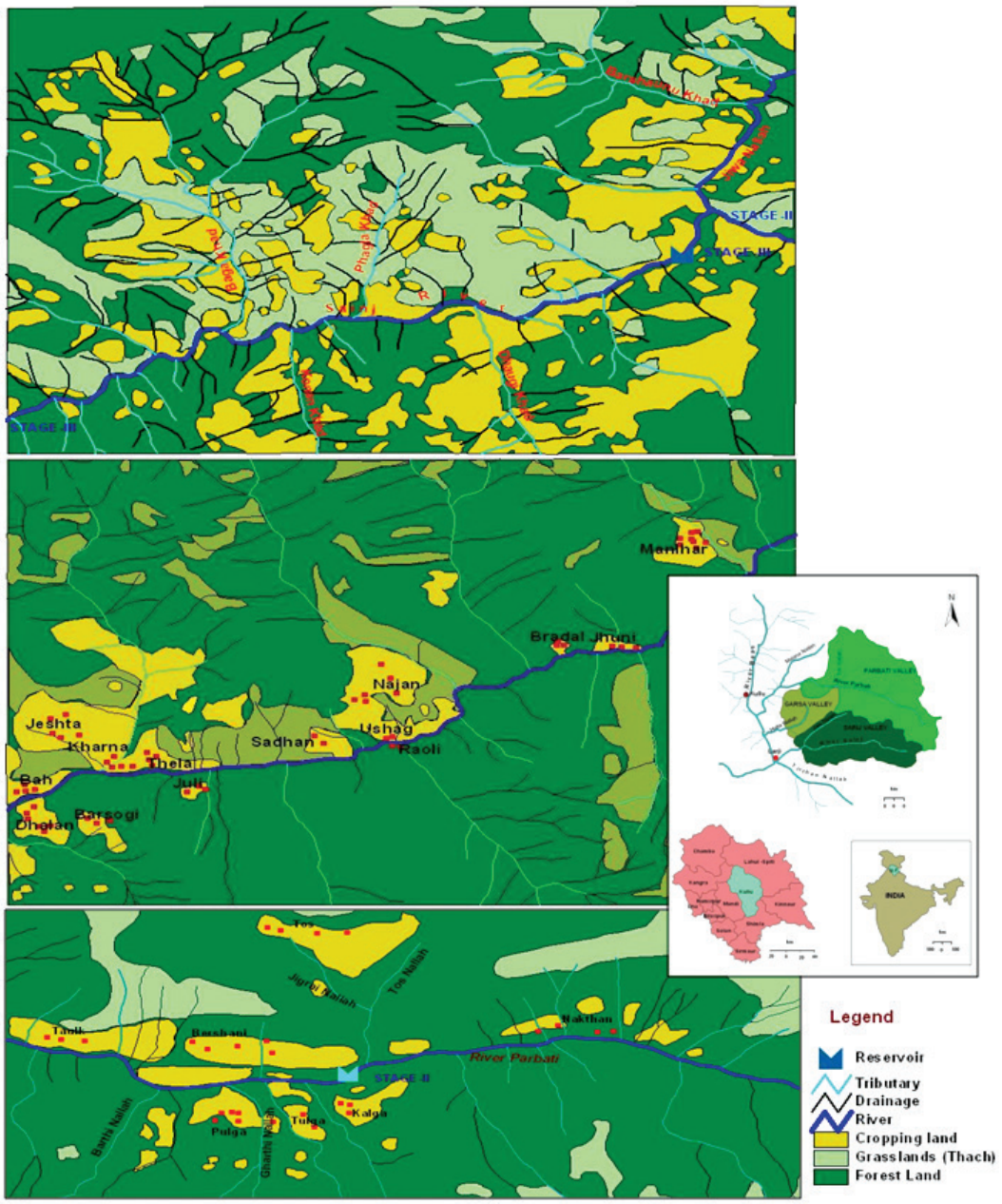

Fig. 1 Location and land use map of study sites in the Kullu valley, Himachal Pradesh.
[See page 122 for the text]

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Impacts of hydropower Construction projects on ECONOMICALLY Important Plants in the Upper Beas Valley, Himachal Pradesh

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Abstract

Hydropower is one of the extremely important energy sources. This renewable source of energy has some serious negative impacts on its ambient environment especially during construction period. These negative impacts have mainly been reflected in both biotic and abiotic environment. The present study was carried out to know the impacts of hydropower construction activities on forest ecosystem. The surrounding area of Parbati Stage II (800 MW) and Stage III (520 MW) hydropower projects near to the Great Himalayan National Park, (World Heritage Site) were taken into account under present study. The present study shows that deforestation and loss of land and plants are increasing continuously due to ongoing construction activities. While adoption of different ecological techniques such as afforestation, check-walls, retaining-walls, reuse of disposal debris, grass plantation in landslips and landslide affected areas, and metalling roads, etc. can minimize forest losses.

Keywords: *Community, deforestation, environment, Himalaya, hydropower*

Introduction

Forest ecosystem is very important to human well-beings at local, national and global levels. In western Himalayan region forest and water constitute the riches resources amongst other resources. The use of forest resources for commercial exploitation is prohibited, as the Indian Forest Act and the National and global requirement. Due to fragile mountain ecosystem there are limitation for industrial development and other exploitation of natural resources. But pressure on forest resources is increasing by introducing many developmental activities like hydropower projects especially in the mountain environment. Deforestation through tree felling is one of the major adverse impacts during construction period of hydropower projects. The accelerating rate of deforestation in the fragile environment is leading towards soil erosion and many other natural hazards. The type and intensity of impacts on forest resources is influenced by the size of the each developmental project and cumulative effects as the number of projects on a single river or a within a river basin. The past studies dealing with the environmental assessment of hydropower projects at global (Udall, 1995; Lerer and Scudder, 1999; Thomas and Adams, 1999; Kwak, 2004) and regional (Sinclair, 2003; Samant et al., 2007) levels indicate that development of water resource projects have many adverse impacts on existing ecology and environment mainly on flora and fauna and results in increased deforestation within the vicinity of hydropower projects. Pillai (1995) explains that most of these

hydropower projects are located in the mountain areas and submergence of forest areas become inevitable. The direct adverse impacts observable on natural vegetation are largely close to the sites of dam, quarrying and muck disposal. Illegal and unscientific dumping of muck in the valley together has caused damage to many Cedrus deodara (deodar trees) and other coniferous species, due to which a fine of more than 2.75 crore of rupees is imposed on National Hydropower Corporation (Anonymous, 2008). Pandit et. al. (2012) conducted study on 292 on going and proposed dams in the Indian Himalaya and investigated 90% Indian Himalayan valley would be affected by dam building and 27% these dams would affects dense forest. On the basis of Species Relation Model (SAR) used by Pandit et. al (2012) projected that "by 2025, deforestation due to dams building would likely result in extinction of 22 anglosperm and 7 vertebrate Tex, it will reduce tree species richness by 35%, tree density by 42% and tree basal cover by 30% in dense forest". Therefore, the present study was carried out to know the site specific situation in the upper Beas Valley in and around Parbati Stage II (800 Mega Watt {MW}) and Parbati Stage III (520 MW) on economically important plants and their uses; extraction of medicinal plants and loss of land; and identification of major hydropower project activities responsible for deforestation and environmental degradation.

Material and research methods

Present study is based on the field based perception survey at households' level with local community; on spot field observation, and literature review on impacts of hydropower projects on plants. The family heads at individual household level from 37 villages with 576 households (25 villages from Parbati Stage II and 12 from Stage III) located from low altitude to high altitude ranged from 1120 to 2286 meter above sea level (m asl) were selected for primary data collection in three sub-valleys (i.e., the Garsa, the Parbati and the Sainj) of the Beas valley in Kullu district of Himachal Pradesh. The survey was intensively and extensively conducted with the help of a well structured questionnaire. More than 81% (around stage II) and 87% (stage III) of the total households were included under the survey. Visual field observation was also done to know the impacts on plants by various construction activities at different location.

Study Area

The present work focused mainly on Parbati Stage II (800 MW) and Stage III (520 MW) hydropower projects under construction which fall in the Parbati, Garsa and Sainj sub-valleys in the upper Beas basin within Kullu district of Himachal Pradesh. The geographical area under these projects extends between 30° 20' 25" N to 32° 25' 0" N and 76° 56' 30" E to 77° 52' 20" E (Fig.1 See page 120). The drainage area of all rivers and streams of hydroelectric projects under study lies between 31° 40' N to 32° 15' N and 77°15' E to 77° 30' E. The catchment area of Stage II lies between 31° 40' N to 32° 15' N and 77° 15' E to 77° 30' E. The catchment area of Stage III at Suind dam site extends in between 31° 42' 19" N to 31° 54' 7" N latitudes and 77°17' 26" E to 77°45' 48" E longitudes.

Table 1. Economically important plants in and around the Parbati Stage II and III hydropower projects

Local Name	Botanical name	Md	Wf	Scv	Fw	F	IP	R	T
Aakh	*Rubus biflorus*	-	+	-	-	-	-	-	-
Akhrot	*Juglans regia*	+	+	-	+	-	-	-	+
Apple	*Malus malus*	-	-	+	+	-	-	-	-
Ban	*Quercus leucotrichophora*	-	-	-	+	+	-	-	+
Ban tambacoo	*Verbascum thapsus*	+	-	-	-	-	-	+	-
Banafsha	*Viola canescens*	+	-	-	-	-	-	-	-
Ban-ajwain	*Thymus linearis*	+	-	+	-	-	-	-	-
Bani	*Quercus glauca*	-	-	-	+	+	-	-	+
Ban-kakri	*Podophyllum hexandrum*	+	-	-	-	-	-	-	-
Basil	*Salix tetrasperma*	-	-	-	+	-	-	-	-
Bathu	*Chenopodium album*	-	-	+	-	-	-	-	-
Beekhal	*Prinsepia utilis*	+	+	-	+	-	-	+	-
Bhang	*Cannabis sativa*	+	-	+	-	-	-	+	-
Bhea	*Chaerophyllum reflexum*	-	-	+	-	-	-		
Bhoj-patta	*Betula utilis*	+	-	-	+	+	-	+	+
Bihul	*Grewia oppositifolia*	-	-	-	+	+	-	-	-
Bital	*Juniperus indica*	-	-	-	+	-	+	-	-
Brass	*Rhododenddron arboretum*	+	+	-	+	-	-	+	+
Chaku	*Spiraea canescens*	-	-	-	+	-	-	+	-
Cheemu	*Morus serrata*	-	+	-	+	+	-	-	-
Chil	*Pinus roxburghii*	-	+	-	+		+		+
Chora	*Angelica glauca*	+	-	-	-	-	-	-	-
Darl	*Toona serrata*	-	-	-	+	+	-		+
Daru	*Punica granatum*	-	+	-	+	-	-	-	-
Dhoop	*Jurinella morocephala*	+	-	-	-	-	-	-	-
Dudhali	*Tragopogon pratense*	-	-	+	-	-	-	-	-
Dyar	*Cedrus deodara*	+	-	-	+	-	+	-	+
Fagu	*Ficus hederacea*	+	+	-	+	+	-	-	-
Farn	*Allium humile*	+	-	+	-	-	-	-	-
Gari	*Sinarundinaria falcata*	-	-	-		+	-	-	-
Guchhi	*Morchella esculenta*	+	+	-	-	-	-	-	-
Hathpanja	*Dactylorhiza hatagirea*	+	-	-	-	-	-	-	-
Jamu	*Prunus cornuta*	-	+	-	+	-	-	-	+
Kagoos (buchhibuti)	*Urtica dioica*	-	-	+	-	-	-	-	-
Kahu	*Olea ferruginea*	+	-	-	+	+	-	-	-

Kail	*Pinus wallichiana*	-	-	-	+	-	-	-	+
Kakar-singhi	*Pistacia integerrima*	+	+	-	-	-	-	-	-
Kala-zeera	*Bunium persicum*	+	+	+	-	-	-	-	-
Safed-kathi	*Desmodium elegans*	-	-	-	-	+	-	-	-
Kaphal	*Myrica esculenta*	-	+	+	-	-	-	-	-
Karal (Kungash)	*Girardinia heterophylla*	-	-	-	-	-	-	-	-
Karu	*Picrorhiza kurrooa*	+	-	-	-	-	-	-	-
Kashmiri-pata	*Rhododendron campanulatum*	-	-	-	+	-	-	-	-
Kathi-Kali	*Indigofera heterantha*	-	-	-	-	+	-	-	-
Khadik	*Celtis australis*	+	-	-	-	+	-	-	-
Khanor	*Aesculus indica*	-	-	-	+	+	-	-	+
Kharsu	*Quercus semecarpifolia*	-	-	-	+	+	-	-	+
Khurmani	*Prunus armenica*	-	+	-	+	-	-	-	-
Kiker	*Acacia* sp.	-	-	-	+	+	-	-	-
Kiwi	*Actinidia deliciosa*	-	-	-		-	-	-	-
Kos	*Alnus nitida*	-	-	-	+	-	-	-	+
Koyes	*Betula alnoides*	-	-	-	+	-	-	-	-
Kunja	*Rosa macrophylla*	-	-	-	+	-	-	-	-
Kuth	*Saussurea lappa*	+	-	-	-	-	+	-	-
Malora	*Rumex costus*	-	-	+	-	-	-	-	-
Mandru	*Acer* spp.	-	-	-	+	-	-	-	-
Masholi	*Berberis aristata*	-	-	-	-	-	-	+	-
Moru	*Quercus floribunda*	-	-	-	+	+	-	-	+
Mushkbala	*Valeriana jatamansi*	+	-	-	-	-	-	-	-
Nashpati	*Prunus communis*	-	-	-	+	-	-	-	-
Nigal	*Arundinan spathiflona*	-	-	-	-	+	-	-	-
Patish	*Aconitum heterohyllum*	+	-	-	-	-	-	-	-
Plum	*Prunus domestica*	-	-	-	+	-	-	-	-
Podina	*Mentha longifolia*	+	-	-	-	-	-	-	-
Popular	*Populus ciliata*	-	-	-	-	-	-	-	-
Buthi	*Elsholtza fruticosa*	-	+	-	+	-	-	-	-
Rai	*Picea smithiana*	-	-		+	-	-	-	+
Ratanjot	*Arnebia benthamii*	+	-	-	-	-	-	-	-
Robinia	*Robinia pseudo-acacia*	-	-	-	+	+	-	-	-
Sabla Pathutra	*Bergenia stracheyi*	+	-	-	-	-	-	-	-
Shegal	*Pyrus pashia*	-	+	-	-	-	-	-	-
Sarara	*Debregeasia salicifolia*	-	-	-	-	+	-	-	-
Sayalu	*Corylus jacquemontii*	+	-	-	-	+	-	-	-

Singli-mingli	*Dioscorea deltoidea*	+	-	-	-	-	-	-	-
Suri	*Hippophae rhamnoides*	-	+	-	-	-	-	-	-
Tos	*Abies pindrow*	-	-	-	+	-	-	-	+
Thalana	*Vibernum cotinifolium*	-	-	-	+	-	-	-	-

Where; Md=medicinal plants; Wf=wild fruits; Scv=subsidiary food and vegetable; Fw=fuelwood; Where; F=fodder; R=religious ceremonies; T=timber; IP=incense and perfurme

Results and discussion

Large numbers of important medicinal plants are found in a scattered form in all over the study area. Some of the economically important plants and their variety of uses in and around the Parbati Stage II and III are listed in table 1. About 832 plants species belonging to 427 genera and 128 families of higher altitude plants are found within Great Himalayan National Park (GHNP, now world heritage site) which is a catchment area of these hydropower projects (Singh and Rawat, 2000). Out of these plants species, about 250 species are having medicinal value and traditionally being used by the local people adjacent to GHNP for the treatment of various ailments. More than 60 species are used for collection mainly for commercial purposes (Singh and Rawat, 2000). Samant et. al., (2007) conducted study in the catchment area of Parbati Stage III in Sainj valley to see the impact of hydroelectric project on the biodiversity, particularly on medicinal plants and recorded 104 species of 93 genera and 59 families belonging to three taxonomic groups, i.e. angiosperms, gymnosperms and pteridophytes. These species belong to different life forms, i.e., trees (23 species), shrubs (22), herbs (57) and ferns (2). The families, Asteraceae (10 species), Rosaceae (7), Lamiaceae (6), Polygonaceae (5), Euphorbiaceae (4), Poaceae (4), Solanaceae (4), Chenopodiaceae (3) and Pinaceae (3), were represented by maximum number of species, respectively. Among the genera, Artemisia (3 species), Chenopodium (3), Solanum (2), Hypericum (2), Polygonum (2), Rumex (2), Prunus (2) and Pinus (2) were rich in species. The study further investigated different parts of plants, such as whole plant (31 species), roots/rhizomes/ tubers (31), leaves (34), flowers (9), fruits (15), seeds (15), stem (4), bark (10), spike (1), nut (1) and insect galls (1) had been used (Samant et al., 2007).

Floral diversity loss due to hydropower projects construction

The perception survey of the local communities confirms that deforestation is increasing due to introducing hydropower projects activities in the region. More than 75% of the total respondents (71.5% of Stage II and 87% of Stage III) surrounding both these projects observed that the adverse impacts of projects on trees were in several ways. The different activities during construction of hydroelectric projects caused a massive damage to the standing trees of various species. As many as 13859 trees were felled and/or damaged surrounding these hydropower projects under survey. The highest percentage of the total number

Table 2. Name and number of felled and/or damaged trees as perceived by the local communities in their region after introducing hydropower projects

Sr. No.	Local name	Botanical name	Parbati Stage II		Parbati Stage III		Grand Total	% of the grand
			Total	%	Total	%		
1.	Apple	*Malus malus*	3159	33.3	2075	32.1	5234	37.8
2.	Plum	*Prunus domestica*	425	4.5	1140	17.6	1565	11.3
3.	Pear	*Prunus communis*	870	9.2	502	7.8	1372	9.9
4.	Almond	*Prunus amygdalus*	458	4.8	35	0.5	493	3.6
5.	Kiwi	*Actinidia deliciosa*	427	4.5	-	-	427	3.1
6.	Apricot	*Prunus armeniaca*	319	3.4	-	-	319	2.3
7.	Walnut	*Juglans regia*	95	1.0	45	0.7	140	1.0
8.	Orange	*Citrus reticulata*	15	0.2	-	-	15	0.1
9.	Shegal, Kainth	*Pyrus pashia*	226	2.4	117	1.8	343	2.5
10.	Popular	*Populus ciliata*	26	0.3	-	0.0	26	0.2
11.	Rubina	*Robinia pseudoacacia*	78	0.8	385	6.0	463	3.3
12.	Khanor	*Aesculus indica*	200	2.1	217	3.4	417	3.0
13.	Darl, Toon	*Toona serrata*	50	0.5	125	1.9	175	1.3
14.	Kikar	*Acacia sp*	67	0.7	107	1.7	174	1.3
15.	Koyes	*Betula alnoides*	36	0.4	13	0.2	49	0.4
16.	Bihul	*Grewia oppositifolia*	51	0.5	310	4.8	361	2.6
17.	Kau	*Olea ferruginea*	78	0.8	419	6.5	497	3.6
18.	Mohru	*Quercus floribunda*	116	1.2	-	-	116	0.8
19.	Brass	*Rhododendron arboretum*	67	0.7	-	-	67	0.5
20.	Tos	*Abies pindrow*	1317	13.9	115	1.8	1432	10.3
21.	Cheel	*Pinus roxburghii*	376	4.0	207	3.2	583	4.2
22.	Kakar singhi	*Pistacia integrrima*	16	0.2	82	1.3	98	0.7
23.	Ban	*Quercus leucotrichophora*	641	6.8	437	6.8	1078	7.8
24.	Karal	*Girardina heterophylla*	1	0.0	45	0.7	46	0.3
25.	Kail	*Pinus wallichiana*	184	1.9	1	0.0	185	1.3
26.	Others		175	1.8	84	1.3	259	1.9
	Total		**9473**	**100.0**	**4386**	**100.0**	**13859**	**100.0**

of felled and damaged trees along Parbati Stage II was apple (Malus malus) which was more than 33% (3159 trees) and major sources of economically for the local natives. The percentage shares and orchards/ tree species felled or damaged were 4.5% plum (Prunus domestica), 9.2% apricot (Prunus communis), 8.2% oak (Quercus leucotrichophora), 8.2% Khurmani (Prunus armenica), and 13.9% tos (Abies pindrow), on the basis of households survey in the study area (Table 2). The loss of trees was more around Parbati Stage II as compared to Stage III due to the run-off-the- river projects. Most of the area comes under Stage III is in downstream of Stage II. The total number of felled trees surrounding Stage III was 4386. Of the total felled trees, apple (Malus domestica) had share of 32.1%, plum (Prunus domestica) 17.6%, pear (Prunus communis) 7.8%, biyul (Grewia oppositifolia) 4.8%, oak (Quercus leucotrichophora) 6.8%, and kau (Olea ferruginea) 6.5% among the major plants. The other adversely affected plants included pear (Prunus communis), poplar (Popupus ciliata), robinia (Robinia pseudoacacia), khanor (Aesculus indica), almond (Prunus amygdalus), kiwi (Actinidia deliciosa), tos (Abies pindrow), darl (Toona ciliata), pine (Pinus roxburghii), kiker (Acacia sp.), shegal (Pyrus pashia), etc. (Fig. 2).

Permanent loss to land property

Massive loss of land and property of the local natives was the major negative impacts assessed during construction period. The land required by the Parbati Stage II project

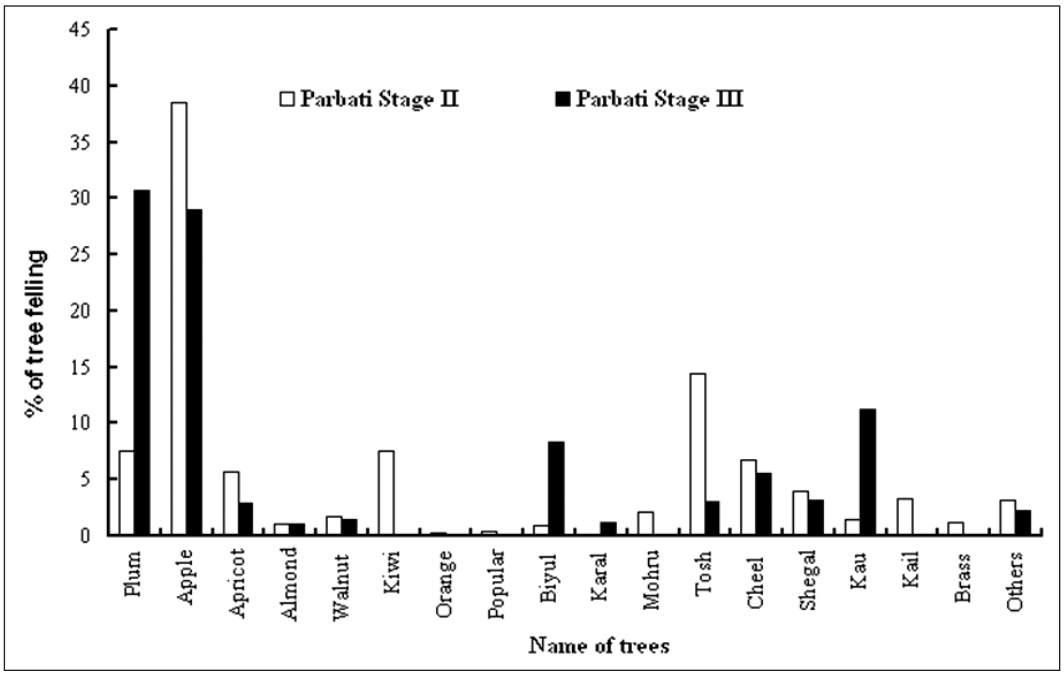

Fig. 2 The number of felled and/or damaged trees/orchards species due to hydropower project activities in the Kullu Valley.

for different constructional activities stood to be 155.94 hectare (ha); out of which 108.64 ha was forest land and 47.23 ha private land. Forest land includes 84.18 ha for permanent uses and 24.47 ha for temporary uses. The private land acquired for the project was more than 27.6 ha in the Sainj valley, 14.5 ha in the Garsa valley and 4.4 ha in the Parbati valley. The total requirement of land by the Parbati Stage III project was 160.45 ha which included 102.61 ha forest land (i.e., 44.44 ha for permanent use and 102.61 ha for temporary use), 55.36 ha private land, and 2.49 ha provincial or government land. Households survey revealed that total available land with the surveyed respondents surrounding the Parbati Stage II was 245.57 ha, out of which 15.4% (37.87 ha) was acquired by the project authorities. In case of Stage III, the total available land was 77.95 ha out of which 36.4% (28.40 ha) of the total available land was acquired or damaged due to project activities (Fig. 3).

Extraction of medicinal plants

The trade of medicinal plants is one of the most important economic activities in the area having ample opportunities to generate income. Many families are engaged in collection of medicinal plants, herbs, various grasses and branches of trees to supplement their income. The extraction of medicinal plants and collection of other minor forest products are major sources of secondary income which contribute as high as 65% of the total annual cash income (Singh and Rawat, 2000). The extraction of medicinal plants comprise mainly of two types during two seasons, i.e., summer (May-June)

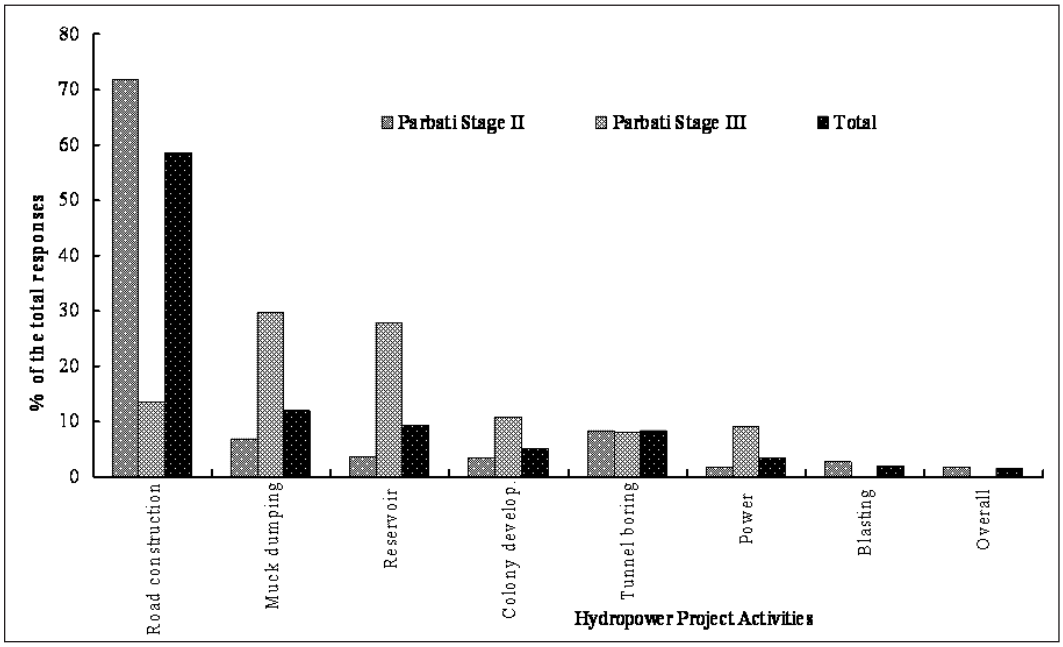

Fig. 3 Major sub-activities of hydropower projects in addition to tree felling and/or damaged trees surrounding the Parbati Stage II and III hydropower projects

and autumn (October-November). On an average one family collects around 2 to 3 quintals of plant material which has a value of Rs. 15,000 in the market. In response to a query made about the collection of medicinal herbs for their traditional use or sale surrounding the vicinity of hydropower projects during household survey, more than 36% respondents surrounding the Parbati project Stage II and more than 17% respondents surrounding Stage III responded that they used to extract medicinal plants for treatment of various ailments as well as to supplements their income from the surrounding area of the project sites. More number of individuals was engaged in the collection of medicinal plants surrounding the Parbati Stage II project as compared to Stage III. The reason is simple that the peoples surrounding the Parbati Stage III mainly reside in lower areas which are away from the availability of medicinal plants and forest trees. The highest number of resident collecting medicinal plants were residing in Thela, Tichna, Ghat, Majhran, Tulga and Kalga villages in the Parbati Stage II near the forests. While more than 25% of the natives of Bihali, Sangpagni, Tarera and Shaloh villages from the Parbati Stage III agreed that the medicinal herbs are extracted from the forests. The villages located near the forest area are more involved in the extraction of medicinal plants as compared to the villages located away from the forests. The major medicinal plants which are usually collected by the local communities from the surroundings of the project sites are Dhoop (Jurinella morocephala) 14.3%, Karoo (Picrorhiza kurrooa) 15.8%, Chora (Angelica glauca) 15.8%, Shingli-Mingli (Dioscorea deltoidea) 7.2%, Mushakbala (Valeriana wallichii) 14.6%, Guchhi (Morchella esculenta) 11.3% and Patish (Aconitum heterophylum) 13.9% for their own uses as well as for commercial purposes. However, the availability of some of these herbs is decreasing day-by-day due to excess collection and unscientific extraction. Guchhi (Morchella esculenta) is one of the high value herbs. As a result, this is collected by maximum number of villagers from February to May as compared to other herbs. Guchhi is available at lower heights and has high market prices as compared to other medicinal plants. The local people consider mainly two reasons for decrease in the medicinal herbs in the region. First, the surrounding area of these villages is nearby GHNP which is visited by large number of outside people. Second, most of the areas surrounding the Parbati Stage II and III projects are now having lots of mining and digging activities due to hydropower projects. The majority of the areas close to hydropower activities particularly the down-slope regions have newly constructed roads and valley beds which are the major sites for muck and debris dumping. More than 67% of the respondents from the Parbati Stage II and about 45% of the respondents from Stage III are of the opinion that medicinal herbs have been adversely affected. Introduction of cash crops in their traditional land-use practices in addition to construction activities and getting high prices of medicinal plants increasing the rate of extraction.

The people have now much interest in extracting medicinal herbs compared to previous years. As a result, due to imposition of certain rules by the forest departments the local communities were found to be discouraged from their traditional economic as well as Ayurvedic treatment practices.

Some of the respondents surrounding the Parbati Stage II were residing relatively in high altitude and most of the villagers remained dependent on the collection of herbs. But after imposing a ban over the collection by GHNP, the natives were unable to go into the national park for collecting such edibles. So now they don't want to take risks for collection of herbs and other grazing fodder to their livestock populations. There were also other reasons for declining collection of medicinal plants such as ever speeding up socio-economic development, more dependency in agriculture and horticulture, availability of other occupational opportunities and alternatives, lack of educated youths in herbal extraction, time consuming and long distance to visit for extraction. While there were more than 20% of the respondents (19.5% from the Parbati Stage II and 22.9% from Stage III) surrounding the hydropower projects who had perceived no change in extraction extent of medicinal plants and other forest resources in the region.

Hydropower projects activities responsible for deforestation

The major hydropower constructional activities surrounding these hydropower projects have caused environmental degradations. Deforestation, stone crushing, disposal of muck and debris along roads in the stream, and frequent quarrying, mining and construction activities in the vulnerable hilly areas, have resulted in more landslides, landslips and debris fall. More than 71% of the respondents from the Parbati Stage II and 13.5% of the respondents of the Stage III ranked road construction due to hydropower projects as the major causes for increasing the rate of the tree felling in the region. In order of ranking muck dumping, construction of reservoir, tunnel boring, construction of labour colony, stores and blasting were the major causes of loss of vegetative cover in the area (Fig. 2). Large number of tree are likely to submerge in the reservoir of the Parbati Stage II and III. For example, trees of plum and apple are to submerge near dam site of Stage III and hundred of deodar trees are likely to submerge at the dam site of Stage II (Fig.4 &5). Fuel wood is the main source of energy for both cooking and heating in the study region. Increased demand of the fuel wood due to outside labourers in the surroundings of the hydropower projects remains other reasons causing deforestation. Inquiring upon the preference for use of fuel energy, more than 97% of the respondents (97.1% surrounding to Parbati Stage II and 98.5% to Stage III) preferred fuelwood consumption as the preferred fuel.

Recommendation and Suggestions

In energy sector hydropower stands as one of the major sources of clean energy which in turn contributes significantly in growing Indian economy. These projects fulfil the state and national interests and improve living standards of the natives. India in general and Himalayan areas in particular are yet to exploit the full potential of hydropower to meet the ever growing demand of energy. Due to fragile topography in the region, deforestations are increasing continuously due to construction activities of hydropower projects. While adoption of different ecological techniques such as afforestation, check-walls, retaining-walls, reuse of disposal debris, grass plantation in landslips and landslide affected areas, metalling unmetalled roads, etc.

can minimise the deforestation and soil erosion. At the same time, there is a need to give preference to the local communities in involving them in the development of hydropower projects and preventive measures. Bioengineering practices should be used to stabilize hill slopes due to positive role of vegetation. It protects all types of soil erosion, landslides, landslips and rolling boulders in the hilly terrain. For stabilising hill slopes in the region, emphasis should be given to the locally available materials which are cost effective in terms of physical structure. The slope stabilization in a fragile environment with frequent occurrence of landslips and landslides need to be managed with micro-level bioengineering techniques in the upslope regions. Grass and grass turfing practices which need to be planted along the contours. Shrubs and trees need to be planted in the downslope regions and near the constructional activity where the erosion prone areas are lying in the affected regions. Bio-structures of vegetation like brush layering and construction of check dams should be a common practice. The low cost technique for hill stabilization are jute netting, gabion works, wire bolster cylinder, rip-rap drains, which should be used in and around the hydropower development structures. A natural composition of the natural vegetation from grass to tree in plantation is to be followed in accordance with low to high altitude respectively. The hardened plant species should be planted in low altitude regions and the grasses in higher locations. Green belt development should be planted. Fast growing trees species for quick recovery of damaged land need to be grown. Bushes should be planted above the trees in appropriate rows around the project site. In an alternate row, shrubs and trees should be planted for the protection of vegetation and sustainable eco environmental development of hydropower projects in the mountain.

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