adscendens* Roxb., *Eupatorium adenophorum* Hort.Berol ex Kunth., *Indigofera cassioides* DC, *Juniperus communis* L., *Woodfordia fruticosa* (L.) Kurz. *Zanthoxylum armatum* DC., *Anaphalis adnata* (D.Don) Hook.f.
39	Vanala HEP	30⁰16’0”	79⁰25’0”	Himalayan Chir Pine forests	*Pinus roxburghii* Sarg. (L.P.) Willd., *Alnus nepalensis* D.Don, *Myrica esculenta* Buch-Ham ex D.Don, *Juglanse regia* L., *Toona ciliata* M.Roem, *Celtis australis* L., *Mallotus philippensis* (Lam.) muell., *Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Syzygium cumini* (L.) Skeels., *Melia azederach* L., *Albizia lebbeck* L. Benth.		*Colebrookia oppositifolia* D.Don, *Adhatoda zeylanica* Medik, *Artemisia nilagirica* (Clarke) Pamp, *Verbascum thapus* L., *Bergenia ciliata* (Haw.) Sternb., *Cannabis sativa* L., *Rubus ellipticus* Sm.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
40	Birahi Ganga HEP	$30^0$34’35”	$79^0$23’56”	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Alnus nepalensis* D.Don, *Toona ciliata* M.Roem, *Quericus leucotricophora* A.Camus, *Celtis australis* L., *Mallotus philippensis* (Lam.) muell.,*Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Pyrus pashia* Buch-Ham ex D.Don, *Juglans regia* L., *Albizia procera* (Roxb.) Benth., *Ficus roxburghii* Steud.		*Berberis aristata* DC, *Canavis sativa* L., *Colebrokia oppositifolia* J.E. Smith., *Adathoda zeylanica* J.E. Smith., *Berberis asiatica* Lour, *Rumex hasitatus* D.Don, *Mallotus philippensis* (Lam) Muell, *Indigofera cassioides* Rottl. ex DC, *Artemisia nilagirica* (Cl.) Pamp., , *Woodfordia fruticosa* (L.) Kurz, *Zanthoxylum armatum* DC., *Verbascum thapus* L.
41	Kail Ganga HEP	$30^0$5’30”	$79^0$36’30”	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Celtis australis* L., *Prunus persica* (L.) Stokes, *Bombex ceiba* L., *Quercus leucotricophora* A.Camus, *Juglans regia* L., *Toona ciliata* M.Roem, *Bauhinia variegta* L.,*Pyrus pashia* Buch-Ham ex D.Don, *Rhus wallichii* Hook.f.	*Datisca cannabina* L.	*Artemisia nilagirica* (Clarke) Pamp., *Berberis asiatica* Roxb. ex DC., *Rumex hastatus* D.Don, *Cinnamomum tamala* (Buch-ham) T.Nees & Ebrrm., *Gardenia spinosa* Thunb., *Mallotus philippensis* (Lam.) muell, *Spondias pinnata* L.f.Kurz., *Asparagus adscendens* Roxb., *Eupatorium adenophorum* Hort.Berol ex Kunth., *Juniperous communis* L., *Woodfordia fruticosa* (L.) Kurz., *Zanthoxylum armatum* DC., *Anaphalis adnata* (D.Don) Hook.f., *Conyza aegyptiaca* (L.) Dryand ex Aiton., *Verbascum thapus* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
42	Kali Ganga I HEP	$30^{0}36'40''$	$79^{0}5'10''$	Banj oak forests	*Alnus nepalensis* D.Don, *Quercus leucotrichophora* A.Camus, *Carpinus viminea* Wall. ex lindl., *Ilex dipyrena* Wall., *Litsea monopetala* (Roxb.) Pers., *Neolitsea pallens* (D.Don) Momiy & H.Hara, *Lyonia ovalifolia* (Wall.) Drude, *Myrica esculenta* Buch-Ham ex D.Don.	*Aconitum heterophyllum* Wall., *Allium stracheyi* Baker, *Picrorhiza kurrooa* Royle., *Podophyllum hexandrum* Royle	*Aconitum heterophyllum* Wall. ex Royle, *Anemone rivularis* Buch.-Ham., *Delphinium vestitum* Wall. ex Royle, *Thalictrum foliolosum* DC., *Paeonia emodi* Wall. ex Royle, *Berberis aristata* DC., *Berberis asiatica* Roxb. ex DC., *Malva verticillata* L., *Geranium nepalense* Sw., *Geranium wallichianum* D.Don ex Sw., *Oxalis corniculata* L., *Skimmia anquetilia* Taylor & Airy Shaw, *Rosa sericea* Lindl., *Bergenia ciliata* (Haw.) Strenb., *Selinum vaginatum* Clarke, *Galium aparine* L., *Valeriana hardwickii* Wall., *Valeriana jatamansi* Jones., *Artemisia nilagirica* (Cl.) Pamp, *Jurinea dolomiaea* Boiss., *Taraxacum officinale* Weber., *Gaultheria trichophylla* Royle., *Maharanga emodi* (Wall.) DC., *Verbascum thapsus* L., *Ajuga brachystemon* Maxim., *Lamium album* L., *Origanum vulgare* L., *Prunella vulgaris* L., *Salvia hians* Royle ex Benth., *Bistorta affinis* (D. Don) Greene, *Rumex nepalensis* Spr., *Euphorbia pilosa* L., *Hedychium spicatum* Buch.-Ham ex Sm., *Dioscorea deltoidea* Wall. ex Griseli., *Arisaema jacquemontii* Bl., *Adiantum capillus-veneris* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
43	Kali Ganga II HEP	$30^0$35'30"	$79^0$4'50"	Banj oak forests	*Alnus nepalensis* D.Don, *Quercus leucotrichophora* A.Camus, *Carpinus viminea* Wall. ex lindl., *Ilex dipyrena* Wall., *Litsea monopetala* (Roxb.) Pers., *Neolitsea pallens* (D.Don) Momiy & H.Hara, *Lyonia ovalifolia* (Wall.) Drude, *Myrica esculenta* Buch-Ham ex D.Don	*Aconitum heterophyllum* Wall., *Allium stracheyi* Baker, *Picrorhiza kurrooa* Royle. *Podophyllum hexandrum* Royle	*Aconitum heterophyllum* Wall. ex Royle, *Anemone rivularis* Buch.-Ham., *Delphinium vestitum* Wall. ex Royle, *Thalictrum foliolosum* DC., *Paeonia emodi* Wallich ex Royle, *Berberis aristata* DC., *Berberis asiatica* Roxb. ex DC., *Malva verticillata* L., *Geranium nepalense* Sw., *Geranium wallichianum* D.Don ex Sw., *Oxalis corniculata* L., *Skimmia anquetilia* Taylor & Airy Shaw, *Rosa sericea* Lindl., *Bergenia ciliata* (Haw.) Strenb. *Selinum vaginatum* Clarke, *Galium aparine* L., *Valeriana hardwickii* Wall. *Valeriana jatamansi* Jones., *Morina longifolia* Wall. ex DC., *Anaphalis triplinervis* (Sims.) Cl., *Artemisia nilagirica* (Cl.) Pamp, *Jurinea dolomiaea* Boiss. *Taraxacum officinale* Weber. *Gaultheria trichophylla* Royle. *Maharanga emodi* (Wall.) DC.,

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
							Verbascum thapsus L., *Ajuga brachystemon* Maxim., *Lamium album* L., *Origanum vulgare* L., *Prunella vulgaris* L., *Salvia hians* Royle ex Benth., *Bistorta affinis* (D. Don) Greene, *Rumex nepalensis* Spr., *Euphorbia pilosa* L., *Hedychium spicatum* Buch.-Ham ex Sm., *Dioscorea deltoidea* Wall. ex Griseli., *Arisaema jacquemontii* Bl., *Adiantum capillus-veneris* L.
44	Madmaheshwar HEP	30^{0}32'55"	79^{0}6'55"	Banj oak forests	*Alnus nepalensis* D.Don, *Bombax ceiba, Casearia graveolens* Dalzell, *Mallotus philippensis* (Lam.) muell., *Neolitsea pallens* (D.Don) Momiy & H.Hara, *Rhus wallichii* Hook.f., *Salix disperma, Sapium, insigne, Ilex dipyrena* Wall., *Quercus leucotrichophora* A.Camus, *Lyonia ovalifolia* (Wall.) Drude., *Pyrus pashia* Buch-Ham ex D.Don etc	*Aconitum heterophyllum* Wall., *Allium stracheyi* Baker, *Picrorhiza kurrooa* Royle., *Podophyllum hexandrum* Royle	*Achyranthes aspera L*., *Bergenia ciliata* (Haw.) Sternb., *Berberis aristata* DC., *Centella asiatica* (L.) Urb., *Cinnamomum zeylanica* Breyn, *Cissampelos pareira* L., *Desmodium triflorum* (L.) DC, *Rhamnus purpureus* Jepson. *Cuscuta reflexa* Roxb., *Dioscorea deltoidea* Wall. ex Griseb., *Thysanolaena latifolia* (Roxb. ex Hornem) Honda, *Verbascum Thapsus* L., *Hippophae salicifolia* D.Don, *Dioscorea esculenta* (Lour) Burkill.,
45	Rishi Ganga HEP	30^{0}28'55"	79^{0}41'53"	Western mixed conifer forests	*Abies pindrow* (Royle ex D.Don) Royle, *Fraxinus micrantha* Lingelsh, *Pinus wallichiana* A.B.Jacks, *Taxus baccata* L., *Cedrus deodara* (Roxb. ex Lamb.) G.Don., *Juglans regia* L. , *Aesculus*	*Aconitum heterophyllum* Wall., *Nardostachys grandiflora* DC., *Allium humile* Kunth.	*Achyranthes aspera* L., *Aconitum balfourii* Stapf, *Aconitum heterophyllum* Wall. ex Royle, *Aesculus indica* (Wall. ex Cambess.) Hook. *Allium cepa* L., *Allium humile* Kunth. *Allium sativum*

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
					indica (Wall. ex camb.) Hook., *Betula utilis* D.Don, *Quercus floribunda* L. ex A.camus, *Quercus semecarpifolica* Sm, *Picea Smithiana* (Wall.) Boiss., *Cupressus torulosa* D.Don, *Caspinus viminea* Wall. ex Lindl, *Corylus jacquemontii* Decne.		L., *Angelica glauca* Edgew. *Arisaema tortuosum* (Wall.) Schott., *Arnebia benthamii* (Wall. ex G. Don) I.M. Johnst., *Asparagus racemosus* Willd., *Berberis aristata* DC., *Berberis lycium* Royle., *Bergenia ciliata* Sternb., *Carum carvi* L., *Centella asiatica* (L.) Urb., *Delphinium denudatum* Wall. ex Hook. f. & Thomson., *Hippophae rhamnoides* L., *Picrorhiza kurrooa* Royle ex Benth., *Rheum australe* D. Don., *Podophyllum hexandrum* Royle., *Zanthoxylum armatum* DC.
46	Balganga II HEP	30⁰29'0"	78⁰37'30"	Himalayan Chir pine forests	*Acacia catechu* Willd., *Aegle marmelous* (L) Correa., *Bombex ceiba L.*, *Toona ciliata* M.Roem ., *Dalbergia sissoo* DC., *Eucalyptus globulus* Labill.., *Ficus cunea* Buch-Ham ex Roxb., *Emblica officinalis* Gaertn, *Grevellia robusta* A.Cunn ex R.Br., *Mallotus philipinensis* (Lam.) muell., *Pinus roxburghii* Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Salix wallichiana* Andersson, *Prunus cerasoides* Buch-Ham ex D.Don, *Syzygium cumini* (L.) Skeels.		*Potentilla fulgens* Wall. ex Hook., *Solanum nigrum* L., *Sanicula europaea* L., *Pimpinella diversifolia* DC., *Galium rotundifolium* L., *Artemisia parviflora* D.Don, *Anaphalis triplinervis* Sims ex clarke, *Leucas lanata* Wall. ex Benth., *Achryanthes aspera* L., *Cautleya spicata* (Sm.) Baker.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
47	Bhilangana II A HEP	30⁰31'37"	78⁰44'52"	Himalayan Chir pine forests	*Acacia catechu* (L.P.) Willd, *Aegle marmelos* (L.) Corr. , *Bombex ceiba* L., *Dalbergia sissoo* Roxb., *Ficus palmata* L. ,*Grewia optiva* J.R. Drumm. Ex Burrett., *Lannea coromendelica* (Houtt.) Merr. *Mallotus philippensis* (Lam.) Muell., *Pinus roxburghii* Sarg. (L.P.) Willd. *Sapium insigne* (Royle) Kurz. *Syzium cumini* (L.) Skeels.		*Swertia chirayita* (Roxb.) H.Karst., *Centella asiatica* (L.) Urban, *Berberis aristata* DC., *Zanthoxylum armatum* DC., *Emblica officinalis* Gaertn , *Calotropis procera* (Ait) R.Br., *Juglans regia* L., *Abrus precatorius* L., *Pyrus pashia* Buch-Ham ex D.Don, *Litsea glutinosa* (Lour) Robins., *Zanthoxylum armatum* L.,
48	Bhilangana II B HEP	30⁰29'30"	78⁰43'15"	Himalayan Chir pine forests	*Acacia catechu* (L.P.)Willd, *Aegle marmelos* (L.) Corr., *Bombex ceiba* L., *Dalbergia sissoo* Roxb., *Ficus palmata* L., *Grewia optiva* J.R. Drumm. Ex Burrett., *Lannea coromendelica* (Houtt.) Merr., *Mallotus philipinensis* (Lam.) muell., *Melia azedarach* L., *Pinus roxburghii* Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Syzygium cumini* (L.) Skeels.		*Apluda mutica* L., *Swertia chirayita* (Roxb.) H.Karst., *Centella asiatica* (L.) Urban, *Berberis aristata* DC.,*Melia azedarach* L., *Zanthoxylum armatum* DC., *Emblica officinalis* Gaertn, *Calotropis procera* (Ait) R.Br., *Juglans regia* L., *Abrus precatorius* L., *Lawsonia inermis* L., *Pyrus pashia* Buch-Ham ex D.Don, *Litsea glutinosa* (Lour) Robins., *Carrisa opaca, Melia azedarach* L., *Zanthoxylum armatum* L., *Clematis Montana* Buch.-Ham ex DC.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
49	Bhilangana II C HEP	30^{0}23'24"	78^{0}36'36"	Himalayan Chir pine forests	*Acacia catechu* (L.P.) Willd, *Aegle marmelos* (L.) Corr. , *Bombex ceiba* L., *Dalbergia sissoo* Roxb., *Ficus palmata* L. ,*Grewia optiva* J.R. Drumm. Ex Burrett., *Lannea coromendelica* (Houtt.) Merr., *Mallotus philipinensis* (Lam.) muell., *Melia azedarach* L., *Pinus roxburghii* Sarg., *Sapium insigne* (Royle) Kurz., *Syzium cumini* (L.) Skeels.		*Swertia chirayita* (Roxb.) H.Karst., *Centella asiatica* (L.) Urban, *Berberis aristata* DC.,*Melia azedarach* L., *Zanthoxylum armatum* DC., *Emblica officinalis* Gaertn, *Calotropis procera* (Ait) R.Br., *Juglans regia* L., *Pyrus pashia* Buch-Ham ex D.Don,*Litsea glutinosa* (Lour) Robins., *Zanthoxylum armatum* L.,
50	Bhyundar ganga HEP	30^{0}38'53"	79^{0}34'50"	Moist temperate deciduous forests	*Aesculus indica* (Wall. ex Camb.) Hook., *Alnus nepalensis* D.Don, Cedrus *deodara* (Roxb. ex lambert.) G.Don, *Celtis australis* L., *Lyonia ovalifolia* (Wall.) Drude., *Pinus wallichiana, Populus ciliata* Wall. ex Royle, *Pyrus pashia* Buch-Ham ex D.Don, *Quercus semecarpifolia* Smith., *Salix wallichiana* Andersson., *Pyrus malus* L.	*Acer caesium* Wall. ex Brandis, *Allium stacheyi* Baker, *Picrorhiza kurrooa* Royle ex Benth., *Epipogium aphyllum* (Schm.) Swartz.	*Adenocaulon himalaicum* Edgew., *Agrimonia pilosa* Ledeb., *Anaphalis contrata* (D.Don) Hook.f., *Anemone vitifolia* Buch.-Ham. ex DC., *Aquilegia pubiflora* Wallich ex Royle., *Arctium lapa* L., *Arisaema concinnum* Schott. , *Barleria crista* L., *Bergenia ciliata* (Haw.)Sternb., *Bupleurum falcatum* L., *Delphinium denudatum* Wall. ex Hook.f., *Dioscorea deltoidea* Wall. ex Griseb. *Girardinia diversifolia* (Link) Friis., *Mentha longifolia* (L.) Huds, *Selinum vaginatum* (Edgew) C.B.Clarke., *Swertia angustifolia* Buch.-Ham. ex D.Don, *Thymus linearis* Benth, *Verbascum thapus* L., *Zanthoxylum armatum* DC.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
51	Birahi Ganga I HEP	30⁰22'30"	79⁰30'0"	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Alnus nepalensis* D.Don, *Toona ciliata* M.Roem, *Quericus leucotricophora* A.Camus, *Celtis australis* L., *Mallotus philipinensis* (Lam.) muell., *Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Pyrus pashia* Buch-Ham ex D.Don, *Juglans regia* L., *Albizia procera* (Roxb.) Benth., Ficus *roxburghii* Steud.		*Berberis aristata* DC, *Cannabis sativa* L., *Adathoda zeylanica* J.E. Smith., *Berberis asiatica* Lour, *Indigofera cassioides* Rottl. ex DC, *Artemisia nilagirica* (Cl.) Pamp., *Woodfordia fruticosa* (L.) Kurz, *Zanthoxylum armatum* DC., *Verbascum thapus* L.
52	Birahi Ganga II HEP	30⁰22'30"	79⁰30'0"	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Alnus nepalensis* D.Don, *Toona ciliata* M.Roem, *Quericus leucotricophora* A.Camus, *Celtis australis* L., *Mallotus philippensis* (Lam.) muell., *Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Pyrus pashia* Buch-Ham ex D.Don, *Juglans regia* L., *Albizia procera* (Roxb.) Benth., Ficus *roxburghii* Steud.		*Berberis aristata* DC, *Canabis sativa* L., *Adathoda zeylanica* J.E. Smith., *Berberis asiatica* Lour, *Mallotus philippensis* (Lam) Muell, *Indigofera cassioides* Rottl. ex DC, *Artemisia nilagirica* (Cl.) Pamp., *Eupatorium adenophorum* Hort.Berol ex Kunth , *Woodfordia fruticosa* (L.) Kurz, *Zanthoxylum armatum* DC., *Anaphalis adnata* DC., *Verbascum thapus* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
53	Dewali HEP	30⁰18'0"	79⁰20'0"	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Toona ciliata* M.Roem, *Celtis australis* L., *Mallotus philipinensis* (Lam.) muell., *Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Dalbergia sissoo* DC., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Syzygium cumini* (L.) Skeels, *Albizia lebbeck* L. Benth.		*Adhatoda zeylanica* Medik, *Artemisia nilagirica* (Clarke) Pamp, *Verbascum thapus* L., *Bergenia ciliata* (Haw.) Sternb., *Cannabis sativa* L.,*Rubus ellipticus* Sm.
54	Gohana Tal HEP	30⁰22'39"	79⁰24'38"	Himalayan Chir pine forests	*Pinus roxburghii* Sarg., *Alnus nepalensis* D.Don, *Toona ciliata* M.Roem, *Quericus leucotricophora* A.Camus, *Celtis australis* L., *Mallotus philippnensis* (Lam.) muell., *Grewia optiva* JR. Drumm ex Burrett, *Bombax ceiba* L., *Bauhinia variegata* L., *Sapium insigne* (Royle) Trimen, *Pyrus pashia* Buch-Ham ex D.Don, *Juglans regia* L., *Albizia procera* (Roxb.) Benth. Ficus *roxburghii* Steud.		*Berberis aristata* DC, *Cannabis sativa* L., *Adathoda zeylanica* J.E. Smith., *Berberis asiatica* Lour, *Mallotus philippensis* (Lam) Muell, *Indigofera cassioides* Rottl. ex DC, *Artemisia nilagirica* (Cl.) Pamp., *Woodfordia fruticosa* (L.) Kurz, *Zanthoxylum armatum* DC., *Anaphalis adnata* DC., *Verbascum thapus* L.
55	Jadh Ganga HEP	31⁰2'18"	78⁰53'17"	Deodar forests	*Cedrus deodara* (Roxb. ex lambert.) G.Don, *Pinus wallichiana* A.B Jackson, *Juniperus semiglobosa* Regel., *Abelia triflora* R.Br. ex Wall., *Prunus cornuta* (Wall. ex Royle) Steud., *Populus ciliata* Wall. ex Royle, *Acer acuminatum* Wall. ex D.Don	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wall.	*Ribes alpestre* Wall. ex D.Don, *Rosa macrophylla* L., *Viburnum cotinifolium* D.Don, *Thalictrum foetidum* L., *Mirabilis himalaica* (Edgew) Heimerl., *Veronica stewartii* Pennell., *Impatiens brachycentra* Kar. & Kir., *Arenaria serpyllifolia* L., *Arabidopsis*

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
							himalaica (Edgew.) O.E.Schulz., *Arisaema flavum* (Forssk.) Schoot., *Salvia nubicola* Wall. ex Sweet., *Ocimum basilicum* Linn., *Geranium nepalense* Sw., *Swertia ciliata* (G. Don) Burtt, *Convolvulus arvensis* L., *Viburnum cotonifolium* D. Don, *Cleome viscosa* Linn, *Berberis asiatica* Roxb.ex DC., *Berberis lycium* Royle, *Taraxacum afficinale* W. ex W etc.
56	Jalandrigad HEP	$31^0$2'51"	$78^0$45'5"	Deodar forests	*Cedrus deodara* (Roxb. ex lambert.) G.Don, *Prunus cornuta* (Wall ex Royle.)Steud., *Betula utilis* D.Don, *Pinus wallichiana* A.B Jackson, *Populus ciliata* Wall. ex Royle, *etc*	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wall. .	*Ribes alpestre* Wall. ex D.Don, *Convolvulus arvensis* L., *Taraxacum afficinale* Weber.
57	Jhalakoti HEP	$30^0$38'53"	$78^0$38'10"	Himalayan Chir Pine forests	*Acacia catechu* Willd., *Bombex ceiba* L., *Celtis australis* L., *Dalbergia sissoo* DC., *Grewia oppositifolia* Roxb. ex DC., *Lannea coromendelica* (Houtt.) Merr., *Mallotus philipinensis* (Lam.) muell., *Moringa oleifera* Lam., Buch-Ham ex D.Don, *Pinus roxburghii* Sarg. (L.P.) Willd., *Sapium insigne* (Royle) Kurz., *Syzygium cumini* (L.) Skeels.		*Potentilla fulgens* Wall. ex Hook., *Solanum nigrum* L., *Sanicula europaea* L., *Pimpinella diversifolia* DC., *Galium rotundifolium* L., *Artemisia parviflora* D.Don, *Anaphalis triplinervis* Sims ex clarke, *Leucas lanata* Wallich ex Benth., *Cyathula tomentosa* (Roth.) Moq., *Achryanthes aspera* L., *Cautleya spicata* (Sm.) Baker, *Avena barbata* Pott ex Link.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
58	Kakoragad HEP	$31^0$3'32"	$78^0$46'20"	Western mixed conifer forests	*Pinus roxburghii* Sarg., *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Prunus cornuta* (Wall ex Royle.) Steud., *Abies pindrow* Royle., *Picea smithiana* Wall., *Quercus leucotriphora* A.Camus., *Betula utilis* D.Don.	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wall., *Caragana sukiensis* Schn.	*Ribes alpestre* Wall. ex D.Don, *Geranium nepalense* Sw., Swertia ciliata (G. Don) Burtt, *Convolvulus arvensis* L., *Viburnum cotinifolium* D. Don, *Cannabis sativa* Linn, *Berberis asiatica* Roxb.ex DC., *Berberis lycium* Royle, *Taraxacum afficinale* Weber.
59	Karmoli HEP	$31^0$6'4"	$78^0$58'5"	Western mixed conifer forests	*Abies pindrow* Royle, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Pinus wallichiana* A.B Jackson, *Taxus baccata* L., *Picea smithiana* Wallich. *Populus ciliata* Wall. ex Royle, *Acer acuminatum* Wall. ex D.Don etc	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wallich.	*Ribes alpestre* Wall. ex Decne, *Rosa macrophylla* Lindl. , *Viburnum cotinifolium* D.Don, *Thalictrum foetidum* L. , *Mirabilis himalaica* (Edgew) Heimerl., *Arabidopsis himalaica* (Edgew.) O.E.Schulz., *Arisaema flavum* (Forssk.) Schoot. *Salvia nubicola* Wall. ex Sweet., *Ribes alpestre* Wall. ex D.Don, Swertia ciliata (G. Don) Burtt, *Convolvulus arvensis* L., *Viburnum cotonifolium* D. Don, *Berberis asiatica* Roxb.ex DC., *Berberis lycium* Royle, *Taraxacum afficinale* Weber.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
60	Khiron ganga HEP	30⁰41'2.5"	79⁰29'27"	Western mixed conifer forests	*Populus ciliata* Wall. ex Royle, *Taxus baccata* L., *Acer villosum* C.Presl., *Pinus wallichiana* A.B.Jacks, *Abies pindrow* (Royle ex D.Don) Royle, *Cedrus deodara* (Roxb. ex Lamb.) G.Don, *Salix lindleyana* Wall. ex Andersson, *Hippophae salicifolia* D.Don, *Rhododendron arboreum* Sm., *Rhododendron campanulatum* D.Don, *Lyonia ovalifolia* (Wall.) Drude.	*Allium humile* Kunth, *Allium stracheyi* Baker., *Hedysarum microcalyx* Baker., *Aconitum heterophyllum* Wallich., *Carum carvi* L.,*Epilobium latifolium* L.,	*Salvia nubicola* Wall. ex Sweet., *Origanum vulgare* L., *Berberis asiatica* Roxb. ex D.Don, *Prunella vulgaris* L., *Plantago major* L., *Prinsepia utilis* Royle, *Taraxcum officinale* F.H. Wigg, *Artemesia vestita* Wall. ex Besser., *Viola serpens* Wall., *Thalictrum foliolosum* DC., *Orobanche epithymum* DC., *Hippophae salicifolia* D.Don, *Paris polyphylla* Sm., *Swertia* ciliata (D.Don ex G.Don, *Allium humile* Kunth, *Trigonella emodi* Benth, *Dioscorea bulbifera* L., *Thymus linearis* Benth, *Ajuga bracteosa* Wall. ex Benth, *Syringa emodi* Wall. ex Royle., *Parnassia nubicola* Wall. ex Royle, *Rheum moorcroftianum* Royle, *Podophyllum hexandrum* Royle, *Jurinea dolomaea* Boiss, *Arnebia* benthamii (Wall. ex G.Don) Johnst., *Polygonum vacciinifolium* Wall. ex Meisn.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
61	Kot budakedar HEP	30^{0}35'13"	78^{0}38'3"	Himalayan Chir pine forests	*Celtis australis* L., *Dalbergia sissoo* DC., *Ficus benghalensis* L., *Grewia oppositifolia* Roxb. ex DC., *Mallotus philipinensis* (Lam.) muell., *Moringa oleifera* Lam., Buch-Ham ex D.Don, *Pinus roxburghii* Sarg., *Sapium insigne* (Royle) Kurz., *Syzium cumini* (L.) Skeels.		*Potentilla fulgens* Wall. ex Hook., *Solanum nigrum* L., *Sanicula europaea* L., *Pimpinella diversifolia* DC., *Galium rotundifolium* L., *Artemisia parviflora* D.Don, *Colebrookea oppositifolia* Sm., *Leucas lanata* Wall. ex Benth., *Achryanthes aspera* L., *Cautleya spicata* (Sm.) Baker.
62	Limcha Gad HEP	30^{0}55'31"	78^{0}41'28"	Western mixed conifer forests	*Pinus wallichiana* A.B Jackson, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Taxus baccata* L., *Alnus nepalensis* D.Don, *Quercus leucotricophora* A.Camus, *Ilex dipyrena* Wall.. *Myrica esculenta* Buch.-Ham ex D.Don,	*Lilium polyphyllum* D. Don ex Royle.	*Berberis aristata* DC. *Pyrus pashia* Buch-Ham ex D.Don, *Berberis asiatica* Roxb. ex DC., *Prinsepia utilis* Royle, *Aspargus filicinus* Buch-Ham ex D.Don, *Juglans regia* L. *Hippophae salicifolia* D.Don.
63	Melkhet HEP	30^{0}1'23"	79^{0}2'20"	Himalayn Chir pine forests	*Pinus roxburghii* Sarg., *Celtis australis* L., *Prunus persica* (L.) Stokes, *Bombax ceiba* L., *Melia azadirach* L., *Quercus leucotricophora* A.Camus, *Juglans regia* L., *Toona ciliata* M.Roem, *Bauhinia variegta* L.,*Pyrus pashia* Buch-Ham ex D.Don, *Rhus wallichii* Hook.f.	*Datisca cannabina* L., *Berberis osmastonii* Dunn.	*Artemisia nilagirica* (Clarke) Pamp. *Berberis asiatica* Roxb. ex DC., *Cinnamomum tamala* (Buch-ham) T.Nees & Ebrrm., *Asparagus adscendens* Roxb., *Juniperous communis* L., *Woodfordia fruticosa* (L.) Kurz., *Zanthoxylum armatum* DC., *Anaphalis adnata* (D.Don) Hook.f., *Verbascum thapus* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
64	Pilang Gad II HEP	30^{0}45'55"	78^{0}39'55"	Himalayan Chir forests	*Pinus roxburghii Sarg*., *Toona ciliata* M.Roem., *Celtis australis* L., *Grewia optiva* JR. Drumm ex Burrett., *Alnus nepalensis* D.Don, *Populus ciliata* Wall. ex Royle, *Rhododendron companulatum* D. Don.	*Datisca cannabina* L.	*Barleria cristata* L, *Achyranthus aspera* Linn, *Centella asiatica* (Linn.) Urban., *Artemisia nilagirica* (Clarke) Pamp., *Berberis asiatica* Roxb.ex DC, *Viburnum cotonifolium* D. Don, *Sapindus mukorossi* Garten, *Terminalia chebula* Retz. , *Hippophae salicifolia* D.Don, *Juglanse regia* L., *Geranium nepalense* Sw.
65	Rishi Ganga I HEP	30^{0}27'37"	79^{0}46'26"	Western mixed conifer forests	*Abies pindrow* (Royle ex D.Don) Royle, *Fraxinus micrantha* Lingelsh, *Pinus wallichiana* A.B.Jacks, *Taxus baccata* L., *Cedrus deodara* (Roxb. ex Lamb.) G.Don., *Juglans regia* L., *Aesculus indica* (Wall. ex camb.) Hook., *Betula utilis* D.Don, *Quercus floribunda* Lindl ex A.camus, *Quercus semecarpifolica* Sm, *Picea smithiana* (Wall.) Boiss., *Corylus jacquemontii* Decne.	*Aconitum heterophyllum* Wall. *Nardostachys grandiflora* DC, *Allium humile* Kunth.	*Aconitum balfourii* Stapf, *Aconitum heterophyllum* Wall. ex Royle, *Allium humile* Kunth., *Angelica glauca* Edgew., *Arisaema tortuosum* (Wall.) Schott., *Arnebia benthamii* (Wall. ex G. Don) I.M. Johnst., *Asparagus racemosus* Willd., *Berberis aristata* DC., *Berberis lycium* Royle., *Bergenia ciliata* Sternb., *Carum carvi* L., *Centella asiatica* (L.) Urb., *Delphinium denudatum* Wall. ex Hook. f. & Thomson., *Picrorhiza kurrooa* Royle ex Benth., *Rheum australe* D. Don., *Podophyllum hexandrum* Royle., *Zanthoxylum armatum* DC.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
66	Rishi Ganga II HEP	$30^{0}28'3''$	$79^{0}43'50''$	Western mixed conifer forests	*Abies pindrow* (Royle ex D.Don) Royle, *Fraxinus micrantha* Lingelsh, *Pinus wallichiana* A.B.Jacks, *Taxus baccata* L., *Cedrus deodara* (Roxb. ex Lamb.) G.Don., *Juglans regia* L., *Aesculus indica* (Wall. ex camb.) Hook., *Betula utilis* D.Don, *Quercus floribunda* Lindl ex A.camus, *Quercus semecarpifolica* Sm., *Picea Smithiana* (Wall.) Boiss.	*Aconitum heterophyllum* Kunth, *Nardostachys grandiflora* DC, *Allium humile* Kunth.	*Aconitum balfourii* Stapf, *Aconitum heterophyllum* Wall. ex Royle, *Allium humile* Kunth., *Angelica glauca* Edgew., *Arisaema tortuosum* (Wall.) Schott., *Arnebia benthamii* (Wall. ex G. Don) Johnst., *Asparagus racemosus* Willd., *Berberis aristata* DC., *Berberis lycium* Royle., *Bergenia ciliata* Sternb., *Carum carvi* L., *Centella asiatica* (L.) Urb., *Delphinium denudatum* Wall. ex Hook. f. & Thomson., *Picrorhiza kurrooa* Royle ex Benth., *Rheum australe* D. Don., *Podophyllum hexandrum* Royle., *Zanthoxylum armatum* DC.
67	Siyangad HEP	$31^{0}1'50''$	$78^{0}41'50''$	Western mixed conifer forests	*Pinus roxburghii* Sarg., *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Prunus cornuta* (Wall ex Royle.) Steud., *Abies pindrow* Royle., *Picea smithiana* Wall., *Quercus leucotriphora* A.Camus., *Betula utilis* D.Don, *Rhododendron companulatum* D. Don.	*Lilium polyphyllum* D. Don ex Royle, *Aconitum heterophyllum* Wall., *Arnebia benthamii* (Wall. ex D. Don) Johnston, *Allium stacheyi* Baker	*Ribes alpestre* Wall. ex D.Don, *Geranium nepalense* Sw., Swertia ciliata (G. Don) Burtt, *Convolvulus arvensis* L., *Viburnum cotonifolium* D. Don, *Cannabis sativa* Linn, *Berberis asiatica* Roxb.ex DC., *Berberis lycium* Royle, *Taraxacum afficinale* W. ex W.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
68	Suwari Gad HEP	30^{0}51’0”	78^{0}37’0”	Western mixed conifer forests	*Alnus nepalensis* D.Don, *Betula alnoides* Buch.-Ham.ex D.Don, *Cedrus deodara* (Roxb. ex lambert.) G.Don, *Juglans regia* L., *Lyonia ovalifolia* (Wall.) Drude. *Pinus roxburghii* Sarg., *Populus ciliata* Wall. ex Royle, *Prunus cerasoides* D.Don, *Quercus leucotrichophora* A.Camus., *Rhododendron arboreum* Smith, *Rhus wallichii* Hook. f., *Toona serrata.*(Royle) M.Roen.	*Datisca cannabina* L., Picrorhiza *kurrooa* Royle ex Benth.	*Artemisia nilagirica* (C.B.Clarke) Pamp., *Berberis asiatica* Roxb. ex DC., *Berbesis aristata* DC., *Urtica dioica* L., *Geranium nepalense* Sweet., *Oxalis corniculata* L., *Rumex nepalensis* Spreng., *Viola pilosa* Blume.
69	Urgam II HEP	30^{0}32’56”	79^{0}28’40”	Banj oak forests	*Alnus nepalensis* D.Don, *Lyonia ovalifolia* (Wall.) Drude, *Juglans regia* L., *Pinus roxburghii* Sarg., *Quercus leucotricophora* A.Camus, *Celtis australis* L., *Pyrus pashia* Buch-Ham ex D.Don., *Prunus persica*, *Ficus roxburghii*, *Toona ciliata* M.Roem, *Rhus wallich* Hook.f., *Rhododendron arboreum* D.Don.	*Picrorhiza kurrooa* Royle ex Benth.	*Artemisia nilagirica* (Clarke) Pamp. *Berberis asiatica* Roxb. ex DC., *Rumex hastatus* D.Don, *Cinnamomum tamala* (Buch-ham) T.Nees & Ebrrm., *Artemisia niligirica* L., *Asparagus adscendens* Roxb., *Indigofera cassioides* DC, *Woodfordia fruticosa* (L.) Kurz., *Zanthoxylum armatum* DC., *Anaphalis adnata* (D.Don) Hook.f., *Verbascum thapus* L.

S.No.	Project site	GPS location		Forest type	Dominant species	RET/ Endemic Species.	Medicinal Plant
		Lati.	Longi.				
70	Tamak Lata HEP	$30^0$23'20"	$79^0$47'0"	Western mixed conifer forests	*Quericus leucotricophora* A.Camus, *Betula alnoides* Buch-Ham ex D.Don, *Carpinus viminea* Wall. ex Lindl., *Lindera pulcherrima* (Nees) Hook.f., *Lyonia ovalifolia* (Wall.) Drude, *Rhododendron arboreum* D.Don, *Cotoneaster obtusus* Wall. ex Lindl, *Myrsine africana* L., *Hedera nepalensis* K.Koch, *Vitis lanata* Roxb., *Taxillus vestitus* (Wall.) Denser, *Populus ciliata* Wall. ex Royle, *Pinus wallichiana* A.B.Jacks, *Pyrus malus* L., *Salix wallichiana* Andersson, *Cedrus deodara* (Roxb. ex. Lamb) G.Don.	*Allium stracheyi* Baker., *Acer caesium* Wall. ex D.Don, *Arenaria curvifolia* Majumdar, *Saussurea costus* (Falc.) Lipch., *Taxus baccata* L., *Arenaria ferruginea* Duthie ex Williams., *Berberis petiolaris* Wallich ex G.Don. *Calamagrostis garhwalensis* C.E Hubb. & Bor., *Carex nandadeviensis* Ghildyal	*Aconitum heterophyllum* wall., *Swertia chirayita* Buch -Ham ex Wall., *Picrorhiza kurrooa* Royle., *Angelica glauca* Edgew, *Rheum webbianum* Royle, *Dactylorhiza hatagirea* (D.Don) Soo., *Rheum australe* D.Don, *Allium humile* Kunth., *Nardostachys grandiflora* DC., *Bergenia ciliata* (Haw.) Sternb., *Megacarpaea polyandra* Benth ex Madden., *Aconitum balfourii* Stapf, *Arnebia benthamii* (Wall. ex G.Don) Johnst., *Zanthoxylum armatum* DC., *Carum carvi* L., *Centella asiatica* (L.) Urban, *Asparagus racemosus* Willd., *Berberis aristata* DC. *Echinops cornigerus* DC. , *Fagopyrum esculentum* Monech., *Rosa macrophylla* L.

UNESCO WORLD HERITAGE CENTRE, PARIS

Statement of Outstanding Universal Value of Nanda Devi and Valley of Flowers World Heritage Sites,Uttarakhand , India

Brief synthesis

The Nanda Devi and Valley of Flowers National Parks are exceptionally beautiful and naturally well protected high-altitude West Himalayan landscapes with biodiversity rich alpine, tree line, subalpine and temperate habitats. Both the parks have high aesthetic value that has been acknowledged by renowned explorers, mountaineers and botanists in literature for over a century and in Hindu mythology since ages. The Valley of Flowers National Park with its gentle landscape, breath-takingly beautiful meadows of alpine flowers and ease of access contrast the rugged, inaccessible, high mountain wilderness of the inner basin of Nanda Devi National Park. With the exception of well regulated community-based eco tourism to small portions of these two parks, there are no anthropogenic pressures in these parks since 1983. Therefore, these parks act as control sites for the maintenance of natural process and are of high significance in long-term ecological monitoring in the Himalaya.

Both the parks have high diversity and density of flora and fauna of the west Himalayan bio-geographic zone. The Nanda Devi National Park park holds significant populations of flora and fauna, many of which have global conservation significance such as the Snow leopard, mountain ungulates and galliformes. The abundance estimates for wild ungulates, galliformes and carnivores inside the Nanda Devi National Park are higher when compared to similar protected areas in the western Himalaya. The high diversity of floral species in Valley of Flowers National Park reflects the valley's location within a transition zone between the Zanskar and Greater Himalayan ranges, and between the Eastern and Western Himalayan flora. A number of plant species are internationally threatened; several have not been recorded from elsewhere in the Himalaya. These two parks and the surrounding buffer zones form the Nanda Devi Biosphere Reserve, a large landscape of 6,407 Km^2 encompassing a wide range of elevation and habitats, that support significant populations of mountain ungulates and galliformes that are prey to carnivores including the Snow leopard. The entire area lies within the Western Himalayan Endemic Bird Area.

Criteria

Criteria (vii): 'contain superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance'

The Nanda Devi west peak (7,817 m) that is revered as a sacred mountain by the local people and its surrounding group of mountains which is now the Nanda Devi National Park are well recognised by mountaineers and explorers world over for their exceptional natural beauty due to the several high mountain peaks, glaciers, moraines, and alpine meadows. The Nanda Devi National Park has an array of challenging high mountain peaks that provide a range of beauty and challenge based on the approach, elevation and ascent. The Valley of Flowers is an outstandingly beautiful high-altitude Himalayan valley that has been acknowledged as such by renowned explorers, mountaineers and botanists in literature for over a century and in Hindu mythology for much longer. Its 'gentle' landscape, breath-takingly beautiful meadows of alpine flowers and ease of access complement the rugged, mountain wilderness for which the inner basin of Nanda Devi National Park is renowned.

Criterion (x): 'contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science and conservation'

The Nanda Devi National Park comprises of the Rishi Ganga Basin that has a rim of high Himalayan peaks and wide range of high altitude habitats from temperate forests to glacial moraines which had remained naturally protected for centuries until its exploration in 1933. This park holds significant populations of flora and fauna, many of which have global conservation significance such as the Snow leopard, mountain ungulates and galliformes. The abundance estimates for wild ungulates, galliformes and carnivores inside the Nanda Devi National Park are higher when compared to similar protected areas in the western Himalaya. The Valley of Flowers is internationally important on account of its diverse alpine flora, representative of the West Himalaya biogeographic zone. The rich diversity of species reflects the valley's location within a transition zone between the Zanskar and Great Himalaya ranges to the north and south, respectively, and between the Eastern and Western Himalaya flora. A number of plant species are internationally threatened, several have not been recorded from elsewhere in Uttaranchal and two have not been recorded in Nanda Devi National Park . The diversity of threatened species of medicinal plants is higher than has been recorded in other Indian Himalayan protected areas. The entire Nanda Devi Biosphere Reserve lies within the Western Himalayas Endemic Bird Area (EBA). Seven restricted-range bird species are endemic to this part of the EBA.

Integrity

The Nanda Devi and Valley of Flowers National Parks are naturally well protected due to their remoteness and limited access. Both the parks were unexplored until the 1930s and have not been subjected to anthropogenic pressures since 1983 with the exception of limited community based ecotourism to small portions of the parks. Therefore, both the parks contain relatively undisturbed natural habitats that now act as control sites for the continuance of natural processes. The integrity of this property is further enhanced by the fact that both the parks form the core zones of the Nanda Devi Biosphere Reserve and are encircled by a large buffer zone of 5142.86 km^2. The Kedarnath Wildlife Sanctuary and the Reserved Forest Divisions located west, south and east of the Biosphere Reserve provide additional buffer to this Biosphere Reserve. The local communities residing in the buffer zones of the Nanda Devi Biosphere Reserve actively participate in the conservation programmes of the Forest Department.

Management and Protection Requirements Necessary to Maintain OUV

The Nanda Devi and Valley of Flowers National Parks are naturally well protected and therefore the State Forest Department ensures the protection of these parks by regular monitoring of the limited routes that provide access to these parks. Both the parks are subjected to very low levels of human use, only community based eco-tourism that is regulated and facilitated by the park management. There is no livestock grazing inside these parks since 1983. Mountaineering and adventure based activities inside Nanda Devi National Park has been banned since 1983 due to garbage accumulation and environmental degradation by such activities in the past. The status of flora, fauna and their habitats inside Nanda Devi National Park has been monitored through scientific expeditions carried out once in every 10 years since 1993. Results of the surveys and time series analysis of remote sensing data indicate substantial improvement in the status of flora, fauna and their habitats inside Nanda Devi National Park. Similarly, studies and annual surveys in Valley of Flowers National Park indicate the maintenance of the status of the flora, fauna and habitats. Both the National Parks and the Reserved

Forests in the buffer zone of the Nanda Devi Biosphere Reserve are well protected and managed as per wildlife management and working plans respectively.

The long-term integrity of the Nanda Devi and Valley of Flowers National Parks would depend on the maintenance of the high levels of protection and current low levels of anthropogenic pressures inside the parks. Regular monitoring of the status of wildlife and their habitats in these parks is critical and needs to be continued. Tourist or Pilgrim management and developmental activities such as hydro power projects and infrastructure in the buffer zone of the Nanda Devi Biosphere Reserve are the existing and potential threats that need to be addressed.

Appendix 6.2

Project wise derivation of impact potential values for different sub-basin

Sub-basin/Projects	River	Type	Capacity (MW)	Status	River Length Affected (score)	Forest Area Loss (score)	Total Impact Potential Score	Impact Potential Value (%)	Category
ALAKNANDA I					3	2	5	50	M
Srinagar	Alaknanda	Storage	330	Under-Construction	1	1	2	20	L
Kotlibhel IB	Alaknanda	Storage	320	Proposed	2	1	3	30	M
ALAKNANDA II					3	1	4	40	M
Bowla Nandprayag	Alaknanda	ROR	300	Proposed	2	1	3	30	M
Vishnugad Pipalkoti	Alaknanda	Storage	444	Under-Construction	2	1	3	30	M
Nandprayag langasu	Alaknanda	ROR	100	Proposed	1	1	2	20	L
Urgam II	Kalpganga	ROR	3.8	Proposed	1	1	2	20	L
Urgam	Kalpganga	ROR	3	Commissioned	1	1	2	20	L
ALAKNANDA III					3	1	4	40	M
Alaknanda	Alaknanda	ROR	30	Proposed	1	1	2	20	L
Vishnuprayag	Alaknanda	ROR	400	Commissioned	3	1	4	40	M
Khirao Ganga	Khirao Ganga	ROR	4	Proposed	1	1	2	20	L
Badrinath II	Rishi Ganga	ROR	1.25	Commissioned	1	1	2	20	L
BHYUNDAR GANGA					1	1	2	20	L
Bhyundar Ganga	Bhyundar Ganga	ROR	24.3	Proposed	1	1	2	20	L
BIRAHIGANGA					5	1	6	60	H

Birahi Ganga I	Birahi ganga	ROR	24	Proposed	2	1	3	30	M
Birahi Ganga II	Birahi ganga	ROR	24	Proposed	1	1	2	20	L
Gohana Tal	Birahi ganga	ROR	50	Proposed	3	1	4	40	M
Birahi Ganga	Birahi ganga	ROR	7.3	Commissioned	1	1	2	20	L
DHAULIGANGA					5	1	6	60	H
Tamak Lata	Dhauli ganga	ROR	250	Proposed	2	1	3	30	M
Lata Tapovan	Dhauli Ganga	ROR	170	Proposed	1	1	2	20	L
Tapovan Vishnugad	Dhauli Ganga	ROR	520	Under-Construction	2	1	3	30	M
Malari Jelam	Dhauli Ganga	ROR	114	Proposed	1	1	2	20	L
Jelam Tamak	Dhauli Ganga	ROR	126	Proposed	1	1	2	20	L
Jummagad	Jummagad	ROR	1.2	Commissioned	2	1	3	30	M
MANDAKINI					3	1	4	40	M
Madhmaheshwar	Mandakini	ROR	10	Under-Construction	1	1	2	20	L
Phata Byung	Mandakini	Storage	76	Under-Construction	1	1	2	20	L
Ram bara	Mandakini	ROR	24	Proposed	1	1	2	20	L
Singoli Bhatwari	Mandakini	ROR	99	Under-Construction	1	1	2	20	L
Kali Ganga I	Kaliganga	ROR	4	Under-Construction	1	1	2	20	L
Kaliganga II	Kaliganga	ROR	6	Under-Construction	1	1	2	20	L
NANDAKINI					3	1	4	40	M
Dewali	Nandakini	ROR	13	Proposed	2	1	3	30	M
Rajwakti	Nandakini	ROR	3.6	Commissioned	1	1	2	20	L
Vanala	Nandakini	ROR	15	Commissioned	1	1	2	20	L
PINDAR					2	1	3	30	M
Melkhet	Pinder	ROR	15	Proposed	1	1	2	20	L
Devsari	Pinder	Storage	252	Proposed	2	1	3	30	M

Kail Ganga	Kail Ganga	ROR	5	Under-Construction	1	1	2	20	L
Debal	Kail Ganga	ROR	5	Commissioned	1	1	2	20	L
RISHIGANGA					2	1	3	30	M
Rishi Ganga I	Rishi Ganga	Storage	70	Proposed	1	1	2	20	L
Rishi Ganga	Rishi Ganga	ROR	13.2	Under-construction	1	1	2	20	L
Rishi Ganga II	Rishi ganga	Storage	35	Proposed	1	1	2	20	L
ASIGANGA					2	1	3	30	M
Asiganga I	Asiganga	ROR	4.5	Under-Construction	1	1	2	20	L
Asiganga II	Asiganga	ROR	4.5	Under-Construction	1	1	2	20	L
Asiganga III	Asiganga	ROR	9	Proposed	2	1	3	30	M
Kaldigad	Kaldigad	ROR	9	Under-Construction	1	1	2	20	L
BALGANGA					2	1	3	30	M
Bal Ganga II	Bal ganga	ROR	7	Proposed	1	1	2	20	L
Jhala koti	Bal ganga	ROR	12.5	Proposed	1	1	2	20	L
Kot Budha Kedar	Bal ganga	ROR	6	Commissioned	1	1	2	20	L
Agunda Thati	Dharam ganga	ROR	3	Commissioned	1	1	2	20	L
BHAGIRATHI II					3	1	4	40	M
Bharon Ghati	Bhagirathi	ROR	381	Proposed	2	1	3	30	M
Loahri Nagpala	Bhagirathi	ROR	600	Under-Construction	2	1	3	30	M
Pala Maneri	Bhagirathi	Storage	480	Proposed	2	1	3	30	M
Maneri Bhali I	Bhagirathi	ROR	90	Commissioned	2	1	3	30	M
Jalandharigad	Jalandharigad	ROR	24	Proposed	2	1	3	30	M
Limcha Gad	Limcha gad	ROR	3.5	Proposed	2	1	3	30	M
Suwari Gad	Suwari gad	ROR	2	Proposed	2	1	3	30	M

Siyangad	Siyangad	ROR	11.5	Proposed	2	1	3	30	M
Kakoragad	Kakoragad	ROR	12.5	Proposed	1	1	2	20	L
Pilangad II	Pilangad	ROR	4	Proposed	1	1	2	20	L
Pilangad	Pilangad	ROR	2.25	Commissioned	1	1	2	20	L
BHAGIRATHI III					4	5	9	90	VH
Maneri Bhali II	Bhagirathi	ROR	304	Commissioned	2	1	3	30	M
Tehri Stage 1 (*Its impacts are majorly in this sub-basin*)	Bhagirathi	Storage	1000	Commissioned	3	5	8	80	VH
BHAGIRATHI IV					5	1	6	60	H
Koteshwar	Bhagirathi	Storage	400	Commissioned	3	1	4	40	M
Kotlibhel IA	Bhagirathi	Storage	195	Proposed	3	1	4	40	M
Tehri Stage 1	Bhagirathi	Storage	1000	*Despite of its location, it impacts majorly the Bhagirathi III sub-basin*					
BHILANGANA					2	1	3	30	M
Bhilangana III	Bhilangana	ROR	24	Commissioned	1	1	2	20	L
Bhilangana IIA	Bhilangana	ROR	24	Proposed	1	1	2	20	L
Bhilangana IIB	Bhilangana	ROR	24	Proposed	1	1	2	20	L
Bhilangana IIC	Bhilangana	ROR	21	Proposed	1	1	2	20	L
Bhilangana	Bhilangana	ROR	22.5	Commissioned	1	1	2	20	L
BHAGIRATHI I					2	1	3	30	M
Karmoli	Jadhganga	Storage	140	Proposed	2	1	3	30	M
Jadh Ganga	Jadhganga	Storage	50	Proposed	1	1	2	20	L
GANGA					5	1	6	60	H
Kotlibhel II	Ganga	Storage	530	Proposed	5	1	6	60	H

Rev Fish Biol Fisheries
DOI 10.1007/s11160-011-9218-6

RESEARCH PAPER

Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives

U. K. Sarkar · A. K. Pathak · R. K. Sinha · K. Sivakumar · A. K. Pandian · A. Pandey · V. K. Dubey · W. S. Lakra

Received: 7 September 2010 / Accepted: 26 April 2011

Abstract The river Ganges is the largest river in India and the fifth longest in the world. Although, many studies on fish ecology and systematic have been conducted largely to improve fisheries but fish diversity and their distribution pattern from conservation point of view have never been adequately addressed in the Ganges. In this connection, current distribution and abundance of freshwater fishes of river Ganges was studied and assessed from April 2007 to March 2009. We documented and described 143 freshwater fish species in the all stretches of the river which is higher than what was reported earlier. Some species were observed with shift in their distribution ranges. First time, a total of 10 exotic fishes, including *Pterygoplichthys anisitsi*, which has never been reported from India found in the Ganges. Alterations of the hydrological pattern due to various types of hydro projects was seems to be the largest threat to fishes of Ganges. Indiscriminate and illegal fishing, pollution, water abstraction, siltation and invasion of exotic species are also threatening the fish diversity in the Ganges and as many as 29 species are listed under threatened category. The study advocates a need to identify critical fish habitats in the Ganga basin to declare them as conservation reserves to mitigate the loss of fish diversity from this mighty large river.

Keywords River Ganges · Freshwater fish diversity · Distribution · Abundance · Conservation issues · India

U. K. Sarkar (✉) · A. K. Pathak · A. K. Pandian · A. Pandey · V. K. Dubey · W. S. Lakra
National Bureau of Fish Genetic Resources, Canal Ring Road, Dilkusha P.O., Lucknow, Uttar Pradesh 226002, India
e-mail: usarkar1@rediffmail.com; uksarkar1@nbfgr.res.in

R. K. Sinha
Department of Zoology, Patna University, Patna, Bihar, India

K. Sivakumar
Wildlife Institute of India, Dehradun, Uttarakhand, India

Present Address:
W. S. Lakra
Central Institute of Fisheries Education, Mumbai, India

Introduction

Riverine ecosystem of India have suffered from intense human intervention resulting in habitat loss and degradation and as a consequence many fresh water fish species have become heavily endangered, particular in Ganges basin where heavy demand is placed on fresh water. This was coupled with irreversible changes in natural population by introduction of exotic species and diseases (Dudgeon et al. 2005; Arthington and Welcomme 1995; Arthington et al. 2004; De Silva and Abery 2007). River conservation and management activities in most countries including India suffer from inadequate

Published online: 13 May 2011

knowledge of the constituent biota. Therefore, research is being pursued globally to develop conservation planning to protect freshwater biodiversity (Pusey et al. 2010; Margules and Pressey 2000; Lipsey and Child 2007).

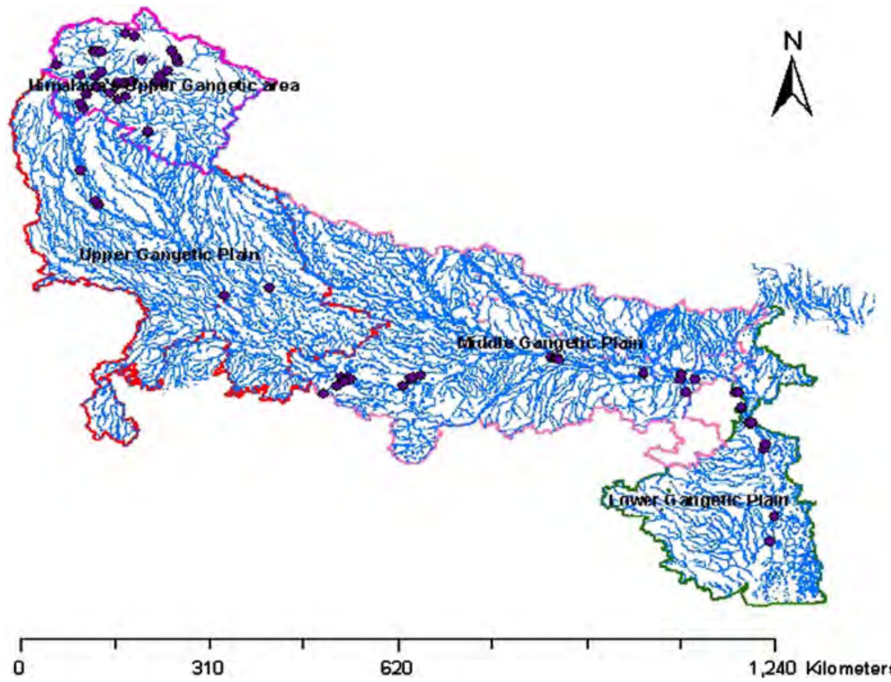
The basin of river Ganges, which has very high cultural, heritage and religious values drains about 1,060,000 km^2 area and it is the fifth largest in the world (Welcomme 1985). The River originates from ice-cave '*Gaumukh*' (30°55′N/70°7′E) in the Garhwal Himalaya at an altitude of 4,100 m and discharges into Bay of Bengal. The length of the main channel from the traditional source of the Gangotri Glacier in India is about 2,550 km. The mean annual water discharge is the fifth highest in the world with a mean of 18,700 m^3/s. Extreme variation in flow exists within the catchment area, to the extent that the mean maximum flow of the river Ganges is 468.7 $\times$ 10^9 m^3 which is 25.2% of India's total water resources and a vast amount of sediment (1,625 $\times$ 10^6 tons) are transported downstream by the river and distributed across the fringing floodplains during the monsoon. The basin sustains more than 300 million people in India, Nepal and Bangladesh (Gopal 2000). In India, all tributaries of the Ganges are controlled by barrages diverting flow for irrigation and as a result fish catch has been declined, and thereafter, loss of species diversity have been reported (Das 2007a; Payne et al. 2004). Moreover, twenty nine freshwater fish species as recorded in this study from river Ganges have been recently listed as threatened under vulnerable and endangered categories (Lakra et al. 2010). Therefore, conservation and restoration of river have become vital for the overall development and nutritional and livelihood security of the Indo-Gangetic region. Although, studies on the fish fauna of the river Ganges and its tributaries have been made by several authors and information was mostly reported on the systematic, biogeographical and ecological aspects (e.g., Hamilton 1822; Hora 1929; Day 1875–1878, 1889; Krishnamurti et al. 1991; Bilgrami and Datta Munshi 1985; Srivastava 1980; Revenga and Mock 2000; Sinha 2006; Payne et al. 2004; Sarkar et al. 2010) but these information are still inadequate to address the critical issues related to the conservation of fishes in the Ganges. In this connection, this study was carried out (1) to determine the current pattern of freshwater fish biodiversity, distribution and abundance; (2) to review the threats to fish diversity; and (3) to make recommendations for fish biodiversity conservation and management.

Materials and methods

In addition to primary data on fish distribution and abundance collected for a period of 3 years, the secondary data from different publications and the data sources (Payne et al. 2004; Sinha 2007a; Vass et al. 2009) have also been used to understand the change in distribution pattern of fishes in the Ganges. The data on annual fish catches in the river were obtained from Vass et al. (2009). The river Ganges was divided into three zones i.e., upper zone (Uttarakhand State) in Northern Himalayan area, where as middle zone (states of Uttar Pradesh and Bihar) and lower zone (States of Bihar and West Bengal) in plain area of river Ganges to sample and monitor fishes. Apart from main stream of the river Ganga, major tributaries of the river also sampled for fishes. In each zone, the sampling sites were further divided into several sub-zones and each sub-zones were sampled in all seasons of the year. Different threats faced by the fish biodiversity of river Ganges in each sampling points were also observed. We also studied status of fishes in four wildlife protected areas falling in the basin, of which, Rajaji National Park, Jhilmil Conservation Reserve falls under upper stretch, Turtle sanctuary in the middle stretch and Vikramshila Gangetic Dolphin Sanctuary in the lower stretch. The detail of the sampling sites of river Ganges is presented in Fig. 1.

In the upper zone (UZ), UZ 1 and UZ 2 cover the Bhagirathi River and its streams. UZ 1 consists of area between Gangotri and Uttarkashi, and sampling points were in Gangotri, Harsil, Ganeshpur and Uttarkashi. UZ 2 consists of area from Tehri to Devprayag and included the sampling points of Bandarkot, Tehri and Devprayag. The zones UZ 3 and UZ 4 were the river Alaknanda and its streams. UZ 3 starts from Phata and up to Karanprayag included the sampling sites of Phata, Nao Gaon, Nandprayag and Karnaprayag. UZ 4 covers from Rudraprayag to Pauri Garhwal included sampling points of Rudra prayag, Chamouli and Sri Nagar. UZ 5 falls outside Himalaya, covering areas from Ajeetpur to Lakshar includes Ajeetpur, Raiwala, Kulhal, Dehradun, Haridwar and Lakshar.

Fig. 1 River Ganga basin map showing study area across the stretch



In the middle zone (MZ), MZ 1 consists of area between below Haridwar to Ramsar site (Brijghat to Narora) which include the sites Brijghat, Narora. MZ 2 covers the area between Narora to Kanpur include Apsara, Ganga barrage, Tutaghat, Kannauj, Kanpur and MZ 3 from Kanpur to Allahabad include Dalerganj, Baruaghat, Sadiyapur and Allahabad. The stretch between Allahabad to Varanasi is termed as MZ 4 contains Varanasi and MZ 5 contains the stretch between Varanasi to Patna include Digha ghat, Adalat ghat, Ghagha ghat, Gai ghat, Lallupokhar ghat.

Similarly, in the lower zone, LZ 1 covers the stretch between Patna to Bhagalpur include Patna, Munger and Bhagalpur and LZ 2 contains the stretch between Bhagalpur to Rajmahal include Bhagalpur, Kahelgaon and Rajmahal., LZ 3 from Rajmahal to Farakka include the sampling sites Taltala ghat, Farakka and LZ 4 from Farakka to Navdeep include Manikchowk, Mushidabad, Raghunathganj, Lalgola, Mathurapur, Ahiron, Radha rghat, Nabwadeep and LZ 5 from Nabwadeep to Hoogly include the sampling sites Triveni ghat, Seraphulighat, Armenianghat and Hoogly.

The sites covered in the upper stretches are Raiwala, Aamsera, Vidoon, Banderkot, Uttarkashi, Harsil, Phata, Karanprayag, Gangotri, Shimili, Naogaon, Duggadda Gad, Khanda gad, Khankara gad. The middle zones consists of Brijghat, Narora, Apsara, Ganga barrage, Tutaghat at Kanpur; Dalerganj, Baruaghat, Sadiyapur at Allahabad and at lower zone the sites, Digha ghat, Adalat ghat, Ghagha ghat, Gai ghat, Lallupokhar ghat, Kastharny ghat, Hanuman ghat, Barari ghat, Kahalgaon, LCT ghat, Mahajan toil, Gudara ghat in Bihar and Manikchowk, Mathurapur, Farakka, Ahiron, Radharghat, Nabadweep, Trivenighat, Seraphulighat, Armenianghat in West Bengal were covered.

Sampling and analysis

Samples were collected at all sites covering pre rain and post rain at daytime (7:00–5:00) during April 2007 to March 2009. Experimental fishing was carried out in all sampling points with help of locally hired professional fishermen. Fishes were collected with gill nets (mesh 2.5 × 2.5 cm; 3 × 3 cm; 7 × 7 cm; length × breadth = 75 × 1.3 m; 50 × 1 m), cast nets (mesh 0.6 × 0.6 cm), drag nets or locally called *mahajal* (mesh 0.7 × 0.7 mm, L × B = 80 × 2.5 m with varying mesh sizes) and fry collecting nets (indigenous nets using nylon mosquito nets tied with the bamboo in both ends. At each site, all gears except cast nets were used at least ten times during each sampling occasion. The cast nets (5.5 m^2) were operated 20 times at each sites/sub sites covering about 100^2 meter of river segment allowing 3–5 min settled times in each cast. The relative abundance (percentage of catch) of fish across different sites was calculated by the following formula.

Number of samples of particular species
$\times$ 100/Total number of samples

Captured fish samples were released after recording of data except for a few individuals which needed to confirm species identifications in the laboratory. The fish diversity indices were calculated following formula (Shannon and Wiener 1963).

$$H = \sum_{i=1}^{n} \left(\frac{ni}{N}\right) \log 2 \left(\frac{ni}{N}\right)$$

where $H =$ Shannon-Wiener index of diversity; $n_i =$ total numbers of individuals of species, $N =$ total number of individual of all species. A data matrix was constructed with presence and absence of fish species for each of the sample stations in the protected and unprotected areas. Analysis of variance was conducted to test the presence of fish species in the different sites in river protected and unprotected area. Comparisons of mean data of diversity index were done using Tukey's Multiple Comparison Test. Statistical calculations were performed using Graph pad Prism 5 software package.

Similarity of the species in all sampling station was calculated using Jacquard's index:

$$S_j = j/(x + y - j)$$

where S_j is the similarity between any two zones X and Y, j the number of species common to both the zones X and Y, x the total number of species in zone X and y total number of species in zone Y. Similarity[1] within the sites was generated by using the Estimates S (version 8) software. Other analyses were carried out using the Statistica package.[2]

[1] Colwell (1996). User's Guide to Estimates- Statistical estimation of Species richness and shared species from samples. Version 8. User's guide and application published at http://www.viceroy.eeb.uconn.edu/estimates.

[2] StatSoft, Inc. (1999). Electronic Statistics Textbook. Tulsa. OK: StatSoft. Web: http://www.statsoft.com/textbook/stathome.html.

All specimens were identified based on the classification system of Nelson (2006) and scientific names were verified using http://www.fishbase.org. The colour, spots if any, maximum size and other characters of the fishes caught were recorded in a format developed for this purpose. Representative specimen ($n = 10$) of all fishes were preserved in 10% formaldehyde and transferred to the laboratory and stored in glass jars. Fishes were also collected from nearby fish market and landing centre associated with the river system which was not collected during experimental sampling. Taxonomy discrepancies were resolved with the latest database.

Results and discussion

Pattern of fish diversity

In India, 2,246 indigenous finfishes have been described of which 765 belongs to freshwater (Lakra et al. 2009). In the present study a total of 143 species belong to 11 orders, 72 genera and 32 families were recorded across all the stretches of river Ganges, which is about 20% of freshwater fish of the total fishes reported in India. This study added three more species in the checklist of freshwater fishes of Ganges basin in India (Payne et al. 2004; Shrestha 1990; Pathak and Tyagi 2010; Krishnamurti et al. 1991). A list of species with present distribution in all the stretch of river Ganges is provided in "Appendix". Out of 143 species, 133 species were native to river Ganges and its tributaries and remaining 10 species were exotics. The overall species richness of the Ganges basin is high (Hamilton 1822; Hora 1929; Venkateswarlu and Menon 1979; Day 1875–1878, 1889; Bilgrami and Datta Munshi 1985) despite several threats.

There was no endemic species reported during this study although in Asia the most number of endemic freshwater finfish species occur in India (De Silva and Abery 2007). However, there were reports of few endemic species in the upper streams of Ganges (Husain 1995; Uniyal 2010) which we could not find. High species richness found in orders of Cypriniformes, Siluriformes and Perciformes, accounting for 50.34, 23.07 and 13.99% of the population, respectively. The family Cyprinidae (53.47%), Bagridae (8.46%) and Channidae (1.47%) were found to be the most dominant in the Ganges (Fig. 2a). Studies in

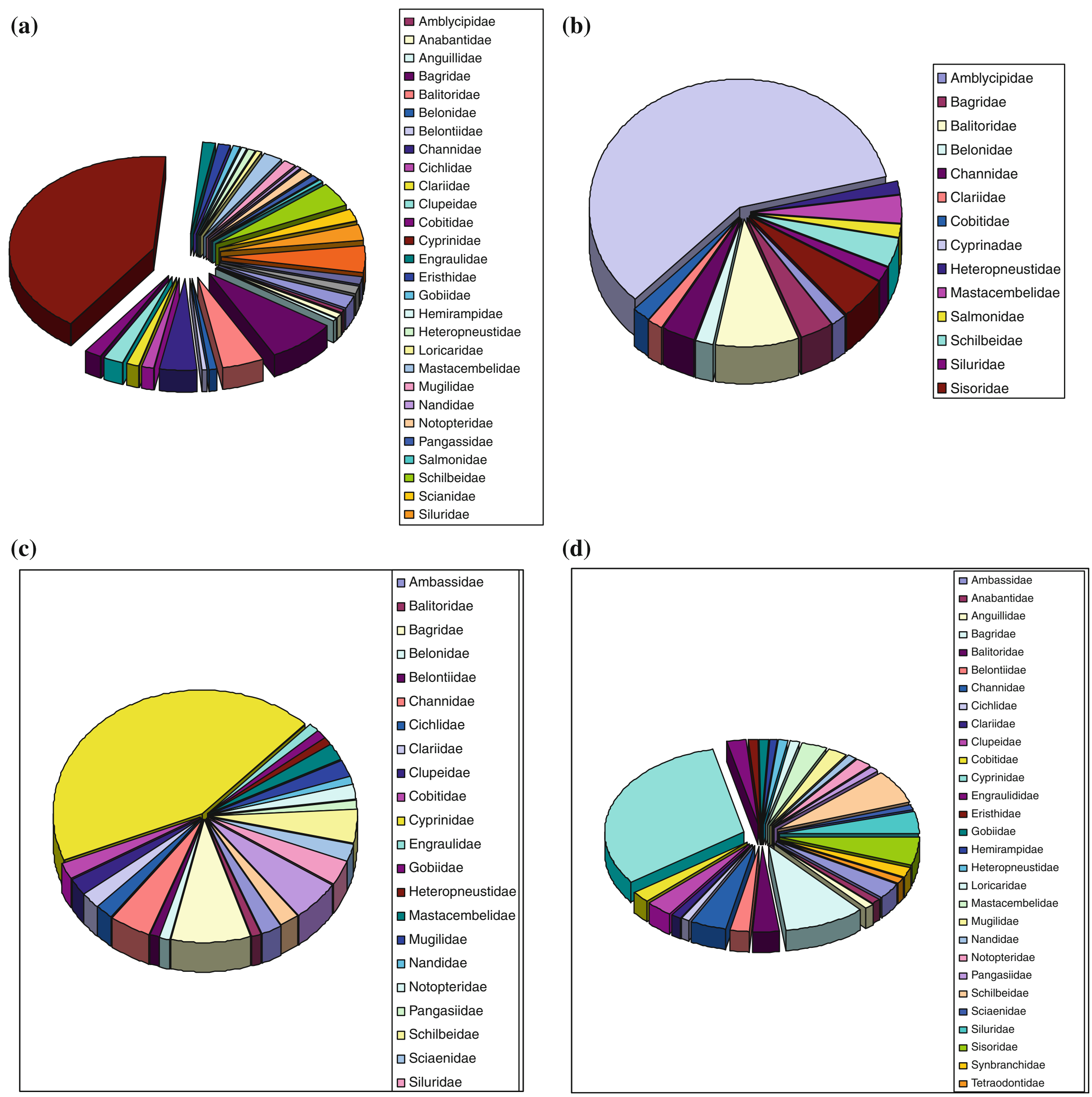


Fig. 2 Representation of families in River Ganga. **a** overall, **b** *upper* stretch, **c** *middle* stretch and **d** *lower* stretch

other Asian rivers have also found the more or less similar patterns (De Silva and Abery 2007; Raghavan et al. 2008; Sarkar et al. 2010). For instance, many of the species found in this river including the Cyprinids (e.g., *Barilius*, *Garra*, *Labeo*), Channids (*Channa*) Mastacembelids (*Mastacembelus*) as well as Notopterids are common to Africa as well. Review of literature shows that fish species richness in the Ganga river basin is low compared to that in other Asian rivers as indicated and the species area relationship could explain this phenomenon, because the area of the basin is second larger than those of other Asian rivers (Table 1).

Relative abundance of fishes of river Ganges showed dominancy of small sized indigenous species such as *S. bacilia* (19.68%), *G. chapra* (6.27%) and *P. ticto* (6.12%). However, this trend was reversed for the conservation important species like *M. vittatus* (2.33%), *R. corsula* (1.12%), *S. aor* (1.11%), *S. richardosonii* (0.74%), *P. sarana* (0.59%), *O. pabda*

Table 1 Drainage area, freshwater fish species number and species density of Asian rivers

River	Drainage area (km^2)	Number of species	Species density (number of species per 10,000 km^2)
Yangtze (China)	1,800,000	361	2.01
Ganges (India)	1,051,540	141,143[a]	1.34
Mekong	802,900	500	6.00
Yellow (China)	750,000	150	2.00
Zhujiang (China)	425,700	296	6.95
Salween (Burma)	279,720	150	5.36
Chao Phraya (Thailand)	177,500	222	12.51
Kapuas (Borneo)	94,480	290	30.69
Mahakam (Borneo)	93,423	147	15.73

Raw data from Kang et al. (2009), Fu et al. (2003)

[a] Present study

(0.51%), *S. silondia* (0.46%), *H. fossilis* (0.45%), *T. ilisha* (0.44%), *B. bagarius* (0.40%), *T. putitora* (0.39%), *T. tor* (0.28%), *C. chitala* (0.15%), *N. notopterus* (0.05%) and *P. pangasius* (0.02%).

The changes in the distribution pattern and range extension of some fishes in the Ganges were observed when compared to earlier reports (Payne et al. 2004; Shrestha 1990; Pathak and Tyagi 2010; Krishnamurti et al. 1991; Hamilton 1822; Hora 1929; Venkateswarlu and Menon 1979; Day 1875–1878, 1889; Bilgrami and Datta Munshi 1985) and there was a reduction in freshwater fish bio-diversity in general (Vass et al. 2009) which was mainly due to compartmentalization of river stretches largely due to hydro projects (Payne et al. 2004). The distribution pattern of the fishes of river Ganga basin has been presented in "Appendix". A total of 28 species including *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*), *B. bagarius*, *C. marulius*, *C. striata*, *C. batrachus*, *C. garua*, *C. latius*, *G. gotyala*, *W. attu* and some minor carps showed long range extension across all the three stretches. However, about 62 species had a narrow range distribution in the three zones. Fish composition of upper and lower zones of Ganges showed a high level of dissimilarity as observed in other rivers (Anderson et al. 2006) this might be due to difference in hydrology and temperature.

However, the Shannon-Weiner diversity index of upper, middle and lower stretches of the river indicated a strong relationship with overall species richness (Table 2). The minimum fish diversity index (3.0) was observed in middle stretch as compared to upper (3.05) and lower stretches (3.59) as shown in Fig. 3. Overall, the fish community indices across the river was low (Table 2) when compared to larger rivers in the world. Based on Namin and Spurny (2004) category, the low Shannon diversity index ($H = 2.85$) indicates that the river Ganges is moderately impacted. The low evenness index (0.27) across all the stretches may be due to phenomenon that river Ganges covers a great variation of latitude

Table 2 Indices of fish community structure of river Ganga

Sampling zones	No. of species	No. of family	Shannon Weiner index (H′)	Evenness (J)
Upper				
UZ 1	8	4	1.72	0.37
UZ 2	19	4	2.45	0.43
UZ 3	10	2	1.86	0.33
UZ 4	13	3	2.16	0.33
UZ 5	37	12	2.96	0.45
Total upper	56	33	3.05	
Middle				
MZ 1	40	16	1.44	0.19
MZ 2	33	12	1.53	0.18
MZ 3	30	14	2.44	0.33
MZ 4	48	13	3.26	0.47
MZ 5	64	23	3.27	0.35
Total middle	92	58	3.0	
Lower				
LZ 1	59	24	2.97	0.35
LZ 2	50	19	3.43	0.41
LZ 3	47	20	2.79	0.33
LZ 4	43	21	2.35	0.28
LZ 5	31	18	2.42	0.29
Total lower	95	65	3.59	
Total				
UZ1–LZ5	143	32	2.85	0.27

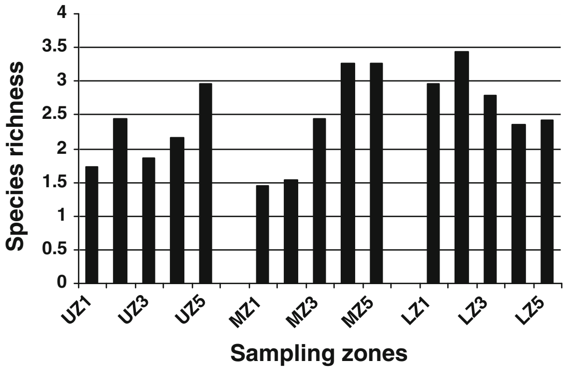


Fig. 3 Shannon Weiner diversity index across all sampling zones of river Ganga

and altitudes (10,000 ft), which mean that the some species are restricted to particular geographical area and do not appear in other areas especially, the cold water species in upper stretch.

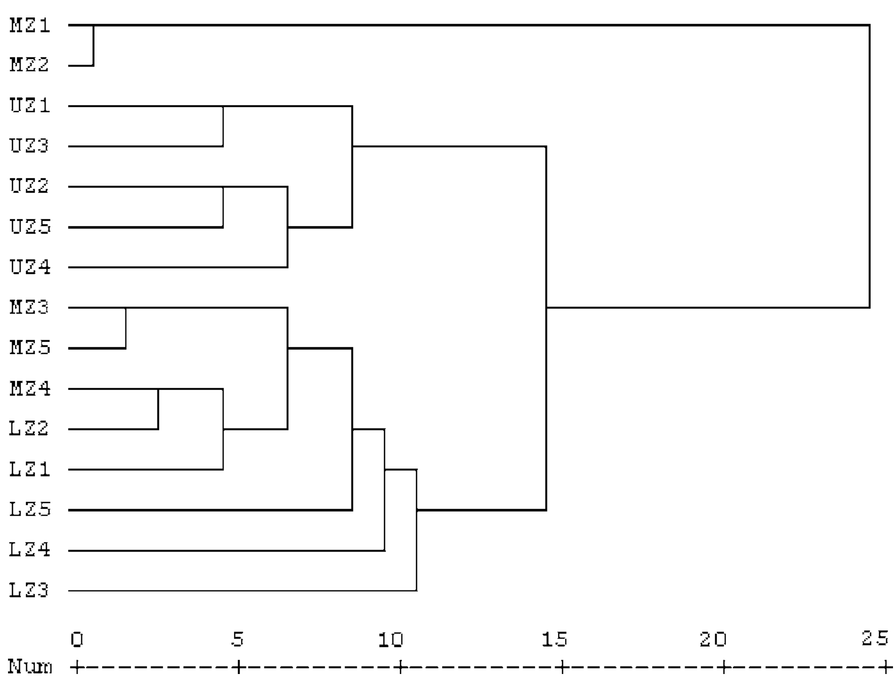
The ANOVA based on tukey's test showed significant difference ($P < 0.05$) between and among the sampling zones of all three stretches except between zone UZ 1 and UZ 3 where the value of "*P*" was observed high at 95% confidence interval. The similarity in species composition across the river is shown in Fig. 4. We have recorded more similarity was between the sampling zones in upper stretch, while sampling zones of middle and lower stretches showed less similarity among themselves. The probable reason can be the more evenness in the fish community in the sampling zones of upper stretch compared to middle and lower stretch.

Stretch-wise fish diversity

Upper stretch

A total of 56 fish species belonging to 32 genera and 13 families were recorded from all the five zones of upper stretch of river Ganges (Table 2). The cyprinidae with 33 species and 14 genera was the major dominant family (78.97%) and much behind were the presence of other families like, Balitoridae (15.58%) and Sisoridae (1.22%) as shown in Fig. 2b. Overall, the community structure in upper stretch of river was characterized by a few specialized cyprinid types, specifically the snow trouts (*Schizothorax* spp.), the mahseers (*Tor* spp.) and the lesser barils (*Barilius* spp.), the hillstream loaches (*Nemacheilus* spp.) and the sisorid torrent cat fishes (*Glyptothorax* spp.). In the upper stretch alone, only 4 species including *S. richardsonii*, *T. putitora*, *B. bendelisis* and *P. chelinoides* were recorded from all the five sampling zones. Restricted distribution was observed for

Fig. 4 Dendrogram showing similarity between all sites in river Ganga



41 species under the genus *Barilius*, *Nemacheilus* and *Schizothorax* species and most of them were restricted to upper three zones. There was no record of fish above 2400–3000 masl elevation. Surveys in Nepal have shown no fish records beyond an altitude of 1,650 masl (Shrestha 1978) and 1,800 masl (Jha 1992). The relative abundance of conservation and management important fish species in this river stretch was dominated by *B. bendelisis* (18.64%) followed by *S. richardsonii* (16.21%), *T. putitora* (8.51%), *S. montana* (5.49%), *T. tor* (4.5%), *G. gotyla* (1.49%) and *G. pectinopeterus* (0.77%).

Although much research was addressed on various ecological aspects (Nautiyal and Lal 1984, 1985; Nautiyal et al. 1998; Singh 1988; Sharma 2003) of the species like golden mahseer (*T. putitora*, *T. tor*) and snow trouts (*Schizothorax* species) from some tributaries in the upper stretches, however, detailed ecological information is still lacking for several cold water species in the region. Estimates of catches at four points along the Alaknanda in the Garhwal Himalaya showed range between 1,035 and 2,475 kg km^{-1} $year^{-1}$ with an average of 1,650 kg km^{-1} $year^{-1}$ while a lower tributary, the Nayar river believed to be an important fish breeding habitat in the region, produced 621 kg km^{-1} $year^{-1}$ (Payne and Temple 1996).

The Shannon-Weiner index within five sub-zones of upper stretch varied from 1.72 to 2.96 (Table 2). More fish diversity in the lower altitude than higher altitudes. However, the evenness index (J′) values ranged between 0.33 and 0.45 in all five sub-zones of upper Ganges reveals that there was a considerable uniformity in the distribution of species in the sampling zones. The evenness index was highest in the sampling zone UZ 5 and lowest at two sampling zones i.e., UZ 3 and UZ 4 (Table 2).

Middle stretch

Among the five zones in the middle stretch of river Ganges, a total of 92 fish species belonging to 58 genera and 24 families were recorded (Table 2). The number was lower than what was recorded earlier i.e., 106 species (Hassan et al. 1998; Srivastava 1968, 1980; Payne et al. 2004). The Cyprinidae with 40 species and 20 genera was the major dominant family (56.10%) followed by, Schilbeidae (10.60% and Clupeidae 8.55%) as shown in Fig. 2c. In the stretch of Allahabad, a constant declining of all economic species observed. For example, major carps catch was 424.91 tons in 1961–1968 which reduced to 38.58 in 2001–2006, similarly cat fishes 201.35 in 1961–1968 to 40.56 2001–2006 (Pathak and Tyagi 2010).

In the middle stretch, the relative abundance of certain threatened species were calculated for *E. vacha* (4.90%) followed *C. garua* (3.41%), *S. aor* (1.75%) *R. corsula* (1.40%), *B. bagarius* (0.78%), *O. pabda* (0.58%), *M. tengara* (0.52%), *C. mrigala* (0.44%), *L. rohita* (0.44%), *N. notopterus* (0.43%) and *C. chitala* (0.08%). This is significantly lower when compared to commonly occurring species like *Salmophasia bacaila* (34.39%), *Puntius ticto* (6.72%) and the clupeids *Gudusia chapra* (8.3%) (Payne and Temple 1996). The present distribution pattern of the fishes in the middle stretch showed that 15 species such as *B. bagarius*, *C. punctatus*, *C. reba*, *R. rita*, *S. aor*, *W. attu* and *C. garua* were common to all the five sampling zones.

The Shannon-Weiner indexes within five sampling zones of middle stretch were varied from 1.44 to 3.27 (Table 2). The highest value was recorded in the sampling zone MZ 5 followed by MZ 4, MZ 3, MZ 2 and lowest in MZ 1. The evenness index (J′) values ranged from 0.18 to 0.35, which indicate that there was high variation in the distribution of species between the sampling zones. The evenness index was recorded highest in the sampling zone MZ 4 and lowest at MZ 2 (Table 2).

Lower stretch

The lower stretch of river that is largely flood plains of the Ganges was recorded with 95 fish species belonging to 65 genera and 29 families (Table 2). Earlier, Bilgrami and Datta Munshi (1985) reported 89 species in this stretch. The Cyprinidae with 30 species and 17 genera was the major dominant family (45.77%, Fig. 2d) followed by Schilbeidae (11.41%) and Bagridae (8.99%). *Labeo rohita* (8.15) and *Johnius coiter* among Sciaenidae (7.59) were dominated in the catch. The relative abundance of economically importance species such as *R. rita* (1.60%), *T. ilisha* (0.82%), *C. panctatus* (0.79%), *O. pabo* (0.18%), *S. silonida* (0.57%), *P. pangasius* (0.51%), *O. pabo* (0.18%) and *C. chitala* (0.15%) were recorded as low except *L. rohita* (8.15%), followed by *A. coila* (5.95%), *M. vittatus* (3.85%), *C. mrigala* (2.29%) and *L. bata* (2.18%).

The rich fish diversity in the lower stretch may be attributed to the significant contributions of larger numbers of tributaries and presence of protected area. A total of 11 species such as *A. coila*, *C. panctatus*, *N. notopterus*, *L. calbasu*, *M. cavasius*, *C. nama*, *P. sophore* and *N. nandus* were recorded from all the five sampling zones, however, about 33 including *A. microlepis*, *A. bengalansis*, *M. albus*, *S. rabdophorus*, *A. gora* and *E. hara* were recorded with fragmented distribution. The recent report (Pathak and Tyagi 2010) on the fish yield at Patna indicates that drastic reduction in the catch of Indian major carps (383.2–118 kg km^2), large cat fishes (373.8–194.48 kg km^2). Migratory hilsa has declined even more dramatically (234.7–1.38 kg km^2).

The Shannon-Weiner index of fishes in the lower stretch ranged from 2.35 to 3.43 (Table 2) with minor variations between zones. The value was highest in the sampling zone LZ 2 followed by LZ 1, LZ 1, LZ 5 and lowest in LZ 4. The considerably low variations within sampling zones indicate that the species composition were almost uniform in this stretch. The evenness index (J′) values mainly ranged from 0.28 to 0.4 also revealed considerable uniformity in the distribution of species in the sampling zones (Table 2).

New distribution and biological changes

In our study, we recorded a number of fish species which were never reported in the upper stretch of the river and were predominantly available in the lower and middle stretches in the 1950s (Menon 1954) were recorded from the upper cold-water region. For instance, the range extensions of several fish species including *Mastacembelus armatus* and *Cyprinus carpio*, var. specularis was recorded in the upper stretch (between Tehri and Rishikesh) and *Glossogobius giuris*, *Macrognathus aral*, *Sperata aor*, *Clupisoma garua*, *Puntius sarana* and *Ompok pabda* was recorded in Haridwar stretch indicating a perceptible shift in distribution pattern of fishes ("Appendix"). Correspondingly, species like *Glyptothorax brevipinnis* and *G. telchitta*, common inhabitants of upland waters were also recorded in the middle stretch of river Ganges during premonsoon periods confirming the range extension of these species towards down stream. Additionally, distribution range of *Panna microdon* which inhibits in brackishwater and marine environment was extended to upstream of Ganges up to Patna. This shift might be due to changes in the hydrology as well as increase in water temperature possibly due to global warming. Globally, in the recent years it has been reported that freshwater fish species could greatly change their present-day distribution in response to climate change (Mohseni et al. 2003; Chu et al. 2005; Buisson et al. 2008) and has now become a serious threat to the freshwater diversity (Habit et al. 2006). In India, analysis of 30 years' time series data on river Ganges and water bodies in the plains, Vass et al. (2009) reported an increase in annual mean minimum water temperature in the upper cold-water stretch of the river (Haridwar) by 1.5°C (from 13°C during 1970–1986 to 14.5°C during 1987–2003) and by 0.2–1.6°C in the aquaculture farms in the lower stretches in the Gangetic plains. Possibly, the considerable changes in temperature clime has resulted in a perceptible biogeographically distribution of the fish fauna we reported here. Furthermore, the shrunken distribution range of cold water species *Schizothorax* spp. towards the upstream could be considered as a warranting situation due to temperature increase. Consequently, we also observed that fishes were gravid during winter months (November to December) which is uncommon and never reported earlier indicating a shift in maturity which might also be due to changes in hydrology of river system due to numerous numbers of hydro projects as well as increase in temperature due to climate change (Table 3). It is evident from the literature that temperature is an important factor which strongly influence the reproductive cycle (Planque and Fredou 1999; Svedang et al. 1996), and growth rate in fishes (Brander 1995). In another study, Vass et al. (2009) also reported that failure in breeding and natural spawning of freshwater fishes and stated that the reasons might be due to shift in the rainfall patterns and also alteration of flow and turbidity of the river water.

Fish diversity of the protected areas

India has more than 690 wildlife protected areas, of these, four protected areas which are located in the river Ganges basin contributes a lot for fish conservation. Many fishes might use these protected areas for breeding and spawning grounds. Fishing is totally prohibited in these areas which resulted high fish diversity in these areas with higher size classes. In our study, considerable fish diversity was observed in the Ganges stretch passing through protected area of

Table 3 List of gravid fishes indicating shift in maturity stages collected from Ganga at different sampling sites

Name of fish species	Location	Collection month	Length (cm)	Weight (gm)
Aspidoparia morar	Patna, Munger and Bhagalpur	December	9.5–12.5	15–30
Eutropiichthys vacha	Patna	December	24	105
Mystus tengara	Munger	January	22	50
Gudusia chapra	Allahabad	November	14.2	19.5
Mystus cavasius	Munger	January	18	45
Mystus menoda	Munger	January	25	125
Nangra punctata	Munger	January	7.5	10
Nandus nandus	Allahabad	November	11.9	25.6
Setipinna brevifilis	Kahalgaon	January	19	38
Xenentodon cancilla	Bhagalpur	January	18.5	25
Rhinomugil corsula	Kanpur	November	22.0	126.4

river Ganga basin. A total of 59 species were recorded from the Turtle Sanctuary located in the middle stretch of river Ganges. Similarly, the Rajaji National Park and Jhilmil Conservation Reserve located in the upper stretch recorded with 40 and 41 fish species, respectively. Many cold water fishes especially *Barilius* spp. was observed breeding in large numbers in these protected areas. The percentage contribution of the fishes of the protected areas to the total diversity were 72, 65 and 44% for upper, middle and lower stretches, respectively showing that protected areas are important for fish conservation in the basin. Baird (2006) reported that fish conservation zones can benefit fish stocks, especially relatively sedentary species, but also highly migratory one and concluded that fish sanctuaries can be important tools in the context of participatory community-based fisheries/co-management programmes. Sarkar et al. (2008) reported more species diversity, greater fish abundance and relatively larger individuals in a protected riverine ecosystem in Northern India. Therefore, management strategies of the large rivers should also include protected habitats and hence, more studies should be encouraged.

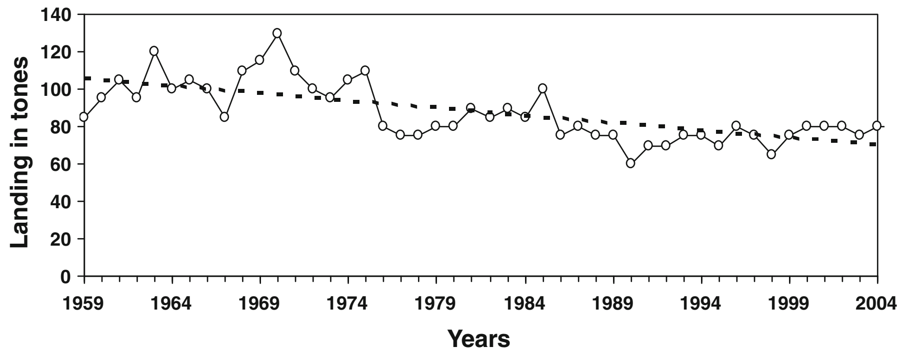
Exotics

A total of 10 exotic fish species were recorded from the river Ganges and distributed in all stretches of Ganges. The relative abundance was recorded highest for *C. carpio* (50.14%) followed by *O. mosambica* (25.82%) and *C. gariepinus* (12.29%). *C. carpio* was distributed in all the stretches of the river. In the upper stretches alone three species viz., *C. carpio* (3.02%), *C. carpio* var. *specularis* (0.14%) and *O. mykiss* (0.27%) were recorded whereas in the middle stretch 7 species viz., *C. gariepinus* (0.04%), *C. idella* (0.22%), *C. carpio* (1.76%), *H. nobilis* (0.03%), *H. molitrix* (0.01%), *O. mossambicus* (0.98%) and *O. niloticus niloticus* (0.31%) and in the lower stretch 5 species viz., *C. carpio* (0.21%), *H. nobilis* (0.02%), *H. molitrix* (0.04%), *O. mosambica* (0.17%) and *Ptrerigoplichthys anisitsi* (0.01%). All these exotic species were not reported earlier from the main channel of the Ganges although some species like *Ctenopharyngodon idellus*, Silver carp (*Hypophthalmychthys molitrix*), *Oreochromis mossambicus*, Thai magur (*Clarias gareipinus*) and *Cyprinus carpio* have been reported in the tributaries of Ganga basin (Bhakta and Bandyopadhyay 2007; Sarkar et al. 2010). Higher abundance and range extension of *C. carpio* threatening the native species. Changes in hydrology especially more reservoir types of situation due to barriers across river seems to responsible for the flourishing of *C. carpio* in the basin. The stretch wise distribution of exotic fish species is shown in "Appendix".

Structural changes and fishery production

The total annual fishing production in the basin had been declined from 85.21 tons during 1959 to 62.48 tonnes during 2004 (Fig. 5). The dynamics of the 4 different major fish groups showed that the percentage of major carps had decreased from 41.4 to 8.3 tons from 1958–1962 to 1996–1997 (Fig. 6). The proportion of major carps in the fishery declined from 43.5 to

Fig. 5 The dynamics of annual fishery landings in the River Ganga during 1959–2004 (*Source*: Das 2007b)



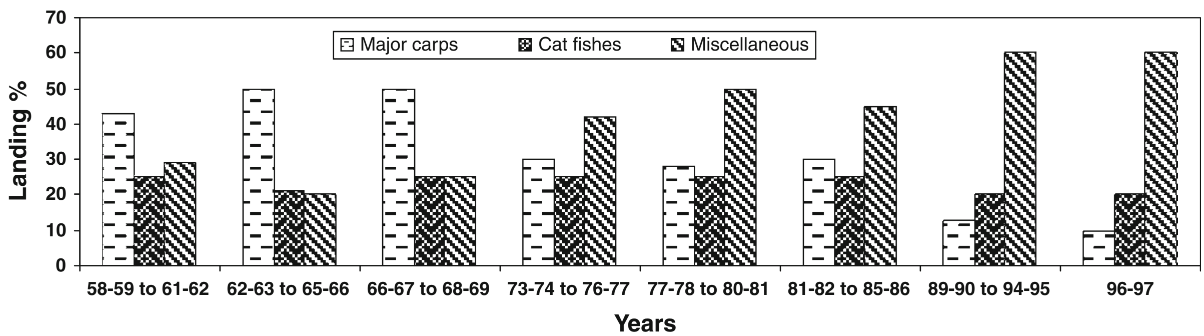


Fig. 6 The dynamics of total annual fishery landings of major fish groups in the River Ganga during 1959–2004. (Source: Das 2007)

29% by 1972–1976 and 13% today (Payne et al. 2004). Significant reductions in catches of around 1,600 tonnes or 13% over 10 years were found at Allahabad. The miscellaneous fish percent increased from 27.1% in 1958–1962 to 63.4% by 1996–1997. During the same time period the catfish percentage increased from 21% to 24.6% (De 1999). The anadromous hilsa (*Tenualosa ilisha*) has also declined due to the Farrakah barrage and the inaccessibility of the connecting canal. The low fish production of the major fish groups in the river Ganges is believed to be the recruitment failure of the young ones due to degradation (decreased runoff, changes in flow, turbidity) of the natural spawning habitat and climate change (Das 2007b). In this light, our findings on the age structure of *Labeo rohita* and *Tor putitora* of river Ganges indicated that the number of older individuals tended to decrease (Khan and Siddiqui 1973; Sarkar et al. 2006) from 1973 to 2006 (Table 4) which is might be due to unsustainable exploitation of the resources. On the other hand, we noticed that the large proportion of younger individuals appears to be expanding as compared to older ones. It is evident that the ratio of various age groups in a population determines the current reproductive status of the population and indicates what may be expected in the future. Usually a rapidly expanding population, will contain a large proportion of young individuals whereas, a declining population will contain a large proportion of old individuals and stationary population will have a more even distribution of age classes (Odum 1971). Therefore, the rapidly expanding population of *Labeo rohita* and *Tor putitora* in river Ganges is nevertheless a stable population. Further, if the effects of unsustainable exploitation can be countered, these populations may rejuvenate itself.

Threats

In the Ganga river basin, alterations in fish diversity and community structure are mainly due to hydrological alterations, dam constructions, over fishing, pollution, water diversions, changing land use pattern, exotic species invasion, rapid sedimentation, deforestation, climatic changes and land erosion etc. Assessing impacts and threats directly informs conservation strategies, management options and priorities for actions (Linke et al. 2007). According to

Table 4 Changes in mean age structure in percentage of *Tor putitora* and *Labeo rohita* in river Ganga and its tributaries

Year	Species	Author	Age																	
			0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+
1980–1981	*T. putitora*	Nautiyal et al. (2008)	19.6	21.2	11.3	9.8	7.5	6.06	5.3	3.7	3.03	3.03	3.03	–	3.03	–	–	–	2.27	0.7
1994–1996	*T. putitora*	Do	18.03	46.7	14.2	6.8	5.2	2.8	3.4	–	1.5	0.02	0.01	0.01	–	0.02	–	–	0.01	0.01
1967–1969	*L. rohita*	Khan and Siddiqui (1973)	–	35.7	15.7	8.6	9.1	8.2	7.7	7.4	4.5	1.9	1.2	–	–	–	–	–	–	–
2000–2004	*L. rohita*	Sarkar et al. (2006)	–	62.5	18.9	10.5	6.6	0.14	–	–	–	–	–	–	–	–	–	–	–	–

Karr and Chu (1995) freshwater ecosystem conservation plans rely mainly on assessing ecological integrity of ecosystems, based on the notion that ecosystems of high ecological integrity support and maintain the full natural range of biological features and ecological processes.

The main ecohydrological alterations are construction of dams and barrages on the river, loss of wetlands and floodplain habitat and water diversions. Alterations of water quantity, seasonal flows and patterns of flow variability such as by damming and abstractions, or inter-basin transfers (IBTs) have substantial and negative consequences for the maintenance of biodiversity in many rivers (Arrington and Winemiller 2003; Linfield 1985; Sinha and Khan 2001; Sinha 2007b; Lakra et al. 2011). A series of barrages and dams have been commissioned in the upper segment of river Ganges from Rishikesh to Narora (Rao 2001) and the Tehri dam constructed in the hills of Uttarakhand has considerably reduced the water flow and have shown detrimental effects on physical attributes and destruction of feeding, spawning, and migration routes of mahseer (Sharma 2003). In addition, along with mahseer (*Tor putitora*, *T. tor*) the other migratory species like dwarf goonch (*Bagarius bagarius*), yellowtail catfish (*Pangasius pangasius*), pangas catfish (*Silonia silondia*), hilsa (*Tenualosa ilisha*) and long whiskered catfish (*Sperata aor*) from the middle and upper stretch is under severe threat due to consequences of damming and water diversions projects. Vast amount of sediment (mean annual 1,625 $\times$ 10^6 tons) are transported downstream by the river and distributed across the fringing floodplains during the period of inundation (July to September) which results into sedimentation of fish spawning sites affecting their breeding. Due to siltation, use for dryland farming and construction of embankments wetlands in the Ganges basin are vanishing very fast. In addition, more than 150,000 km^2 of the Ganges basin is irrigated using some 85,000 m^3 of river water which has led to extensive problems of soil salinisation and as a result the salt load of the returning irrigation water over 6.3 million tones of salt are estimated to be added to the water annually (CPCB 1984). Large number of industries located in the basin discharge enormous amounts of toxic wastes to the Ganges. The severe impacts of industrial effluents disposed into the river have resulted in fish kills reported from time to time (Sunderesan et al. 1983; Das et al. 2007). Bioaccumulation of heavy metals was observed in fishes in the lower stretch of the river and at Varanasi (Ghosh et al. 1982; Sinha 2004). The agriculture sector drains about 134.8 million waste into the river basin. Similarly, 2,573 tonnes pesticides, mainly DDT and BHC-Y are applied annually for pest control (Sinha 2007b). The Ganges Basin is reported to carry some 200 tonnes of biological oxygen demand (BOD) per day gross pollution. However, it is still relatively localized and focused on urban centers including Hardwar, Kanpur, Varanasi and Diamond Harbour near Kolkata. This appears to be related to the decline in catch of fisherfolk from 30–40 kg to 15 kg per day downstream of the town (Kumra 1995). Our result suggests that, dominance of exotics, over exploitation and effects of climate change are also posing serious threat to native fishes of Ganges.

Conservation status

The conservation assessment of fishes of river Ganges has been presented in Fig. 6. Of the 143 freshwater fish species, about 20% of fish species in Ganges were assessed as threatened category following IUCN Red List Criteria. More number of threatened fishes found in upper stretch (26%) followed by lower (23%) and middle (20%; Fig. 7). Distinctly threatened species are characteristically those fish belong to very defined taxonomic units of restricted geographic range, and appears to be particularly sensitive to one or more human threats and those populations or range which have undergone a significant decline and seems likely to continue (Lakra et al. 2010).

Conservation and management recommendations

Current efforts

India has legislated the Wildlife (Protection) Act, 1972, Biological Diversity Act (2002) and Biological Diversity Rules (2004), which aimed to conserve and protect the biodiversity in the country and also ensure the sustainable utilizations. Several protected areas declared using the Wildlife (Protection) Act, 1972 which are directly or indirectly conserving fish diversity in the country although none of freshwater fishes listed in the Act. Among current conservation efforts, an innovative approach has been adopted for the first time in the country by NBFGR, Lucknow which involves integration of the key stakeholders in the conservation exercise by the strategies of declaring a State Fish, and 16 states have declared State Fish in order to achieve the real time conservation benefits. Successful artificial propagation of several species like *Chitala chitala*, *Ompok pabo*, *O. pabo*, *Anabas testudineus*, *Nandus nandus* were achieved (Lakra and Sarkar 2009). In

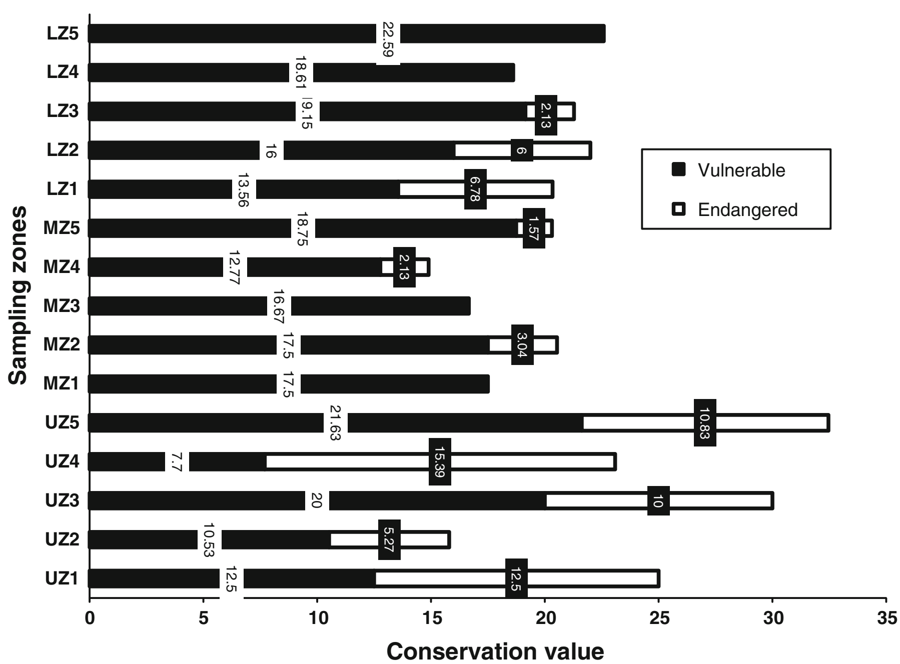


Fig. 7 Conservation status (%) of threatened fish species in different zones in river Ganga

addition, several measures like, in situ conservation, habitat fingerprinting, ex-situ conservation and developing live gene banks have been implemented to conserve the native fish diversity. In this light, in Northern India, observations were made in the water bodies of the selected wildlife sanctuaries in order to conceptualize the need and approach for developing freshwater aquatic sanctuaries (FAS) within the protected area network (Sarkar et al. 2008).

Recommendations

The creation of specially targeted fish protected areas is an important step in the conservation of Ganges and its biodiversity. We identified the Nayar, Mandal, Saung and Kho rivers which are tributaries in the upper stretch of river Ganges, are important habitats of fish to breed and spawn (Atkore et al. 2011; Anupama and Gusain 2007; Nautiyal and Lal 1984) which may be declared as protected areas in consultation with local communities. A proper environment assessment is required before taking up any hydro projects in the Ganges. In the middle and lower stretches of the river Ganges the conservation strategies for fishes must take into account the life history traits and habitat requirements of migratory species. Biological characters of the many species are still unknown and therefore studies are needed. Restoring the natural stocks of the species should be a priority, which includes ensuring minimum flow requirements and revival of lost breeding grounds and thereby restoring the failed recruitment process. This may be achieved by negotiation with the stakeholders so that the required flow and depth of the river is maintained. In addition, restoration of floodplain and associated wetlands should be a priority for conservation because floodplains play an integral part of riverine ecosystem. Many floodplains have already lost their connection with main channel due to heavy siltation. Floodplains serve as breeding and nursery grounds for several species. Towards restoring those critical habitats, research efforts should be translated into social and political actions as early as possible. Efforts should be made to check the sediment flow by extensive plantation of native trees, shrubs, etc. on the riverbank and adjoining catchment area. Effective construction of fish passage structure is necessary. Conventional fish ladders designed may not be successful because most fishes do not jump. In the middle stretch of the river Ganges (Allahabad), Hilsa (*Tenualosa ilisha*), which used to form a good share in catches below Allahabad has almost disappeared after inception of Farakka barrage despite fish ladders were installed. Steps should be taken to improve fish pass way so that the fishes may negotiate upstream areas.

Research efforts on generating the life history of 29 threatened fishes in the river (as listed in "Appendix") is necessary for successful conservation. An ecosystem approach of fish conservation is a new management of fish community in many countries (Frissell 1997; Sarkar and Bain 2007). Therefore, information on the role of species diversity is the functioning of ecosystems should be incorporated into comprehensive environmental management policies of the large Indian rivers.

Conclusions

Range extension of certain species and reduction in ranges of few species is a serious concern in the long term conservation of fishes in the Ganges. Moreover, higher abundance of exotics, fragmentation and changes in the hydrology of river due to hydro projects and barriers are major threat to the fishes in the Ganges apart from indiscriminate fishing, pollution, poor land use pattern. So far, in India fishes are considered as commercial product and failed appreciate their ecological services which pushed large number of species under threatened categories. Fish conservation areas, landscape level conservation plan, proper Environment Impact Assessment for any developmental activities in the basin, habitat restoration plan, species recovery plan for certain threatened species in the Ganges etc. may help the native fish diversity restore in the Ganges. India has recently formed a National River Ganga Basin Authority (NRGBA), Chaired by the Honorable Prime Minister of India, would certainly help to mitigate the threats and conserve the aquatic biodiversity.

Acknowledgments The authors are grateful to the ICAR (Indian Council of Agricultural Research), New Delhi for financial support and Director, NBFGR, Lucknow, Director and Dean, Wildlife Institute of India for guidance and encouragement. We are also thankful to the anonymous reviewer for his valuable suggestions to improve this paper.

Appendix

See Table 5.

Table 5 List of freshwater fishes of river Ganga

Fish species		Distribution														
		Upper zone					Middle zone					Lower zone				
		UZ1	UZ2	UZ3	UZ4	UZ5	MZ1	MZ2	MZ3	MZ4	MZ5	LZ1	LZ2	LZ3	LZ4	LZ5
1.	*Alia coila* (Hamilton 1822)						*	*	*		*	*	*	*	*	
2.	*Acanthocobitis botia* (Hamilton 1822)									*		*				
3.	*Amblyceps mangois* (Hamilton 1822)[d]					*										
4.	*Amblypharyngodon gora* (Hamilton 1822)											*	*			
5.	*Amblypharyngodon microlepis* (Bleeker 1854)											*				
6.	*Amblypharyngodon mola* (Hamilton 1822)										*	*	*	*	*	*
7.	*Anabas testudineus* (Bloch 1792)											*	*	*		*
8.	*Anguilla bengalensis* (Gray 1831)											*				
9.	*Aspidoparia jaya* (Hamilton 1822)								*			*	*			
10.	*Aspidoparia morar* (Hamilton 1822)								*			*	*	*		*
11.	*Bagarius bagarius* (Hamilton 1822)[e]					*	*	*	*	*	*	*	*	*	*	
12.	*Bagarius yarrelli* (Sykes 1839)[d]											*	*			
13.	*Barilius barila* (Hamilton 1822)		*						*	*	*					
14.	*Barilius barna* (Hamilton 1822)					*			*							
15.	*Barilius bendelisis* (Hamilton 1807)	*	*	*	*	*						*				
16.	*Barilius tileo* (Hamilton 1822)					*										
17.	*Barilius vagra* (Hamilton 1822)		*		*											
18.	*Batasio batasio* (Hamilton 1822)							*								
19.	*Botia almorhae* (Gray 1831)											*				
20.	*Botia dario* (Hamilton 1822)[e]						*					*	*	*		
21.	*Botia lohachata* (Chaudhuri 1912)		*								*	*				
22.	*Catla catla* (Hamilton 1822)					*	*		*	*		*	*	*	*	
23.	*Chagunius chagunio* (Hamilton 1822)[d]					*					*	*	*			
24.	*Chanda nama* (Hamilton 1822)								*	*	*	*	*	*	*	
25.	*Chanda ranga* (Hamilton 1822)											*	*	*		
26.	*Channa punctatus* (Bloch 1793)						*	*		*	*	*	*	*	*	
27.	*Channa marulius* (Hamilton 1822)					*	*			*	*	*	*	*	*	*
28.	*Channa orientalis* (Bloch & Schneider 1801)									*	*					
29.	*Channa stewartii* (Playfair 1867)									*						
30.	*Channa striatus* (Bloch 1793)					*			*	*	*	*	*	*	*	*

Table 5 continued

	Fish species	Distribution														
		Upper zone					Middle zone					Lower zone				
		UZ1	UZ2	UZ3	UZ4	UZ5	MZ1	MZ2	MZ3	MZ4	MZ5	LZ1	LZ2	LZ3	LZ4	LZ5
31.	*Chela laubuca* (Hamilton 1822)							*			*	*				
32.	*Chela cachius* (Hamilton 1822)									*						
33.	*Chitala chitala* (Hamilton 1822)[d]					*	*	*			*	*	*	*		
34.	*Cirrhinus mrigala* (Hamilton 1822)		*				*	*	*	*	*	*	*	*		*
35.	*Cirrhinus reba* (Hamilton 1822)						*	*	*	*	*	*	*	*	*	*
36.	*Clarias batrachus* (Linnaeus 1758)					*					*	*		*		*
37.	*Clarias gariepinus* (Burchell 1822)[c]								*							
38.	*Clupisoma garua* (Hamilton 1822)[a]						*	*		*	*	*	*	*	*	
39.	*Colisa fasciata* (Bloch & Schneider 1801)										*	*		*	*	
40.	*Crossocheilus latius latius* (Hamilton 1822)[e]					*		*				*	*	*		
41.	*Ctenopharyngodon idella* (Valenciennes 1844)[c]								*							
42.	*Cyprinus carpio* (Linnaeus 1758)[c]		*			*	*	*	*		*	*	*			
43.	*Cyprinus carpio* (Var. *Specularis*) (Lacepède 1803)[c]		*													
44.	*Danio devario* (Hamilton 1822)											*				
45.	*Erethistes hara* (Hamilton 1822)											*				
46.	*Esomus danricus* (Hamilton 1822)											*				
47.	*Eutropiichthys murius* (Hamilton 1822)								*			*	*			
48.	*Eutropiichthys vacha* (Hamilton 1822)[e]						*	*	*	*	*	*	*	*	*	*
49.	*Gagata cenia* (Hamilton 1822)						*	*			*	*	*	*		
50.	*Garra gotyla gotyla* (Gray 1830)[e]											*	*			
51.	*Glossogobius giuris* (Hamilton 1822)[a]							*	*	*	*	*	*		*	*
52.	*Glyptothorax pectinopterus* (McClelland 1842)		*		*											
53.	*Glyptothorax brevipinnis* (Hora 1923)[a]								*							
54.	*Glyptothorax telchitta* (Hamilton 1822)[a,e]				*							*				
55.	*Gonialosa manmina* (Hamilton 1822)[e]										*	*	*	*		
56.	*Gudusia chapra* (Hamilton 1822)						*					*	*	*	*	*
57.	*Hemibagrus menoda* (Hamilton 1822)[d]											*				
58.	*Heteropneustes fossilis* (Bloch 1794)[e]					*	*				*	*		*	*	*
59.	*Hypophthalmichthys molitrix* (Valenciennes 1844)[c]													*		
60.	*Hypophthalmichthys nobilis* (Richardson 1845)[c]									*		*				

Table 5 continued

	Fish species	Distribution														
		Upper zone					Middle zone					Lower zone				
		UZ1	UZ2	UZ3	UZ4	UZ5	MZ1	MZ2	MZ3	MZ4	MZ5	LZ1	LZ2	LZ3	LZ4	LZ5
61.	*Hyporhamphus limbatus* (Valenciennes 1847)[b]											*	*			
62.	*Johnius coiter* (Hamilton 1822)						*				*	*	*	*	*	*
63.	*Johnius gangeticus* (Talwar 1991)										*					
64.	*Labeo angra* (Hamilton 1822)									*						
65.	*Labeo gonius* (Hamilton 1822)						*					*	*			
66.	*Labeo bata* (Hamilton 1822)		*			*	*	*		*	*	*	*	*	*	*
67.	*Labeo boggat* (Sykes 1839)						*				*					
68.	*Labeo calbasu* (Hamilton 1822)			*			*	*	*		*	*	*	*	*	*
69.	*Labeo (Bangana) dero* (Hamilton 1822)									*				*		
70.	*Labeo dyocheilus* (McClelland 1839)		*			*										
71.	*Labeo fimbriatus* (Bloch 1795)									*	*			*		
72.	*Labeo pangusia* (Hamilton 1822)[e]					*				*	*					
73.	*Labeo rohita* (Hamilton 1822)					*	*	*		*		*	*	*	*	*
74.	*Lepidocephalichthys guntea* (Hamilton 1822)											*	*	*		
75.	*Macrognathus aral* (Bloch and Schneider 1801)[a]		*								*	*	*	*	*	
76.	*Macrognathus pancalus* (Hamilton 1822)						*	*	*		*	*	*	*	*	*
77.	*Mastacembelus armatus* (Lacepède 1800)[a]					*	*	*	*			*	*	*	*	
78.	*Megarasbora elanga* (Hamilton 1822)									*						
79.	*Monopterus albus* (Zuiew 1793)											*				
80.	*Monopterus cuchia* (Hamilton 1822)													*	*	*
81.	*Mystus bleekeri* (Day 1877)										*	*	*			
82.	*Mystus cavasius* (Hamilton 1822)						*	*		*	*	*	*			
83.	*Mystus tengara* (Hamilton 1822)						*	*			*	*	*	*	*	
84.	*Mystus vittatus* (Bloch 1794)										*	*	*			
85.	*Nandus nandus* (Hamilton 1822)						*			*				*	*	*
86.	*Nangra nangra* (Hamilton 1822)[d]													*		
87.	*Nangra punctata* (Hamilton 1822)									*		*	*			
88.	*Nemacheilus beavani* (Günther 1868)		*													
89.	*Nemacheilus botia* (Hamilton 1822)		*			*			*		*			*	*	
90.	*Nemacheilus corica* (Menon 1987)				*											

Table 5 continued

	Fish species	Distribution														
		Upper zone					Middle zone					Lower zone				
		UZ1	UZ2	UZ3	UZ4	UZ5	MZ1	MZ2	MZ3	MZ4	MZ5	LZ1	LZ2	LZ3	LZ4	LZ5
91.	*Nemacheilus montanus* (McClelland 1838)		*													
92.	*Nemacheilus mooreh* (Sykes 1839)															
93.	*Nemacheilus rupecola* (McClelland 1838)				*											
94.	*Notopterus notopterus* (Pallas 1769)						*			*	*	*	*	*	*	*
95.	*Ompok bimaculatus* (Bloch 1794)										*	*		*		*
96.	*Ompok pabda* (Hamilton 1822)[a,e]					*				*	*	*	*	*	*	
97.	*Ompok pabo* (Hamilton, 1822)[d]											*	*	*	*	
98.	*Oncorhynchus mykiss* (Walbaum 1792)[c]	*														
99.	*Oreochromis mossambicus* (Peters 1852)[c]										*	*	*			*
100.	*Oreochromis niloticus niloticus* (Linnaeus 1758)[c]								*	*						
101.	*Osteobrama cotio* (Hamilton 1822)							*		*	*	*	*	*		
102.	*Pangasius pangasius* (Hamilton 1822)[e]											*	*	*	*	
103.	*Panna microdon* (Bleeker 1849)[b]											*	*			
104.	*Pseudambassis baculis* (Hamilton 1822)										*	*				
105.	*Pseuedeutropius atherinoides* (Bloch 1794)											*	*			
106.	*Pterygoplichthys anisitsi* (Eigenmann & Kennedy 1903)[c]											*				
107.	*Puntius chelynoides* (McClelland 1839)		*	*	*	*										
108.	*Puntius chola* (Hamilton 1822)[e]											*	*	*		
109.	*Puntius conchonius* (Hamilton 1822)									*		*				
110.	*Puntius amphibious* (Valenciennes 1842)								*							
111.	*Puntius binotatus* (Valenciennes 1842)								*							
112.	*Puntius puntio* (Hamilton 1822)									*						
113.	*Puntius phutunio* (Hamilton 1822)															
114.	*Puntius sarana* (Hamilton 1822)[a,e]					*				*	*	*	*	*	*	*
115.	*Puntius sophore* (Hamilton 1822)						*	*	*		*	*	*	*	*	
116.	*Puntius terio* (Hamilton 1822)									*						
117.	*Puntius ticto* (Hamilton 1822)					*	*	*	*		*	*	*	*	*	
118.	*Raiamas bola* (Hamilton 1822)						*									
119.	*Rasbora daniconius* (Hamilton 1822)		*			*					*			*		
120.	*Rasbora rasbora* (Hamilton 1822)									*						

Table 5 continued

Fish species		Distribution														
		Upper zone					Middle zone					Lower zone				
		UZ1	UZ2	UZ3	UZ4	UZ5	MZ1	MZ2	MZ3	MZ4	MZ5	LZ1	LZ2	LZ3	LZ4	LZ5
121.	*Rhinomugil corsula* (Hamilton 1822)[e]							*	*		*	*	*	*	*	*
122.	*Rita rita* (Hamilton 1822)					*	*	*		*	*	*	*	*	*	
123.	*Salmophasia bacaila* (Hamilton 1822)					*	*	*	*		*			*	*	*
124.	*Salmophasia phulo* (Hamilton 1822)											*				
125.	*Schizothorax curvifrons* (Heckel 1838)				*											
126.	*Schizothorax progastus* (McClelland 1839)	*		*	*											
127.	*Schizothorax richardsonii* (Gray 1832)[e]	*	*	*	*											
128.	*Schizothorax sinuatus* (Heckel 1838)				*											
129.	*Securicula gora* (Hamilton 1822)						*				*					
130.	*Setipinna brevifilis* (Valenciennes 1848)											*	*			
131.	*Setipinna phasa* (Hamilton 1822)										*					
132.	*Sicamugil cascasia* (Hamilton 1822)[e]						*		*		*	*	*	*		
133.	*Silonia silondia* (Hamilton 1822)[e]						*		*			*	*	*		
134.	*Sisor rabdophorus* (Hamilton 1822)[d]							*				*				
135.	*Sperata aor* (Hamilton 1822)[a,e]					*	*	*	*			*	*	*	*	*
136.	*Sperata seenghala* (Sykes 1839)						*	*	*	*		*	*	*		
137.	*Tenualosa ilisha* (Hamilton 1822)[e]											*	*	*	*	*
138.	*Tetraodon cutcutia* (Hamilton 1822)										*	*	*	*	*	
139.	*Tetraodon fluviatilis* (Hamilton 1822)									*						
140.	*Tor putitora* (Hamilton 1822)[d]		*	*	*	*										
141.	*Tor tor* (Hamilton 1822)[d]		*	*	*	*				*						
142.	*Wallago attu* (Bloch & Schneider 1801)					*	*	*	*		*	*	*	*	*	*
143.	*Xenentodon cancila* (Hamilton 1822)					*	*	*		*	*	*	*	*	*	

[a] New distribution

[b] Marine species

[c] Exotic species

[d] Endangered species

[e] Vulnerable species

References

Anderson MJ, Ellingsen KE, McArdle BH (2006) Multivariate dispersion as a measure of beta diversity. Ecol Lett 9:683–693

Anupama, Gusain OP (2007) Recent catch record of golden mahseer *Tor putitora* (Hamilton) from Garhwal, Himalayas. Fish Chimes 27(1):110–111

Arrington DA, Winemiller KO (2003) Diet changeover in sand-beach fish assemblages in a neotropical floodplain river. Environ Biol Fish 63:442–459

Arthington AH, Welcomme RL (1995) The condition of large river systems of the world. In: Voigtlander CW (ed) Proceedings of the world fisheries congress, chap 4. Oxford and IBH Publishing Co Pty Ltd., New Delhi, pp 44–75

Arthington AH, Lorenzen K, Pusey BJ, Abell R, Halls A, Winemiller KO, Arrington DA, Baran E (2004) River fisheries: ecological basis for management and conservation. In: Welcomme R, Petr T (eds) Proceedings of the second international symposium on the management of large rivers for fisheries volume I. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2004/16, pp 21–60

Atkore VM, Sivakumar K, Johnsingh AJT (2011) Patterns of diversity and conservation status of freshwater fishes in the tributaries of Ramganga river, in the Shiwaliks of the Western Himalaya. Current science vol 100. No 4

Baird IG (2006) *Probarbus jullieni* and *Probarbus labeamajor*: the management and conservation of two of the largest fish species in the Mekong River in southern Laos. Aquat Conserv Mar Freshw Ecosyst 16:517–532

Bhakta JN, Bandyopadhyay PK (2007) Exotic fish biodiversity in Churni river of West Bengal, India. Electron J Biol 3(1):13–17

Bilgrami KS, Datta Munshi JS (1985) Ecology of River Ganges (Patna-Farakka); impact of human activities and conservation of aquatic biota. Final Technical Report, Department of Environment Research Project under MAB Programme

Biological Diversity Rules (2004) National Biodiversity Authority, Chennai, India, pp 31–57

Brander KM (1995) The effect of temperature on growth of Atlantic cod (*Gadus morhua* L.). ICES J Mar Sci 52:1–10

Buisson L, Thuiller W, Lek S, Lim P, Grenouillet G (2008) Climate change hastens the turnover of stream fish assemblages. Glob Chang Biol 14:2232–2248

Chu C, Mandrak NE, Minns CK (2005) Potential impacts of climate change on the distributions of several common and rare freshwater fishes in Canada. Divers Distrib 11:299–310

Colwell RK (1996) User's Guide to Estimates- Statistical estimation of Species richness and shared species from samples. Version 8. User's guide and application published at http://www.viceroy.eeb.uconn.edu/estimates

CPCB (1984) Basin sub-basin inventory of water pollution. The Ganga Basin part I. New Dehli, Central Board for the prevention of and control of water pollution CPCB, Department of Environment, p 204

Das MK (2007a) Environment and fish health: a holistic assessment of Inland fisheries in India. In: Goswami UC (ed) Natural and anthropogenic hazards on fish and fisheries. Narendra Publishing House, Delhi, pp 137–151

Das MK (2007b) Environment and fish health: a holistic assessment of Inland fisheries in India. In: Goswami UC (ed) Natural and anthropogenic hazards on fish and fisheries. Narendra Publishing House, Delhi

Das MK, Samanta S, Saha PK (2007) Riverine health and impact on fisheries in India. Policy Paper No. 01, Central Inland Fisheries Research Institute, Barrackpore, Kolkata

Day F (1875–1878) The fishes of India; being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon

Day F (1889) The Fauna of British India, including Ceylon and Burma fishes. Taylor and Francis, London, pp 1548–2509

De DK (1999) The river Ganga-environment and fishery. Summer School on Ecology, Fisheries and Fish stock assessment in Indian River. CIFRI, Barrackpore

De Silva SS, Abery NW (2007) Endemic freshwater finfish of Asia: distribution and conservation status. Divers Distrib 13:172–174

Dudgeon D, Arthington AH, Gessner MO, Kawabata Z, Knowler D, Leveque C, Naiman RJ, Prieur-Richard AH, Soto D, Stiassny MLJ (2005) Freshwater biodiversity: importance, threats, status, and conservation challenges. Biol Rev 8:163–182

Frissell CA (1997) Ecological principles. In: Williams JE, Wood CA, Dombeck MP (eds) Watershed restoration: principles and practices. American Fisheries Society, Bethesda

Fu C, Wu J, Chen J, Wu Q, Lei G (2003) Freshwater fish biodiversity in the Yangtze River basin of China: patterns, threats and conservation. Biodivers Conserv 12:1649–1685

Ghosh BB, Mukhopadhya MK, Bagchi MM (1982) Some observations on bioaccumulation, toxicity, histopathology of some fishes in relation to heavy metal pollution in the Hoogly estuary between Nabadwip and Kakdwip. First National Environment Cogress. Indian Environmental Cogress Assoc. and Dept. of Environ. Govt of India, p 25

Gopal B (2000) River conservation in the Indian subcontinent. In: Boon PJ, Davies BR, Pelts GE (eds) Global perspectives on river conservation: science, policy and practice. Wiley, London, pp 233–261

Habit E, Belk MC, Tuckfield RC, Parra O (2006) Response of the fish community to human-induced changes in the Biobio River in Chile. Freshw Biol 51:1–11

Hamilton F (1822) An account of the fishes found in the river Ganges and its branches. Edinburgh and London

Hassan SS, Sinha RK, Hassan N, Ahsan I (1998) The current seasonal variation in catch diversity and composition of fish communities vis-à-vis various factors in the Ganges at Patna (India) and strategies for sustainable development. J Freshw Biol 10:141–157

Hora SL (1929) An aid to the study of Hamilton-Buchanan's "Gangetic fishes". Mem Indian Mus 9:169–192

Husain A (1995) Pisces. In: Fauna of Western Himalaya (U.P.) Zool. Surv. of India Him. Eco. Series (Part-I), pp 117–150

Jha PK (1992) Environment and man in Nepal. Know Nepal series no. 5. Craftsman Press, Bangkok

Kang B, He D, Perrett L, Wang H, Hu W, Deng W, Wu Y (2009) Fish and fisheries in the upper Mekong: current assessment of the fish community, threats and conservation. Rev Fish Biol Fish. doi:10.1007/s11160-009-9114-5

Karr JR, Chu EW (1995) Ecological integrity: reclaiming lost connections. In: Westra L, Lemons J (eds) Perspective on ecological integrity. Kluwer Academic Publ., Netherlands, pp 34–48

Khan RA, Siddiqui AQ (1973) Studies on the age and growth of rohu, *Labeo rohita* (Ham.) from a pond (Moat) and rivers Ganga and Yamuna. Proc Indian Natn Sci Acad 39(5):582–597

Krishna Murti CR, Bilgrami KS, Das TM, Mathur RP (1991) The Ganga, a scientific study. Ganga Project Directorate. Northern Book Center, New Delhi

Kumra VK (1995) Water quality in the River Ganges. In: Chapman GP, Thompson M (eds) Water and the quest for sustainable development in the Ganges Valley. Mansell Publishing Ltd, London, pp 130–140

Lakra WS, Sarkar UK (2009) Biodiversity of the Native Fish Fauna and their conservation. INFISH Souvenir, National Fisheries Development Board, Hyderabad, pp 36–43

Lakra WS, Sarkar UK, Gopalakrishnan A, Pandian AK (2010) Threatened freshwater fishes of India. NBFGR publication, Lucknow

Lakra WS, Sarkar UK, Dubey VK, Sani R, Pandey A (2011) River interlinking in India: status, issues, prospects and implications on aquatic ecosystems and freshwater fish diversity. Rev Fish Biol Fish. doi:10.1007/s11160-011-9199-5

Lakra WS, Singh AK, Mahanta PC (2009) Fish genetic resources. Narendra Publishers, New Delhi

Linfield RJ (1985) An alternative concept to home range theory with respect to populations of appinids in major river systems. J Fish Biol 27:187–196

Linke S, Pressey RL, Bailey RC, Norris RH (2007) Management options for river conservation planning: condition and conservation re-visited. Freshw Biol 52:918–938

Lipsey MK, Child MF (2007) Combining the fields of reintroduction biology and restoration ecology. Conserv Biol 21:1387–1388

Margules RC, Pressey LR (2000) Systematic conservation planning. Nature (London) 405:243–253

Menon AGK (1954) Further observation of the fish fauna of the Manipur state. Rec Indian Mus 52:21–26

Mohseni O, Stefan HG, Eaton JG (2003) Global warming and potential changes in fish habitat in US streams. Clim Change 59:389–409

Namin JI, Spurny P (2004) Fish community structure of the middle course of the Beeva River Czech. J Animal Sci 49(1):43–50

Nautiyal P, Lal MS (1984) Food and feeding habit of fingerlings and juveniles of mahseer *Tor putitora* (Ham.) in Nayar River. J Bombay Nat Hist Soc 81:642–646

Nautiyal P, Lal MS (1985) Fecundity of golden Himalayan mahseer *Tor putitora*. J Bombay Nat Hist Soc 82(2):253–257

Nautiyal P, Bhatt JP, Rawat VS, Kishor B, Nautiyal R, Singh HR (1998) Himalayan Mahseer: magnitude of commercial fishery in Garhwal hills. Fish Genet Biodiv Conserv 5:107–114

Nautiyal P, Rizvi AF, Dhasmanaa P (2008) Life- history traits and decadal trends in the growth parameters of golden Mahseer *Tor putitora* (Hamilton 1822) from the Himalayan Stretch of the Ganga River System. Turkish J Fish Aquat Sci 8:125–132

Nelson JS (2006) Fishes of the world, 4th edn. Wiley, New York

Odum EP (1971) Fundamentals of ecology. Sounders College Publishing, Philadelphia

Parameters of Golden Mahseer Tor putitora (Hamilton 1822) from the Himalayan Stretch of the Ganga river system. Turkish J FishAquat Sci 8:125–132

Pathak V, Tyagi RK (2010) Riverine ecology and fisheries vis-à-vis hydrodynamic alterations: impacts and remedial measures. CIFRI, bulletin no. 161

Payne AI, Temple SA (1996) River and floodplain fisheries in the Ganges Basin. Final Report. DFID Fisheries Management Science Programme, MRAG Ltd, London

Payne AI, Sinha RK, Singh HR, Haq S (2004) A review of the Ganges Basin: its fish and fisheries. In: Welcomme RL, Peter T (eds) Proceedings of the second international symposium on the management of large rivers for Fisheries, vol 1, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, pp 229–251

Planque B, Fredou T (1999) Temperature and recruitment of Atlantic cod (*Gadus morhua*). Can J Fish Aquat Sci 56:2069–2077

Pusey BJ, Arthington AH, Stewart-Koster B, Kennard MJ, Read MG (2010) Widespread omnivory and low temporal and spatial variation in the diet of fishes in a hydrologically variable northern Australian river. J Fish Biol 77:731–753

Raghavan R, Prasad G, Ali A (2008) Fish fauna of Chalakudy River, part of Western Ghats biodiversity hotspot, Kerala, India: patterns of distribution, threats and conservation needs. Biodiv Conserv 17:3119–3131

Rao RJ (2001) Biological resources of the Ganga river. Hydrobiologia 458:159–168

Revenga C, Mock G (2000) Pilot analysis of global ecosystems: freshwater systems and world resources 1998–99. World Resources Institute, Washington, DC

Sarkar UK, Bain MB (2007) Priority habitats for the conservation of large river fishes in the Ganges River basin. Aquat Conserv Mar Freshw Ecosyt 17:349–359

Sarkar UK, Deepak PK, Negi RS (2006) Age structure of Indian carp *Labeo rohita* (Hamilton Buchanan) from different wild population. Environ Ecol 24(4):803–808

Sarkar UK, Pathak AK, Lakra WS (2008) Conservation of freshwater fish resources of India: new approaches, assessment and challenges. Biodiv Conserv 17:2495–2511

Sarkar UK, Gupta BK, Lakra WS (2010) Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India). Environmentalist 30(1):3–17

Shannon CE, Wiener W (1963) The mathematical theory of communication. University of Illinois Press, Urbana

Sharma R (2003) Protection of an endangered fish *Tor tor* and *Tor putitora* population impacted by transportation network in the area of Tehri Dam project, Garhwal Himalaya, India. ICOET Proceedings

Shrestha J (1978) Fish Fauna of Nepal. J Mus Nat Hist 2:33–43

Shrestha TK (1990) Rare fishes of the Himalayan waters of Nepal. J Fish Biol 37:213–216

Singh HR (1988) Bio ecological studies on the mahseer and snow trout of Garhwal Himalaya. Final Technical Report, ICAR

Sinha RK (2004) Monitoring of heavy metal load in the River Ganga at Varanasi. Final Tech. Rep. Submitted to National River Conservation Directorate, MOEF, Govt of India, New Delhi

Sinha RK (2006) The Ganges river dolphin Platanista gangetica. J Bombay Nat Hist Soc 103:254–263

Sinha RK (2007a) Ecological basis for management and conservation of riverine fisheries with special reference to the Ganga river system. In: Vass et al (eds) River fisheries in India: issues and current status, pp 83–97

Sinha RK (2007b) Impact of man-made and natural hazards on fisheries of the river Ganga in India. In: Goswami UC (eds) Natural and anthropogenic hazards on fish and fisheries. Inland Fisheries Society of India, Barrackpore, pp 245–261

Sinha M, Khan MA (2001) Impact of environmental aberrations on fisheries of the Ganga (Ganges) river. J Aquat Ecosyst Health Manage. Taylor & Francis, USA 4:493–504

Srivastava GJ (1968) Fishes of Eastern Uttar Pradesh. Vishwavidyalaya Prakashan, Varanasi, India

Srivastava GJ (1980) Fishes of U.P. and Bihar. Vishwavidyalaya Prakashan, Varanasi, India

StatSoft Inc (1999) Electronic Statistics Textbook. Tulsa, OK, StatSoft. Web: http://www.statsoft.com/textbook/stathome.html

Sunderesan BB, Subrahmanyam PVR, Bhinde AD (1983) An overview of toxic and hazardous waste in India, UNEP Industry and Environment (Spec. Issue), pp 70–73

Svedang H, Neumann E, Wickstrom H (1996) Maturation patterns in female Europian eel: age and size at the silver eel stage. J Fish Biol 48:342–351

The Biological Diversity Act (2002) National Biodiversity Authority, Chennai, India, pp 1–29

Uniyal DP (2010) Pisces. Zool. Surv. India. State fauna series 18(1), Uttarakhand, pp 533–621

Vass KK, Das MK, Srivastava PK, Dey S (2009) Assessing the impact of climate change on inland fisheries in River Ganga and its plains in India. Aquat Ecosyst Health Manage 12(2):138–151

Venkateswarlu T, Menon AGK (1979) A list of fishes of the river Ganges and its branches. Acta Ichthyologica et Piscatotia 9(1):45–70

Welcomme RL (1985) River fisheries. Food and Agriculture Organization, Technical Paper 262. Rome, Italy