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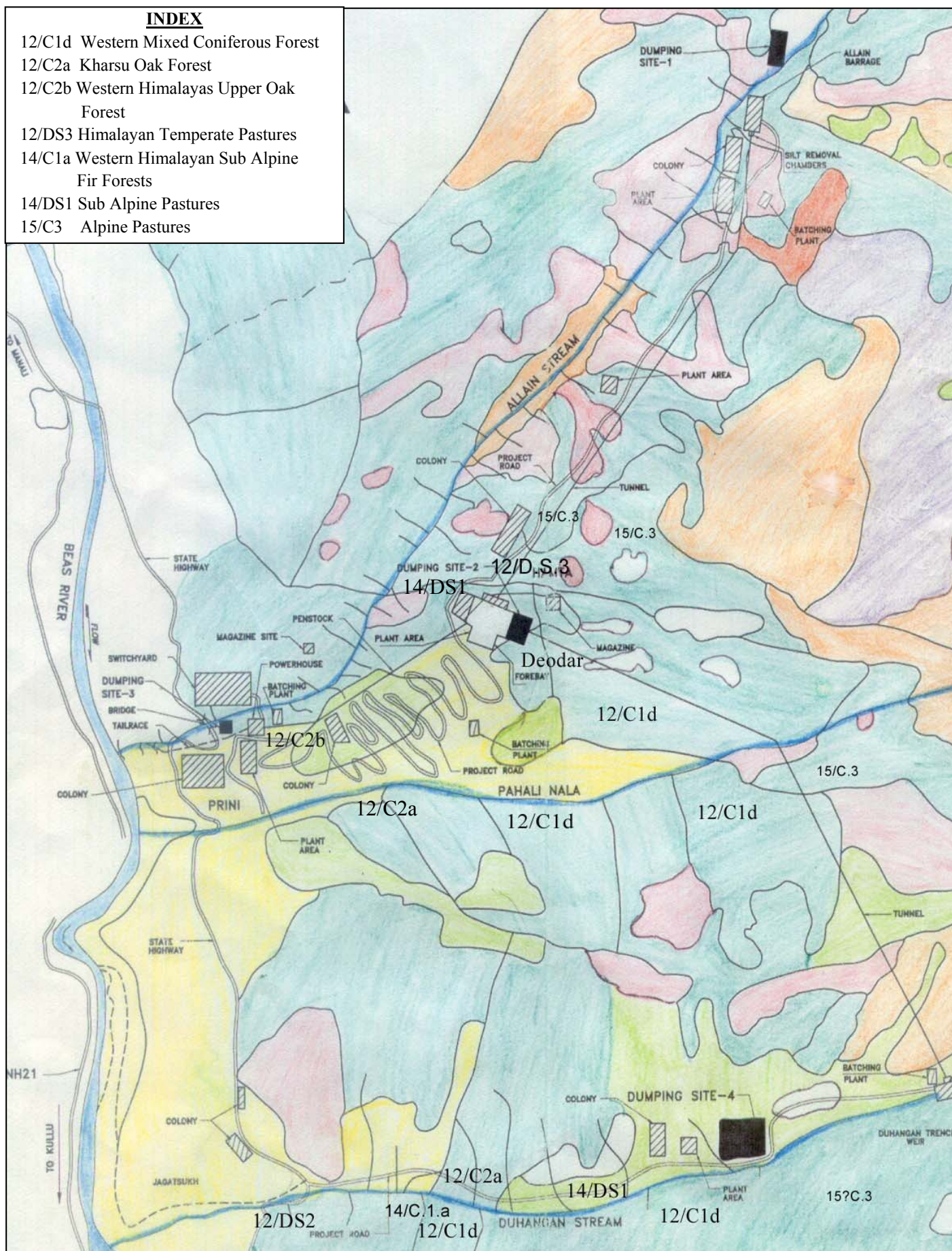


Figure 4.11: Forest types within the Project Catchment Area

The following Table describes tree species to be affected due to Allain and Duhangan project with details on respective forest compartment.

Table 4.27: Tree species, forest compartment numbers and numbers of individuals recorded at Allain and Duhangan sites

Compartment Number	Tree species	Number of individuals	Timber Volume (cu m)
2/17 C III C	<i>Quercus dialtata</i>	232	296.78
2/17 C III C + 2/17 C I A	<i>Acer sp</i>	88	195.10
J III	<i>Kosh</i>	1	2.75
J III	<i>Mohran</i>	1	1.30
2/17 C II C	<i>Juglans nigra</i>	10	47.50
2/17 C III C + 2/17 C II C	<i>Black Cherry</i>	48	52.60
J III + 2/18 C III	<i>Quercus semicarpifolia</i>	270	609.68
2/18 C III	<i>Aesculus indica</i>	3	19.35
J III and 1/17	<i>Cedrus deodara</i>	78	354.37
J III + 1/7 + 2/17 C-I-A	<i>Pinus wallichiana</i>	133	302.10
J III + 1/17 + 2/17 C-I-A + C II C + C II B	<i>Rai</i>	195	985.48
2/18 C III	<i>Tosh</i>	268	1837.09
15 C/III	<i>Willow</i>	3	8.75
15 C/III	<i>Bhoj Patra</i>	8	23.32
15 C/III	<i>Khanur</i>	1	2.92
15 C/III	<i>Rekhel</i>	6	17.49
15 C/III	<i>Hemari</i>	7	20.41
Total		1352	4776.98

At Allain site, a total of 882 trees are going to be affected while at Duhangan site these would be 470.

#### 4.5.14 Habitat Types and Ecological features

Besides these forest types reported from the study area, a number of habitat types are also found. Some of the prominent of these are:

- River bed
- Rocky habitat on mountain slopes
- Rocky habitat near streams
- Boulders
- Steep grassy slopes
- Mountain cliffs and cut slopes
- Glaciers and glacial moraines
- Sheltered valleys
- Small streams on mountain slopes
- Sub alpine pastures
- Marshy patches near pastures

The detailed ecological observations, including the habitat types, recorded during ecological survey are presented below in Table 4.28. The ecological description of each of the line transect 1 to 4 is also the ecological description of the project catchment area.



**Table 4.28:** *Description of physical and ecological features of transects*

Transect	Physical Description	Ecological Features
Transect 1 Region encompassing the area covered along the Upstream of Duhangan stream.  (LHS, RHS have been described w.r.t movement upstream of Duhangan from the east bank of Beas river)	<ul style="list-style-type: none"> <li>The line transect started from about 100 m from the road towards the upstream of Duhangan stream.</li> <li>As one faces Duhangan from the road, the line transect was on the northern side of the stream.</li> <li>The transect gained altitude gradually.</li> <li>The maximum width of the stream, as observed from the line transect varied from 5 to 15 m.</li> <li>The stream was strewn and littered with boulders ranging from small to medium size.</li> <li>The northern side of Duhangan stream has rocky outcrops of varying sizes. These rocky outcrops continued for almost the entire length of the line transect.</li> <li>The gradient of the stream was moderate to steep and the flow rate was fast.</li> <li>The stream has contributed to the formation of a characteristic 'V' shaped valley, which at places narrows down, imparting a gorge like appearance. However, such narrowing of the Duhangan valley is rare.</li> </ul>	<ul style="list-style-type: none"> <li>The northern side slopes of the Duhangan valley, rises gradually and is dominated by typical Western Mixed Coniferous Forests (12/C.1.d).</li> <li>These forests are typically rich in <i>Abies</i> and <i>Picea</i>. At lower altitudes, some incursions by <i>Pinus</i> were also observed. At very high elevation, presence of <i>Cedrus</i> was encountered.</li> <li>At lower elevation of the streams, Western Himalayan Sub-Alpine Fir Forests (12/D.S.2) were seen. As the name suggests, these forests are dominated by Fir (<i>Abies</i>).</li> <li>A number of apple orchards were found on the northern side of Duhangan. These orchards have some <i>Prunus</i> trees as well.</li> <li>Further up and after the apple orchards, a distinct patch of <i>Quercus semicarpifolia</i> (oak) forest was encountered. This is classified as Kharsu Oak Forest (12/C.2.a). Besides oaks, some Barberry bushes and a few young pine trees along with grassy patches were observed in this forest.</li> <li>A small rivulet/stream was flowing down to Duhangan stream from the left side slope, immediately after the end of private land. This stream flow was observed in a small sheltered valley within the slope and this area was more species rich than other area of the open slope. Birds were also noted on this high-diversity patch of mixed vegetation. The small sheltered valley was devoid of large trees and had good herbaceous vegetation with a few shrubs.</li> <li>There were a few of such narrow sheltered valleys with high diversity.</li> <li>The moderate to steep slopes culminates into hilltops, which were mostly dominated by large trees with little or sparse ground flora at this time of the year. Some dry grasses and small herbs were also seen.</li> <li>The hilltops were composed of <i>Abies</i> and <i>Picea</i> mixed forests and are representatives of the Western Mixed Coniferous Forests (12/C.1.d).</li> <li>Further upstream (about 2.5 km from road) the transect entered into spruce forest (<i>Picea</i>) on a very steep slope. Along with large spruce trees some scattered bushes and dry grasses could be seen interspersed between</li> </ul>

Transect	Physical Description	Ecological Features
Transect 2 Region encompassing the area covered along the route from Prini to Sainthal village, via Hamta village, Surge shaft	<ul style="list-style-type: none"> <li>The transect started after the Prini village, which is at about 1 km from road.</li> <li>The transect passed through moderate to steep slopes almost up to its entire length and terminated at the hilltop, below which is the site for Surge shaft.</li> <li>The steep slope uphill was spread with rock pieces and small to medium sized boulders.</li> <li>Large number of rock pieces were also observed en-route.</li> </ul>	<p>small rocks.</p> <ul style="list-style-type: none"> <li>At the confluence of Duhangan and Kala nalla and in the stream were small to medium-sized boulders, which were contributing to the abrupt change in the speed of flow.</li> <li>In this area, there is a typical sub-alpine pasture (locally called as thatch). This region is classified as Sub Alpine pastures (14/D.S.1).</li> <li>The thatch showed good diversity with respect to herbs and shrubs.</li> <li>Further up from this point, snow was encountered and steep slopes rising to the hilltops were observed. The hilltops appeared to be again dominated by Fir and Spruce trees.</li> </ul>
		<ul style="list-style-type: none"> <li>The transect, at lower elevations, had good growth of <i>Pinus wallichiana</i> forest, which gradually followed other forest type.</li> <li>Western Mixed Coniferous Forests (12/C.1.d) was encountered further up to the hilltop. This forest patch was again dominated by Spruce and Fir forests, which are characteristic of this region.</li> <li>About half-way to Hamta village, a rich deodar forest was observed. This region was dominated by large trees of <i>Cedrus deodara</i>, which were present on steep slope. This forest is Class I forest and rich in commercial timber.</li> <li>Besides deodar, the slopes were full of grass patches along with other herbaceous vegetation, such as members of Leguminosae and Labiatae families of flowering plants.</li> <li>Soil erosion from the steep slopes was also observed. The soil on most steep slopes in the Western Himalayan ranges is skeletal and mixed with rock crust.</li> <li>In and around village Hamta, apple orchards were observed.</li> <li>A few trees of Juglans were also found in Hamta.</li> <li>The forest on the left side of Hamta is typical Western Mixed Coniferous Forests (12/C.1.d) dominated by Spruce and Fir trees. The forest in this area is luxuriant.</li> <li>From Hamta to the hilltop is a steep slope, which had snowmelt running down at places.</li> <li>During the survey period, there was heavy snow at the top.</li> <li>These steep slopes are typical sub-alpine pastures and support a good diversity of small flowering herbs.</li> </ul>

Transect	Physical Description	Ecological Features
<p>Transect 3</p> <p>Region encompassing the area covered along the Pahali stream, upto Prini Village from Surge shaft site.</p> <p>(LHS, RHS have been described w.r.t movement upstream of Pahali stream from the east bank of Beas river)</p>	<ul style="list-style-type: none"> <li>• The transect started from a little distance from the road to upstream of Pahali stream.</li> <li>• The flow of water was observed to be fast during the survey period.</li> <li>• The gradient of the stream was also moderate to steep at some places during its course up to the river Beas.</li> <li>• The left-hand side of the stream is a moderate to steep slope with a large number of rocky outcrops.</li> <li>• The stream could be seen emanating from a glacier, snow covered from recent snowfall.</li> <li>• Downstream of Pahali stream was more narrower and gorge like than the upstream area of the stream.</li> <li>• There are a number of boulders, mostly small in the stream up to the river Beas.</li> </ul>	<ul style="list-style-type: none"> <li>• The hilltop was flat and land use of this area has been observed to be terrace farming.</li> <li>• A number of potato fields were observed, which during the survey period were full of snow and were giving an appearance of snowfields.</li> <li>• Gradual to moderate slopes were observed beyond the hilltop site, where the line transect ended.</li> <li>• These forests were of good quality Western Mixed Coniferous Forests (12/C.1.d) dominated by Spruce and Fir trees.</li> <li>• On the left-hand side of the stream and close to the road there are a number of apple orchards. Some of the apple orchards have a few Prunus trees.</li> <li>• Just below the orchards and close to the stream, a grass-dominated patch was observed.</li> <li>• This patch had a number of small boulders with only a few medium-sized boulders in between.</li> <li>• The right-hand side of the stream is a moderate slope dominated by grasses and leads to a patch of Kharsu trees (<i>Quercus semicarpifolia</i>).</li> <li>• Beyond this patch of oaks, the typical Western Mixed Coniferous Forests (12/C.1.d) with spruce and fir trees starts. No deodar were observed in this slope.</li> <li>• The right-hand side of the stream is dominated by Western Mixed Coniferous Forests (12/C.1.d) with typical and majestic spruce and fir forests.</li> <li>• The steep slopes are dominated by pine trees (<i>Pinus wallichiana</i>).</li> <li>• Some patches of the pine forest showed mix of Fir trees and gradually with increasing altitude, the pine forests followed the Western Mixed Coniferous Forests (12/C.1.d).</li> <li>• The steep slopes had good diversity with respect to herbs.</li> <li>• Only a few shrubs were observed on the slopes and these shrubs were similar to the ones observed in Transect 2.</li> <li>• The slopes were mostly barren with a few fir trees.</li> <li>• On top of the barren slopes there was a plum orchard and a few planted apple trees.</li> </ul>

Transect	Physical Description	Ecological Features
Transect 4 Region encompassing the area covered along the Allain stream, and adjoining areas where the proposed switchyard, magazine site (near powerhouse) would come-up  (LHS, RHS have been described w.r.t movement upstream of Allain stream from the east bank of Beas river)	<ul style="list-style-type: none"> <li>The transect started from a little distance from the road to upstream of Allain nalla.</li> <li>Further upstream of Allain, the slopes are less steep.</li> <li>The flow of the stream is fast and the gradient quite steep.</li> <li>The streambed is strewn with small to medium sized boulders. Only a few moderate sized boulders were found towards the upstream of Allain nalla.</li> <li>The left-hand side slopes of the stream are moderate to steep in gradient.</li> <li>These slopes have a large number of rocky outcrops and scattered boulders of varying sizes.</li> <li>These slopes rise steeply and gradually merge into the area close to the Drift Tunnel.</li> <li>The area of the drift tunnel is quite rocky. At this point the upstream of Allain is quite steep with the streambed full of moderately sized boulders.</li> </ul>	<ul style="list-style-type: none"> <li>Further downstream there were steep grassy slopes.</li> <li>On the right-hand side of the slope a few houses were found on the slopes.</li> <li>The right-hand side slopes of the stream are largely barren with exposed rock outcrops with little or no vegetation cover.</li> <li>Slopes are still largely barren but show occasional tree cover in the form of Moru (<i>Quercus dialatata</i>).</li> <li>The Moru oak forest represents the Western Himalayan Upper Oak Forest (12/C.2.b).</li> <li>The vegetation of these slopes show variation with a few trees, but mostly grasses covering the slopes.</li> <li>Some shrubby species as also herbaceous vegetation is common on the right-hand side slopes.</li> <li>Upstream of Allain lies the area for the proposed powerhouse and downstream, close to the road is the site for discharge of tailrace.</li> <li>Through the Moru oak forest, the route, a small trail, reaches the drift tunnel.</li> <li>At this point the rock face over the drift tunnel shows regeneration forest of blue pines (<i>Pinus wallichiana</i>).</li> <li>On way to this area also, vegetation gradually changes with the presence of some pine trees.</li> <li>Further upstream, there were forests of spruce and fir constituting the characteristic Western Mixed Coniferous Forests (12/C.1.d).</li> <li>The habitat is quite patchy and rocky and support increased herb and grass diversity.</li> <li>Downstream of Allain, there was a small patchy forest of Spruce and Fir trees. The rest of the area was largely barren with a few grasses present in the slopes.</li> </ul>

#### 4.5.15

#### ***Biodiversity Aspects of Floral and Faunal Species in Project Catchment***

##### *Phytosociological and Biodiversity Aspects of Flora*

During the ecological assessment of the study area, a number of species were recorded from the quadrants. These details are presented for all the species found in the quadrants for the entire study area in *Table 4.29*, which also give the other biodiversity aspects of the species found. The Phytosociological details are also provided for each of the Transect sampled individually in *Table 4.30*.

Table 4.31 gives the biodiversity aspects of the animal and bird species found within the study area. Due to the time of survey many of the herbs have not been found and some of the high altitude areas could not be sampled, as they were snow bound. Due to this the observed bird diversity is also low and some of the animals found in the study area could not be sighted.

A wide variation is observed with respect to the phytosociological parameters of frequency, density and abundance. Some of the species show good variation among Transects, whereas certain other species follow a similar trend across all the Transects. Variation is also observed from the values at individual Transects when the phytosociological parameters of a specific species are pooled together for determining the pattern of distribution for the entire project catchment.

With respect to the phytosociological parameters, *Bromus*, a grass is found to be the most frequent in the study area, with a frequency of 50%. The other grass that is in the list of top ten floral species in terms of frequency is *Cynodon dactylon* with 22.5% frequency. This is followed by *Abies*, which has a frequency of 42.5%. This is quite evident from the composition of the forests and the presence of Western Mixed Coniferous Forests, which are chiefly composed of majestic fir trees. Similarly, *Picea* also show a relatively high frequency in trees at 32.5%. These two trees, fir and spruce, are the major tree species in the study area. Although pure stands of deodar, blue pine and oaks have been found in the study area, based on the ecological survey, fir and spruce are the most common and dominant trees in the entire study area.

Amongst herbs, *Rumex* is the most frequently encountered species with 37.5% frequency followed by *Stellaria* with 26.25%. For shrubs, *Berberis*, is the most commonly found one with a frequency of 30%.

The pure deodar forest patches in the study area are mostly confined to one or two locations and thus the frequency of this otherwise common tree of western Himalayas has a low frequency of 8.75%. However, this tree is of great commercial value for which is often felled.

With respect to the phytosociological parameter of density, again *Bromus* clearly stands out at a density of 2.54. This is followed by *Rumex* at 1.86. *Stellaria*, which also figured as one of the species with high frequency is the third most dense species within the sampled area (quadrants) at a density of 1.61. Other dominant tree species, such as *Abies* and *Picea* have density values of 0.89 and 0.69 respectively. This means that although fir and spruce trees are very frequently sighted, they do not have large number of individuals within the actual area sampled (quadrants). This is true due to their large size.

With respect to the phytosociological parameter of Abundance, *Trifolium repens* and *T. tomentosum* both show a high abundance value of 7 and 6.17 respectively. Another herb, *Fragaria numbicola* also has a high abundance value of 6.2. It is interesting to note that although, spruce and fir trees have high frequency and relatively higher densities, their abundance values are quite low at 2.12 and 2.09 respectively. This means that even though they are most frequent, that is there are more chances of encountering them their numbers in a given plot of forest are not many. This is because of the fact that these are large trees attaining a

height of up to 50 m with large canopies and occupy large area in a given plot of forest. Each tree takes up a large area and this results in a lower abundance value.

At each individual Transect surveyed, *Abies* is most frequent at Transect 1 (Duhangan) followed by at Transect 3 (Pahali). This is also confirmed by our field observations, as both these streams have large tracts of Western Mixed Coniferous Forests on the north facing slopes, which are chiefly composed of fir and spruce trees. Same is true for *Picea* also. Other phytosociological traits of density and abundance also reflect the same trend.

The grass species, *Bromus*, is most frequent at Transect 1, followed by at Transect 3 where its values for density and abundance are even higher than those for Transect 1. This indicates that although it is present in more quadrants in Transect 1, its distribution within the quadrants is more even in Transect 3 where perhaps, more individuals represent it.



**Table 4.29: Phytosociological aspects of plant species encountered in the four Transects sampled in the project catchment area**

(F – Frequency; D – Density; A – Abundance)

S. No.	Species	Transect 1 – Duhangan			Transect 2 – Hamta			Transect 3 – Pahali			Transect 4 – Allain		
		Total Quadrantes – 25			Total Quadrantes – 25			Total Quadrantes – 15			Total Quadrantes – 15		
		F (%)	D	A	F (%)	D	A	F (%)	D	A	F (%)	D	A
1	<i>Abies pindrow</i>	72	1.56	2.17	36	0.6	1.67	40	1.07	2.67	7	0.7	1
2	<i>Acer caesium</i>	8	0.08	1	8	0.12	1.5	-	-	-	-	-	-
3	<i>Aesculus indica</i>	8	0.08	1	12	0.12	1	-	-	-	-	-	-
4	<i>Ageratum housbuianum</i>	20	0.64	3.2	12	0.36	3	33	1.0	3	27	0.93	3.5
5	<i>Alnus nitida</i>	4	0.04	1	-	-	-	-	-	-	-	-	-
6	<i>Artemisia sp</i>	8	0.2	2.5	24	0.8	3.33	27	0.87	3.25	20	0.73	3.6
7	<i>Berberis asiatica</i>	36	0.96	2.67	24	0.72	3	33	1.07	3.2	27	0.93	3.5
8	<i>Berginia ciliata</i>	4	0.12	3	8	0.28	3.5	-	-	-	7	0.13	2
9	<i>Boehmeria sp</i>	12	0.44	3.67	8	0.28	3.5	7	0.27	4	27	1.33	5
10	<i>Brassica sp</i>	-	-	-	8	0.24	3	-	-	-	-	-	-
11	<i>Bromus sp</i>	56	2.8	5	48	2.48	5.17	53	3.4	6.38	40	1.33	3.33
12	<i>Campanula cashmeriana</i>	4	0.28	7	4	0.12	3	-	-	-	7	0.27	4
13	<i>Caryopteris odorata</i>	4	0.08	2	-	-	-	-	-	-	-	-	-
14	<i>Cedrus deodara</i>	8	0.12	1.5	20	0.64	3.2	-	-	-	-	-	-
15	<i>Corydalis rutifolia</i>	4	0.24	6	8	0.44	5.5	-	-	-	20	0.8	4
16	<i>Cuscuta reflexa</i>	-	-	-	8	0.16	2	-	-	-	13	0.33	2.5
17	<i>Cyanadon dactylis</i>	16	0.84	5.25	28	1.52	5.43	27	1.33	5	20	1.07	5.33
18	<i>Equisetum sp</i>	-	-	-	4	0.12	3	-	-	-	-	-	-
19	<i>Fragaria nubicola</i>	24	1.6	6.67	16	1.28	8	20	0.93	4.67	13	0.47	3.5
20	<i>Gagea elegans</i>	8	0.24	3	8	0.28	3.5	-	-	-	7	0.2	3
21	<i>Gentiana sp</i>	12	0.86	5.67	16	0.84	5.25	-	-	-	-	-	-
22	<i>Hedera nepalensis</i>	4	0.16	4	8	0.12	1.5	7	0.2	3	-	-	-
23	<i>Iris kumaonensis</i>	4	0.2	5	8	0.24	3	-	-	-	20	0.67	3.33
24	<i>Juglans nigrum</i>	-	-	-	4	0.08	2	-	-	-	-	-	-
25	<i>Leucas sp</i>	12	0.44	3.67	20	0.48	0.4	13	0.4	3	13	0.2	1.5
26	<i>Majus</i>	16	0.84	5.25	16	0.96	6	27	1.2	4.5	20	0.93	4.66

S. No.	Species	Transect 1 – Duhangan			Transect 2 – Hamta			Transect 3 – Pahali			Transect 4 – Allain		
		Total Quadrantes – 25			Total Quadrantes – 25			Total Quadrantes – 15			Total Quadrantes – 15		
		F (%)	D	A	F (%)	D	A	F (%)	D	A	F (%)	D	A
27	<i>Malus malus</i>	8	0.28	3.5	4	0.16	4	-	-	-	-	-	-
28	<i>Melilotus indica</i>	16	0.84	5.25	16	0.96	6	13	0.73	5.5	13	0.53	4
29	<i>Penisetum lanatum</i>	-	-	-	8	0.28	3.5	-	-	-	-	-	-
30	<i>Phlomis rotata</i>	8	0.28	3.5	12	0.44	3.67	7	0.33	5	7	0.27	4
31	<i>Picea</i>	48	1.0	2.08	28	0.6	2.14	40	0.73	1.83	7	0.27	4
32	<i>Pinus wallichiana</i>	8	0.27	2.5	12	0.36	3	-	-	-	7	0.27	4
33	<i>Populus ciliata</i>	4	0.04	1	-	-	-	-	-	-	-	-	-
34	<i>Primula sp</i>	8	0.36	4.5	8	0.28	3.5	-	-	-	7	0.2	3
35	<i>Princepia utilis</i>	8	0.2	2.5	-	-	-	-	-	-	-	-	-
36	<i>Prunus cerasoides</i>	4	0.08	2	4	0.04	1	-	-	-	-	-	-
37	<i>Q. dialatata</i>	6	0.12	1.5	-	-	-	13	0.4	3	-	-	-
38	<i>Quercus semicarpifolia</i>	-	-	-	-	-	-	-	-	-	27	0.8	3
39	<i>Ranunculus scleratus</i>	8	0.32	4	12	0.48	4	7	0.2	3	13	0.6	4.5
40	<i>Rhus cotinus</i>	-	-	-	4	0.08	2	-	-	-	-	-	-
41	<i>Rubia cordifolia</i>	-	-	-	4	0.04	1	-	-	-	7	0.07	1
42	<i>Rubus ellipticus</i>	8	0.2	2.5	8	0.02	2.5	7	0.07	1	13	0.2	1.5
43	<i>Rubus nepalensis</i>	4	0.12	3	-	-	-	-	-	-	-	-	-
44	<i>Rumex sp</i>	28	1.2	4.29	36	1.76	4.87	53	2.6	4.88	40	2.4	6
45	<i>Saccharum sp</i>	-	-	-	8	0.24	3	-	-	-	7	0.13	2
46	<i>Salix tetrasperma</i>	24	0.72	3	16	0.4	2.5	13	0.2	1.5	7	0.2	3
47	<i>Sarcocoea pruniformis</i>	4	0.12	3	4	0.04	1	-	-	-	-	-	-
48	<i>Sassuria sp</i>	8	0.16	2	8	0.12	1.5	-	-	-	-	-	-
49	<i>Scurulla sp</i>	-	-	-	-	-	-	-	-	-	7	0.33	5
50	<i>Sonchus asper</i>	12	0.36	3	4	0.16	4	7	0.13	2	13	0.47	3.5
51	<i>Stellaria media</i>	32	1.6	5	24	1.44	6	27	1.87	7	20	1.67	8.3
52	<i>Tagetes minutus</i>	4	0.16	4	-	-	-	-	-	-	-	-	-
53	<i>Thaspi griffithianum</i>	-	-	-	4	0.2	5	-	-	-	-	-	-
54	<i>Trifolium repens</i>	20	1.6	8	28	2.12	7.57	13	1.13	8.5	27	1.07	4
55	<i>Trifolium tomentosum</i>	8	0.44	5.5	12	0.84	7	-	-	-	7	0.33	5

S. No.	Species	Transect 1 – Duhangan			Transect 2 – Hamta			Transect 3 – Pahali			Transect 4 – Allain		
		Total Quadrantes – 25			Total Quadrantes – 25			Total Quadrantes – 15			Total Quadrantes – 15		
		F (%)	D	A	F (%)	D	A	F (%)	D	A	F (%)	D	A
56	<i>Urtica sp</i>	20	0.52	2.6	20	0.6	3	20	0.4	2	20	0.53	2.66
57	<i>Veronica agrestis</i>	4	0.16	4	4	0.12	3	-	-	-	7	0.13	2
58	<i>Vicia perigrina</i>	8	0.44	5.5	4	0.24	6	-	-	-	7	0.2	3
59	<i>Viola sp</i>	8	0.36	4.5	12	0.76	6.33	7	0.33	5	13	0.6	4.5
60	<i>Viscum album</i>	-	-	-	-	-	-	7	0.27	4	20	0.47	2.33

**Table 4.30: Phytosociological and Biodiversity aspects of plant species encountered during ecological survey in the entire project catchment area**

(RLF – Raunkiers Life Form; T – Tree; S – Shrub; H – Herb; C – Climber; G – Grass)

Sl. No.	Species	Frequency (%)	Density	Abundance	RLF	Conservation Status	Whether listed in Red Data Book	Whether endemic to the region or project catchment
1	<i>Abies pindrow</i>	42.5	0.89	2.09	T	Common	No	No
2	<i>Acer caesium</i>	5	0.06	1.25	T	Common	No	No
3	<i>Aesculus indica</i>	6.25	0.06	1	T	Common	No	No
4	<i>Ageratum houstonianum</i>	21.25	0.68	3.18	H	Common	No	No
5	<i>Alnus nitida</i>	1.25	0.01	1	T	Common	-	No
6	<i>Artemisia sp</i>	18.75	0.61	3.27	H	Common	No	No
7	<i>Berberis asiatica</i>	30	0.9	3	S	Rare	Yes	No
8	<i>Berginia ciliata</i>	5	0.15	3	H	Common	No	No
9	<i>Boehmeria sp</i>	12.5	0.53	4.2	H	Common	No	No
10	<i>Brassica sp</i>	2.5	0.08	3	H	Common	No	No
11	<i>Bromus sp</i>	50	2.54	5.08	G	Common	No	No
12	<i>Campanula cashmeriana</i>	3.75	0.18	4.67	H	Common	No	No
13	<i>Caryopteris odorata</i>	1.25	0.03	2	H	Common	-	No
14	<i>Cedrus deodara</i>	8.75	0.24	2.71	T	Common	No	No
15	<i>Corydalis rutifolia</i>	7.5	0.36	4.83	H	Common	No	No
16	<i>Cuscuta reflexa</i>	5	0.11	2.25	C	Common	No	No

Sl. No.	Species	Frequency (%)	Density	Abundance	RLF	Conservation Status	Whether listed in Red Data Book	Whether endemic to the region or project catchment
17	<i>Cyanadon dactylis</i>	22.5	1.19	5.28	G	Common	No	No
18	<i>Equisetum sp</i>	1.25	0.04	3	H	Rare	Yes	No
19	<i>Fragaria nubicola</i>	18.75	1.16	6.2	H	Common	No	No
20	<i>Gagea elegans</i>	6.25	0.2	3.2	H	Common	No	No
21	<i>Gentiana sp</i>	8.75	0.48	5.43	H	Common	No	No
22	<i>Hedera nepalensis</i>	5	0.13	2.5	H	Common	No	No
23	<i>Iris kumaonensis</i>	7.5	0.26	3.5	H	Common	No	No
24	<i>Juglans nigrum</i>	1.25	0.03	2	T	Common	No	No
25	<i>Leucas sp</i>	15	0.4	2.67	S	Common	No	No
26	<i>Majus</i>	18.75	0.96	5.13	H	Common	No	No
27	<i>Malus malus</i>	3.75	0.14	3.67	T	Common	No	No
28	<i>Melilotus indica</i>	15	0.8	5.33	H	Common	No	No
29	<i>Penisetum lanatum</i>	2.5	0.09	3.5	G	Common	No	No
30	<i>Phlomis rotata</i>	8.75	0.34	3.86	H	Common	No	No
31	<i>Picea</i>	32.5	0.69	2.12	T	Common	No	No
32	<i>Pinus wallichiana</i>	7.5	0.23	3	T	Common	No	No
33	<i>Populus ciliata</i>	1.25	0.01	1	T	Common	No	No
34	<i>Primula sp</i>	6.25	0.24	3.8	H	Common	No	No
35	<i>Princepia utilis</i>	2.5	0.06	2.5	S	Common	No	No
36	<i>Prunus cerasoides</i>	2.5	0.04	1.5	T	Common	No	No
37	<i>Quercus dialatata</i>	5	0.11	2.25	T	Common	No	No
38	<i>Quercus semicarpifolia</i>	5	0.15	3	T	Common	No	No
39	<i>Ranunculus scleratus</i>	10	0.4	4	H	Common	No	No
40	<i>Rhus cotinus</i>	1.25	0.03	2	H	Common	No	No
41	<i>Rubia cordifolia</i>	2.5	0.03	1	H	Common	No	No
42	<i>Rubus ellipticus</i>	8.75	0.18	2	S	Common	No	No
43	<i>Rubus nepalensis</i>	1.25	0.04	3	S	Common	No	No
44	<i>Rumex sp</i>	37.5	1.86	4.97	H	Common	No	No
45	<i>Saccharum sp</i>	3.75	0.1	2.67	G	Common	No	No

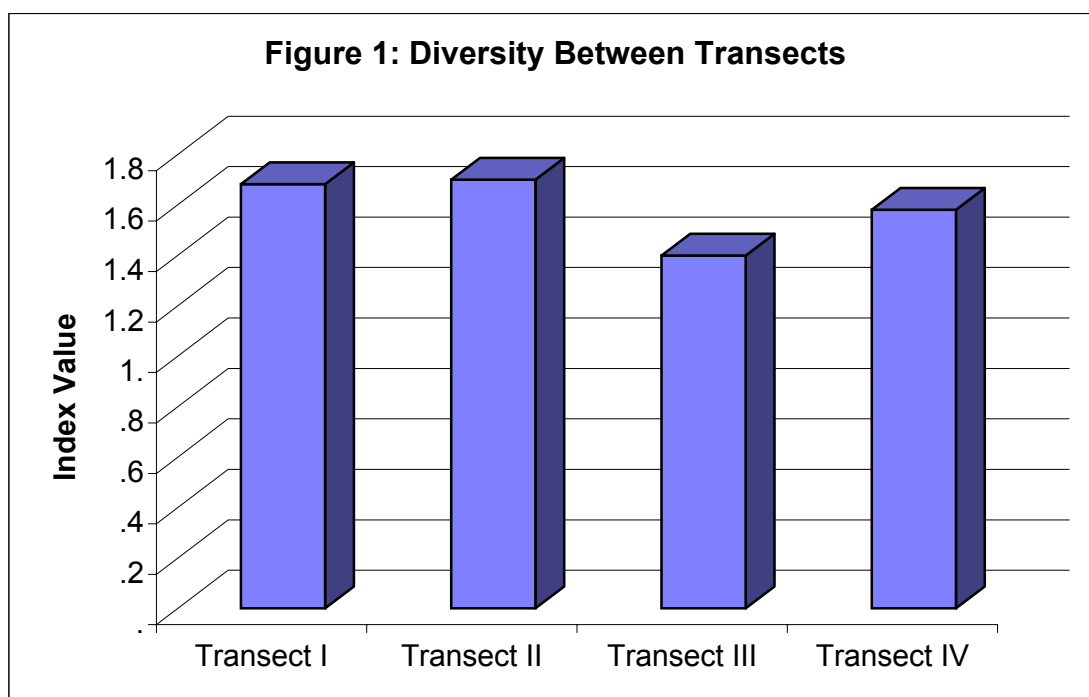


Sl. No.	Species	Frequency (%)	Density	Abundance	RLF	Conservation Status	Whether listed in Red Data Book	Whether endemic to the region or project catchment
46	<i>Salix tetrasperma</i>	16.25	0.43	2.62	S	Common	No	No
47	<i>Sarcocoea pruniformis</i>	2.5	0.05	2	H	Common	No	No
48	<i>Sassuria sp</i>	5	0.09	1.75	H	Rare	Yes	No
49	<i>Scurulla sp</i>	1.25	0.06	5	H	Common	No	No
50	<i>Sonchus asper</i>	8.75	0.28	3.14	H	Common	No	No
51	<i>Stellaria media</i>	26.25	1.61	6.14	H	Common	No	No
52	<i>Tagetes minutus</i>	1.25	0.05	4	H	Common	No	No
53	<i>Thaspi griffithianum</i>	1.25	0.06	5	H	Common	No	No
54	<i>Trifolium repens</i>	22.5	1.58	7	H	Common	No	No
55	<i>Trifolium tomentosum</i>	7.5	0.46	6.17	H	Common	No	No
56	<i>Urtica sp</i>	20	0.53	2.63	H	Common	No	No
57	<i>Veronica agrestis</i>	3.75	0.11	3	H	Common	No	No
58	<i>Vicia perigrina</i>	5	0.25	5	H	Common	No	No
59	<i>Viola sp</i>	10	0.53	5.25	H	Common	No	No
60	<i>Viscum album</i>	5	0.14	2.75	H	Common	No	No

All the four Transects sampled were compared to bring out the extent of diversity within each of them and between them. The Shannon-Weiner Diversity Index was used to highlight the extent of diversity. The results are presented below in Table 4.31 and graphically shown below.

**Table 4.31: Shannon Diversity Index Results for the four sampled Transects**

Index	Transect 1	Transect 2	Transect 3	Transect 4
Shannon H' Log Base 10	1.484	1.513	1.241	1.446
Shannon Hmax Log Base 10	1.681	1.699	1.398	1.58



As is clear from the results of the Shannon Diversity Index, Transect 1 and 2 are most diverse with Transect 2 displaying the highest diversity for the two types of Shannon Diversity Indices.

Transect 2 is the route to Hamta village and beyond up to the hill tops and it passes through varied types of habitats, which include Spruce-Fir dominated forests, Deodar forests, steep to moderate slopes, grasslands and sub alpine pastures etc. Therefore, the high diversity in habitat types is able to support the high biodiversity encountered in this Transect, as is confirmed by the Diversity Index.

For Transect 1, which is the upstream area of Duhangan, the diversity is also quite high, as it is very close to the values for Transect 1. This fact is also supported by our field observations, as Duhangan upstream also has a varied range of habitats in the form of slopes, pastures, rocky patches etc. Further, during our field visit, we also noted small sheltered valleys within the south facing slopes and these sheltered valleys support high diversity.

Transects 1 and 2 are followed by Transect 4 in terms of high diversity. This result is also in line with our observations. Transect 4, the Allain upstream and the region near the drift tunnel had barren slopes thereby depriving the Transect of some species that are characteristic of this region and found on other Transects. Further, some areas of Transect 4 were almost pure stands of Oak forests and Blue Pine forests. Being almost monoculture stands the extent of diversity is generally low in such areas.

According to the results, Transect 3 has the lowest diversity. Transect 3 is more or less homogenous with Spruce-Fir forests dominating large tracts of the slopes. Our observations from the field are in line with the results of the Diversity Index.

Besides the species encountered during ecological survey (species that were present in the quadrants), a number of other species were also observed, which did not fall within the quadrants. These species are listed below, which also include a few species that are reported from the study area and were not seen. This happened primarily because the ecological survey was conducted quite early in the summer season. Most of the species not falling in the quadrants are herbs, as they have just started emerging after snowmelt started. Later in the season many of the flowering plants are more established and widespread. Also, during summer months the high altitude forests are also accessible, as at this time they were snow bound. These species are listed below in *Table 4.32*.

**Table 4.32:** *Species observed during ecological survey of project catchment but not encountered in the quadrants*

S. No.	Species	RLF	Conservation Status	Whether listed in Red Data Book	Whether endemic to the region or project catchment
1	<i>Corylus colurna</i>	T	Common	No	No
2	<i>Taxus baccata</i>	T	Endangered	Yes	No
3	<i>Betula utilis</i>	T	Common	No	No
4	<i>Rhododendron arboretum</i>	H	Common	No	No
5	<i>Carpinus</i>	T	Common	No	No
6	<i>Ulmus wallichiana</i>	H	Common	No	No
7	<i>Populus ciliata</i>	S	Common	No	No
8	<i>Juniperous</i>	T	Common	No	No
9	<i>Viburnum</i>	H	Common	No	No
10	<i>Cotoneaster</i>	H	Common	No	No
11	<i>Indigofera sp</i>	S	Common	No	No
12	<i>Desmodium</i>	H	Common	No	No
13	<i>Ilex dipyrena</i>	H	Common	No	No
14	<i>Lonicera</i>	H	Common	No	No
15	<i>Deutzia</i>	H	Common	No	No
16	<i>Strobilanthus</i>	H	Common	No	No
17	<i>Impatiens</i>	H	Common	No	No
18	<i>Rosa</i>	S	Common	No	No
19	<i>Polygonatum</i>	H	Common	No	No
20	<i>Valeriana</i>	H	Common	No	No
21	<i>Anemone</i>	H	Common	No	No

S. No.	Species	RLF	Conservation Status	Whether listed in Red Data Book	Whether endemic to the region or project catchment
22	<i>Potentilla</i>	H	Common	No	No
23	<i>Delphinium</i>	H	Common	No	No
24	<i>Balsam</i>	H	Common	No	No
25	<i>Anaphalis</i>	H	Common	No	No
26	<i>Festuca</i>	G	Common	No	No
27	<i>Agrostis</i>	G	Common	No	No
28	<i>Danthonia</i>	G	Common	No	No
29	<i>Brachipodium</i>	G	Common	No	No
30	<i>Aconitum</i>	H	Rare	No	No
31	<i>Podophyllum</i>	H	Common	No	No
32	<i>Jurinea</i>	H	Common	No	No

Some mosses and a number of both fruticose and crusteose lichens were found on tree bark and rock respectively. Ferns were also observed in some locations in Transect 1, 2 and 4.

#### 4.5.16

##### *Fisheries*

With respect to fishing, the streams of Himachal Pradesh fall under two categories; General waters and Trout waters, with estimated length of 600 and 2400 kms respectively. The major State's streams include- Beas, Sutlej,

Kullu district is honey combed by the perennial river and streams with considerable flow of water. There is a lot of scope for pisciculture in the Kullu district. In official records, Fish species are also found in Allain, Duhangan, Kasol, Jagatsukh streams and Ravi, Tirthan, Sainj, Uhl, Baspa, Pabar, Lambadug, Giri, Rana, Nugal Gai, Baner, Bata, etc. The major fishes available in these streams are Trout, Mahseer, Nemacheilus spp, Barilus sp, Schizothoracids Crossocheilus sp. Glyptothorax spp. etc. Fishing in these streams is regularised under the state fisheries Act. In trout water licences only for rod and line are permitted while in general water both rod and line as well as cast netting is all allowed. The fishing department of Himachal Pradesh has identified certain stretches as potential fishing sports for trout and mahseer. A fish hatchery is also being set up downstream Duhangan stream before its confluence with Beas River.

The river stretch of Beas falling within the study area does not fall under these identified stretches. The species are Trout, Rainbow Orienus and Himalayan Barbel. The district of Kullu has 302-registered fisherman. The total production of fish in the district is 177 ton/year. The market price is about Rs.40 per Kg. The production of fish per person is about 250 gm/year in Kullu.

#### 4.5.17

##### *Fish Catch Studies*

Since both Allain and Duhangan streams are cold streams fed by snowmelt from higher reaches. Only cold water fish are expected to withstand such temperature range and habitat conditions. A special type of fish with adaptation to stick to rocks through modified gill as suckers can also survive. However, attempts to catch such fish by using dragnets failed to yield any catch.



Both the streams, Allain and Duhangan were found devoid of any fish species. Only near the confluence of Duhangan and Beas, fingerlings of Desi carp were caught in the nets. The ecological conditions of the catchment suggest that there is an upward migration of fishes from Beas to these streams. Some species of fishes are reported from Beas and are mentioned in *Table 4.33*. The upward migration of fishes from Beas to Allain and Duhangan is season specific and is mostly post-monsoon when the water in Beas swells up. It is likely that at that time fishes migrates upwards in search of food and spawning sites.

To ascertain the fish biodiversity, a visit was made to the fisheries department at Pattlikuhl and Kullu. No records of fish biodiversity could be found from the fisheries department. At Pattlikuhl, some fishermen were found to be angling. After enquiry the only fish catch recorded from them was *Desi carp* – a local fish. No other fishes were found. Pictorial guidebooks were shown to the fishermen, who reported some fishes are available in Beas only in the post monsoon period. According to the local fishermen, sometimes *Mahaseer* and *Rainbow Trout* are also found in the Beas River. Fish catches were also evaluated at Kullu market. Local fishermen brought the fishes caught through angling in the river Beas. Again only *Desi carp* fish catch was found during the month of April 2003.

#### 4.5.18 *Biodiversity Aspects of Fauna*

The population sizes of the species observed is limited to visually observed and their individuals were counted and recorded. Mammals, Birds, Reptiles, Amphibians, Mollusks and Fishes represent the biodiversity aspects of faunal species. Amongst the terrestrial faunal species, reptiles, such as, snakes were not observed. Only a few lizards were seen. Porcupine was not sighted but its quill was found, which was taken as an indirect measure of the presence of the species in the project catchment area. In the category of aquatic faunal species, only a few fingerlings of '*desi*' carp fish were found, besides a few tadpoles. No frogs were seen, although, a few tree frog species are reported from the project catchment area. No mollusks were found during the ecological survey. The species of the area are given in *Table 4.33*.

**Table 4.33: *Biodiversity Aspects of Faunal Species (Mammal, Bird, Reptile, Amphibian, Mollusk and Fish Species in the Project Catchment Area)***

Class	Species	Endan- gered	Threat- ened	Vuln- erable	Rare	Com- mon	Whether listed in Schedule 1 of Wildlife Protection Act
Mammals							
	Fox				✓		No
	Porcupine				✓		No
	Common Langur					✓	No
	Ibex*	✓					Yes
	Blue Sheep (Bharal)*	✓					Yes
	Black Bear*		✓				No
	Brown Bear*	✓					Yes
	Musk Deer*	✓					Yes
	Ghoral*	✓					Yes
Reptiles							
	Cobra*					✓	No

Class	Species	Endan- gered	Threat- ened	Vuln- erable	Rare	Com- mon	Whether listed in Schedule 1 of Wildlife Protection Act
	Krait*					✓	No
	Pit Viper				✓		No
	House Gecko					✓	No
	Garden Lizard					✓	No
	Rock Lizard					✓	No
Amphibians							
	Bull frog*					✓	No
Mollusks							
	Fresh Water Snail*					✓	No
* Species reported to be present in the study area but not sighted during ecological survey							
Birds							
	<i>Passer domesticus</i> (Sparrow)					✓	No
	<i>Streptopelia chinensis</i> (Spotted dove)					✓	No
	<i>Urocissa erythrorhyncha</i> (Red billed blue Magpie)					✓	No
	<i>Corvus macrorhynchos</i> (Large-billed crow)					✓	No
	<i>Chaimarrornis leucocephalus</i> (White capped water redstart)					✓	No
	<i>Arborophila torqueola</i> (Hill partridge)				✓		No
	<i>Coturnix coturnix</i> (Common quail)					✓	No
	<i>Lophophorus impejanus</i> (Monal)	✓					Yes
	<i>Gyps fulvus</i> (Eurasian griffon)				✓		No
	<i>Neophron percnopterus</i> (Egyptian vulture)					✓	No
	<i>Acridotheres ginginianus</i> (Bank Myna)					✓	No
	<i>Acridotheres tristis</i> (Common Myna)					✓	No
	<i>Sternus pagodarum</i> (Brahminy Myna)					✓	No
	<i>Accipiter badius</i> (Shikra)					✓	No
	<i>Megalaima haemacephala</i> (Coppersmith barbet)					✓	No

Class	Species	Endan- gered	Threat- ened	Vuln- erable	Rare	Com- mon	Whether listed in Schedule 1 of Wildlife Protection Act
	<i>Coloumba livia</i> (Rock pigeon)					✓	No
	<i>Streptopelia decaocto</i> (Ringed dove)					✓	No
	<i>Cercomela fusca</i> (Common Rock Chat)					✓	No
	<i>Carpodacus erythrinus</i> (Rose finch)					✓	No
	<i>Motachilla alba</i> (White wagtail)					✓	No
	Woodpecker					✓	No
Fishes							
	<i>Salma gairdnerii</i> gairdnerii# (Rainbow Trout)					✓	No
	<i>Salma trutta fario</i> # (Brown Trout)					✓	No
	<i>Tor Pituitora</i> # (Mahaseer)					✓	No
	<i>Catla catla</i> #					✓	No
	<i>Lebio rohita</i> #					✓	No
	<i>Lebio batu</i> #					✓	No
	<i>Desi Carp</i>					✓	No
	<i>Lebio dero</i> #					✓	No
	<i>Lebio dyochelus</i> #					✓	No
	<i>Cirrhina mrigala</i> #					✓	No
	<i>Notopterus chitala</i> #					✓	No
	<i>Wallgo attu</i> #					✓	No
	<i>Nemachilus botio</i> #					✓	No
	<i>Pontius ticto</i> #					✓	No
	<i>Pontius sarana</i> #					✓	No
	Silver Carp#					✓	No
	<i>Mastacimballus armatus</i> #					✓	No

# Fish species reported to be present in river Beas but not observed in the Fish Catch Survey in April 03

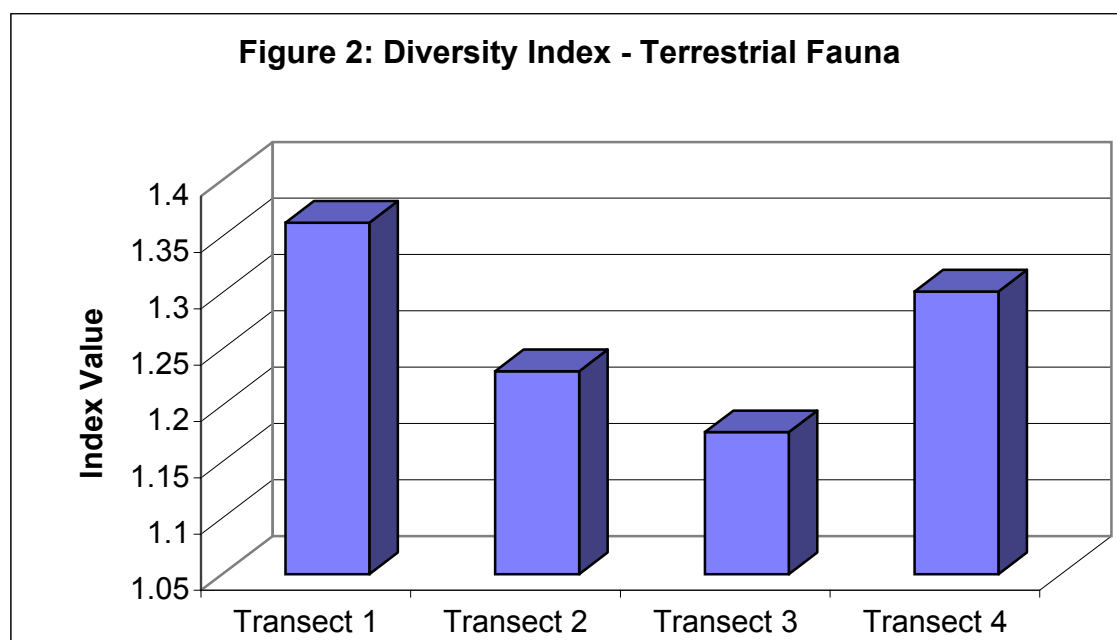
#### Diversity Index – Fauna

Based on the data collected from the field Shannon diversity index was calculated. The results are given in Table 4.34 and graphically represented in graphic.

**Table 4.34: Shannon Diversity Index Results for Fauna in the Project Catchment Area**

Index	Transect 1	Transect 2	Transect 3	Transect 4
Shannon H' Log Base 10	1.202	1.099	1.102	1.215
Shannon Hmax Log Base 10	1.362	1.23	1.176	1.301

As is clear from the Shannon diversity index above, Transect 1 is the most species rich in the project catchment, followed by Transect 4. Transect 1 (Duhangan stream) is a pristine area with little or no disturbances. Thus a number of faunal species, including birds were observed here. Even some endangered species, like the Ibex and Musk Deer are reported from upstream Duhangan catchment area. Transect 4 was also rich in faunal diversity, particularly bird diversity. This transect supports a number of habitat types, which display a somewhat patchy distribution in the landscape and thus provide shelter, food and breeding sites for many species. Consequently, the Transect 4 stood at second position, as per the Shannon Diversity Index. Transect 2 was low in species richness, as this area of the project catchment had three villages, namely, Prini, Hamta and Sethan. Of these Prini is a large village and is located close to the road (State Highway). Clearing of land for apple orchards and extraction of firewood by village inhabitants causes disturbances to wild animals. The upper reaches of Transect 4, near the site for Surge shaft and up to the site of barrage on Allain, were snow bound. Similarly, large tracts of Transect 3 (Pahali stream) were also snow bound, as a result of which the Shannon index for this transect is the lowest.



#### 4.5.19

#### *Salient Findings of the Ecological Survey*

Parallel slopes of the mountain ranges, i.e. south facing slopes of Allain, Pahali and Duhangan streams are quite similar with respect to vegetation and other ecological features. Similarly, the north facing slopes of these streams are closely related with respect to vegetation and other ecological features.

This indicates that geo-climatic forces are shaping evolution of vegetation types and the resulting forest types are governed largely by photoperiod, precipitation and soil types.

The soil across the project catchment is relatively loose and is mixed variously with rock crust. At most locations, and particularly on steep to moderate slope,



the soil is skeletal. The soil is a fine gravel and loam, usually sandy loam to clayey loam. Fir (*Abies pindrow*) and Spruce (*Picea*) are the most frequent tree species in the entire study area.

### ***Estimation of Land and Forest Loss in Project Catchment Area***

One of the major sources of ecological impact would be loss of land, and more specifically loss of forestland. Tree felling and loss of forestland is likely to have long-term impacts as are discussed in the next section of Ecological Concerns Matrix. It is estimated that about 77.272 ha of land will be lost due to various project activities, like barrage and reservoir, silt removal chamber, roads, plant area, switch yard and tail race, colony and office, dumping area, powerhouse and magazine storage. *Table 4.35* gives the estimates of loss of forestland due to project activities.

**Table 4.35: Estimated loss of forestland due to project activities**

Project Activity	Loss of Forestland Area (ha)
Barrage/Reservoir/ Surge shaft	6.84
Silt removal chamber	0.187
Project roads	12.00
Plant area	5.00
Switch yard/tail race	5.14
Colonies	1.00
Powerhouse	1.00
Magazines	1.00
Total	32.167

Due to loss of trees and forestland, it is estimated that compensatory afforestation will need to be carried out in about 64.334 ha of land. The per ha afforestation cost calculated by Forest Officials stands at about Rs 29,525.00 per ha. Therefore, the total cost of afforestation is estimated at about Rs 20,13,400.00.

### ***Ecological Concerns Matrix***

The ecological assessment has highlighted certain concerns regarding the developmental phase of the project that may have an adverse implication on the ecology of the project catchment and surrounding area. These are presented below in *Table 4.36*.

**Table 4.36: Ecological concerns along with their sources of threats and affected ecological parameters**

Ecological concern	Whether Impact is Negative & Timescale	Source of threat	Affected Ecological Parameters
Deforestation	Yes; Long-term	Road building	Loss of habitats Loss of soil Loss of species Impact on animal movement Variation in local climate

Ecological concern	Whether Impact is Negative & Timescale	Source of threat	Affected Ecological Parameters
Soil erosion	Yes; Long- term	Road building	Loss of soil microbes and invertebrates Reduced soil fertility
		Tunneling	Damage to habitats through dumping of waste material Sedimentation in streams
Habitat destruction	Yes; Long-term	Road building	Loss of species Reduced ecosystem productivity Reduced ecosystem resilience Biological invasions and introduction of exotics
Threat to wildlife	Yes; Long-term	Colonization	Teasing of wild animals Incidences of poaching and illegal trade Restricted movement of wild animals
Firewood extraction	Yes; medium-term	Labourers and workers' colony	Reduced ecosystem productivity. Rampant firewood extraction or lopping could permanently damage some trees and reduce their regeneration potential. Wood cutting during flowering and fruiting will result in reduced number of propagules for regeneration.

Bio monitoring of surface water as well as sediment was carried out in the study area. Bio monitoring of surface water was carried out to evaluate the quality of water. There are two methods adopted for biological water quality evaluation.

Saprobic Score (BMWP) method involves inventory of the presence of benthic macro-invertebrate fauna up to the family level with the taxonomic precision. All possible families having saprobic indicator value are classified on score scale of 1 to 10 according to their preference for saprobic water quality. The saprobic scores of all the families are registered and averaged to produce BMWP score. Diversity Score (Sequential Comparison) method involves pairwise comparison of sequentially encountered individuals and the difference of two benthic animals can be observed upto the species level, where no taxonomic skill is required. The diversity is the ratio of total no. of different animals (runs) and the total number of organisms encountered. The ratio of diversity has a value between 0 and 1.

**Table 4.37: Results of Bio Monitoring of Surface Water in Study Area**

Sampling Point	Diversity Index	Saprobity Index	Water Quality	Remarks
BW-1RI	4.5	0.50	C	Poor Water Quality
BW-2R2	6.0	0.33	B	Slightly Polluted Water
BW-3-R3	7.25	0.47	A	Clean Water
BW-4-R4	7.0	0.29	A	Clean Water
BW-5-SRF-1	7.25	0.67	A	Clean Water
BW-6-SRF-2	7.0	0.43	A	Clean Water
BW-7-SRF-3	8.33	0.62	A	Clean Water
BW-8-SRF-4	4.5	0.50	C	Poor Water Quality
BW-9-SRF-5	7.25	0.66	A	Clean Water

Sampling Point	Diversity Index	Saprobity Index	Water Quality	Remarks
BW-10-SRF6	7.25	0.70	A	Clean Water
BW-11-SRF7	6.33	0.50	B	Slightly Polluted Water
BW-12-SRF-8	4.55	1.00	C	Poor Water Quality

BW-1-R-1-U/s Confluence of River Allain to River Beas, River Beas; BW-2-R-2-D/s confluence of River Allain to River Beas, River Beas; BW-3-R-3- U/s Confluence of River Dhuhanagan to River Beas, River Beas; BW-4-R-4-D/s Confluence of River Dhuhanagan to River Beas, River Beas; BW-5-SRF-1-U/s Bridge, Phali Nal at Prini; BW-6-SRF-2-U/s Bridge; Dhuhanagan River, at Jagat Sukh; BW-7-SRF-3-U/s Bridge, Allain River, at Prin; BW-8-SRF-4-Hamta Nala, Vill. Hamta; BW-9-SRF-5-In take point on River Allain at Bhujdhar; BW-10-SRF-6-Marasu Nala, Proposed Plant Area, Marasu Dhar; BW-11-SRF-7-D/s In take point on Dhuhanagan River; BW-12-SRF-8-U/s In take Point on Dhuhanagan River;

Biological examination of the benthic sediments was carried at 6 different locations in Allain and Duhangan streams. The benthic sediments comprised mostly of rocks. Results of biological examination performed for the various samples collected are tabulated under Tables 4.38 – A, B, C, D E & F.

**Table 4.38A: Results of Biological Examination in the Sediments from Duhangan near Chorpani, 3 km upstream Jagatsukh Bridge**

Sl. #	Name of the fauna	Number	Plates used for comparison
1	Larva with cause of <i>Ochroticha sp.</i> ; Family <i>Hydropapsychidae</i>	31	Plate 24 (J)
2	Larva of order <i>Diapters</i>	37	Plate 23
3	Larva of <i>Tahanus sp.</i> ; Family : <i>Tabaniae</i>	30	Plate
Total number of fauna		98	

\* Refer to Annex G for reference of Plates

**Table 4.38B Results of Biological Examination in the Sediments from Duhangan near Jagatsukh bridge**

Sl. #	Name of the fauna	Number	Plates used for comparison
1	Larva with cause of <i>Ochroticha sp.</i> ; Family <i>Hydropapsychidae</i>	20	Plate 24 (J)
2	Family: <i>Pteronarcidae</i>	05	Plate 21
3	Larva of <i>Tabanus sp.</i> Family : <i>Tabaniae</i>	03	Plate 26 (E)
4.	Larva of <i>Narpus sp.</i> ; Family: <i>Elmidae</i>	05	Plate 27 (E)
5.	Larva of <i>Simulium sp.</i> ; Family: <i>Simulidae</i>	09	
6	Larva/pupa of <i>Antocha</i> ; Family: <i>Tipulidae</i>	12	Plate 26 (G)
Total number of fauna		54	

\* Refer to Annex G for reference of Plates

**Table 4.38C Results of Biological Examination in the Sediments from Duhangan Stream near Beas confluence**

Sl. #	Name of the fauna	Number	Plates used for comparison	Remarks if any
1	Larva Narpus sp.; Family : Elimidae	05	Plate 27 (B)	
2	Larva/midge of Nalabesmyia sp; Family: Chironomidae	10	Plate 25 (C)	
3	Larva of Tabanus sp.; Family : Tabaniae	06	Plate 26 (F)	
4.	Larva with case of Ochroticha sp. ; Family: Hydropsychidae	16	Plate 24 (J)	10 Shells Were Empty
5.	Identified Molluse	02	-	Emty Molluse shell
6.	Larva of Chaoborous sp Family : Culicidae	02	Plate 21 (E)	
7	Larva/midge of Chironomous sp.; Family : Chironomidae	03	Plate 25 (B)	
Total number of fauna		44		

\* Refer to Annex G for reference of Plates

**Table 4.38D Results of Biological Examination in the Sediments from Allain Stream, upstream of Powerhouse Location near Guage**

Sl. #	Name of the fauna	Number	Plates used for comparison	Remarks if any
1	Larva with cause of Ochroticha sp.; Family Hydropapsychidae	16	Plate 24 (J)	
2	Larva of non-insect	05	-	
3	Unidentified Larva	07	-	Very early stage of development
Total number of fauna		28		

\* Refer to Annex G for reference of Plates

**Table 4.38E Results of Biological Examination in the Sediments from Allain near Beas Confluence**

S. No.	Name of the fauna	Number	Plates used for comparison	Remarks if any
1	Larva with case of Ochroticha sp Family: Hydropsychidae	19	Plate 24 (J)	
2	Larva of Tabanus sp. Family: Tabanidae	07	Plate 26 (E)	
3	Larva of Narpus sp; Family: Elmidae	05	Flate 27 (B)	
4.	Larva/midge of Ablabesmyia sp. Family: Chironomidae	10	Plate 25 (C)	
5.	Larva of non-insect Arthropod	07		
6.	Un-identified larva	02		Very early stage of development
Total number of fauna		50		



**Table 4.38F Results of Biological examination in the Sediments from Allain, near Hotel Imperial**

Sl. #.	Name of the fauna	Number	Plates used for comparison	Remarks if any
1	Larva with cause of Ochroticha sp.; Family Hydropapsychidae	17	Plate 24 (J)	
2	Larva of non-insect arthropod	08		
3	Unidentified Larva Very early stage of development	06		All larva are similar in structure
Total number of fauna		31		

Diversity indices for benthos observed for each sampling location are:

**Table 4.40: Diversity Indices for Benthos observed for each Sampling Location**

Location	Diversity index
Duhangan near Chorpani, 3 km u/s of Jagatsukh bridge	2.28
near Jagatsukh bridge	4.54
Duhangan – Beas confluence	4.85
Allain U/s of powerhouse, near guage	2.50
Near Hotel Imperial	3.60
Allain-Beas confluence	4.55

#### 4.6

#### DESCRIPTION OF CULTURAL ASPECTS & TOURISM IN STUDY AREA

The Kullu Valley and the Beas River have a human history extending over several millennia. The passes at the head of the Beas, namely Rohtang and Hampta have long provided access to and from the trans-Himalayan region. Earlier known as the Arjikiya (RigVeda) and Vipara (Sanskrit), the river was later renamed Beas (Vyasa). For Hindus, the Beas has long been an important destination for pilgrimage though not to the same scale as such other Himalayan destinations such as Gangotri, Badrinath, and Amaranth. Unlike many other areas of the Himalaya, the Kullu District has experienced a relatively long period of social and political stability.

The area also was visited by hunting, scientific and exploration groups on a frequent basis in the early part of the 20<sup>th</sup> century, thus establishing the basis of a summer tourist trade unrelated to the traditional, pilgrimage-based tourism. Manali developed somewhat in this period but came into prominence only in the 1950's when the descendants of some of the original British settlers established tourist "guest houses". The best known were the Banon's (Banon 1952). At this time, the motor road was extended beyond Manali to the base of Rohtang Pass and thence, in the subsequent decade, over the Pass to Keylong, the capital town of Lahul, and Leh in Ladakh. Until the late 1960's, Kullu, and Manali specifically, remained a destination summer vacation spot for relatively small numbers of expatriate individuals and families and small mountaineering expeditions. Toward the end of this period, Manali itself became a seasonal destination of large numbers of foreign young people, otherwise described as "hippies", and known for the associated "drug" culture. With the extension and improvement of the road network, which was done for national security

purposes and to support the growing commercialization of agriculture in the area, more short-term visitors were attracted to the area.

The growth of tourism in Kullu and Manali in particular has been stimulated by three factors since 1970. These include the noted development of transportation; construction of accommodation facilities; and the development of a system of promotion and advertising. Today, Manali is fully linked by all-season roads to the national highway network. Public and private bus and taxi services are readily available to major centers such as Shimla, Chandigarh, and Delhi. Scheduled air transport is available from such centers to Bhuntar, 60 km south of Manali. Tourist accommodation has grown from the few orchard and cottage based guest houses to a myriad of hotels of all sizes and standards, including five-star accommodation. As Singh (1989) notes, Manali exhibited a shortage of suitable tourist accommodation until the late 1980's. This has been reversed in the 1990's as a result of unprecedented construction, encouraged in part by state subsidies to investment in the hotel business.

Widespread publicity and advertising have made the tourist amenities of the Kullu Valley wellknown throughout India. The Himachal Pradesh Tourist Development Corporation has taken the lead in this. Domestic (i.e. Indian) tourists dominate the tourist economy with the peak visitation seasons being in June (pre-monsoon) and mid-September to mid-October (post-monsoon). The latter coincides with the well-known Kullu Dussehra (religious festival). In 1975 total visitation was on the order of 38,000 people. By 1980 this figure had reached 68,000 and by 1985 it was 130,000. Visitations were projected to be 250,000 by 1990.

The situation changed substantially in 1989-90. In Kashmir, conflict escalated to the point where the well-developed domestic and foreign tourist industry there collapsed. In addition, the primary surface transportation route to Ladakh, which passes through Kashmir, was no longer regarded as safe for tourist traffic. Both tourist interest and tourist services shifted to alternative locations, with the Kullu Valley and Manali being the foremost. In addition, the old route through Kullu to the trans-Himalayan region provided the only alternative surface transport route to Ladakh. Tourist visitations to Manali as a destination and a stopping point have increased markedly since 1990. Even more evident are the many hotels, which have been built in the same period in response to this trend. Growing affluence in a segment of the population of India, in addition, has increased the tourist demand. Manali is seen as an easily accessible and affordable mountain paradise in which to escape the heat of the pre-monsoon and post-monsoon seasons south of the Himalaya. Publicity and advertising has continued apace. More recently, the Manali area has developed a small winter tourist trade. For the adventurous, a helicopter ski operation has developed and is advertised worldwide. It is modeled on successful operations in Canada, U.S.A. and New Zealand and, like them, attracts affluent foreign tourists. For the domestic market, Manali is being presented as a "winter wonderland" and place to come to learn to ski. These attractions extend even into June and early July when people are encouraged to visit the remaining snowfields at Rohtang Pass.

Both a cause and an effect of the growth in tourism in Kullu, is the development of infrastructure to transport and accommodate tourists. Tourism has spawned related services in the area. The indigenous work force of the area is insufficient in number and training to support this growth in economic activity. In its turn, this has stimulated the in-migration of seasonal and permanent workers and their families, which further stresses available accommodations and services. The stress on available land has been particularly notable in the Manali vicinity where suitable building sites are at a premium. Small areas of agricultural land have been converted to residential and commercial uses. Much of the traditional agricultural land is retained in the village use areas and some is being used for the equally lucrative commercial orchardry and horticulture.

#### 4.6.1

##### *Pressure on Forest Resources*

The historical land settlement provided with relatively well-defined rights to resources in this area. Since the villages in this area have resource use areas and livelihoods to a large extent tied to the land, the threats to biophysical sustainability in the study area were also threats to the economic and social wellbeing of the people. These threats included the replacement of biologically diverse traditional field crops with orchard monocultures; the heavy use of government-subsidized pesticides; and the loss of collective decision-making traditions in certain kinds of land use area, which had been privatized. Extensive illegal felling of trees was a major threat to the forest environment as well as to the villagers' collective livelihoods. Local institutions as well as government agencies were struggling with these resource management problems.

The framework of law which structured the use of resources in the Manali area and Kullu valley is the 1886 Anderson settlement report and a later report prepared by A.H. Diack (1898). Under this settlement village rights in the Kullu district appear to have been more generously defined than elsewhere. Contrary to indications from other areas in India, the process of settlement rights in Kullu valley did not result in the termination of local people's rights, but rather their acceptance and formalisation. Anderson's report seemed to have a concern for village rights, noting that rights to forest resources were important to the livelihoods of villagers: "The people are dependant on these rights for their very existence, and extinction of the rights would be the most unjustifiable expropriation"

However, these concerns for village rights still had to operate under the framework of the 1878 Indian Forest Act which was intended to affirm the state ownership of Indian forests and abridge village forest rights. One method to define local rights, under the overall state ownership of forests, was to assign a forest area based on precolonial tributary use areas to each revenue village created by the settlement process. These forest rights were vested in the individual landholder and recorded at the time of the revenue settlement. The vesting of forest rights in the individual, rather than the village, made it difficult for a village to regulate the activities of their members. In law, the village was given a portion of a state forest, within which each landholder of the village could exercise recorded forest rights, but management, regulation and enforcement were carried out by the Forest Department. The result was a state forest divided into village forest right areas, to be utilized by villagers, but

managed by the state, as determined on the basis of the *de jure* property rights established in 1886. Eventhough, these rights were initially defined as *individual* rights by the colonial administration following the European tradition, they were in fact practised as *communal* rights, following the Indian and Pahari tradition. Considering the importance of the diversity of *interdependent* uses of the local mountain environment, this shift in practice may help explain how "tragedy of the commons" in the use of resources was avoided. Because of the interdependence of many kinds of livelihood activities, common property resources were the key to sustainability, and common property institutions made possible the complex of diverse and shifting relationships.

#### 4.6.2

#### *Social Setup of Pirni, Hamta, and Jagatsukh villages*

##### *Sacred Groves*

In Himachal Pradesh, as in many other regions of India, religion and belief systems have traditionally been integrated with natural resource use and management. This complex of religion and natural resources often forms the core of social and cultural life. This integration is exemplified in the institution of the devaban. Devaban is the local term used to refer to forests that are considered sacred in the Kullu region of Himachal Pradesh, India.

Devaban are found all over Himachal Pradesh, particularly in the moist temperate regions of the state that are densely forested. Often, such forests are visible markers in the landscape. They stand out as oases of dense diverse forests amidst an agricultural landscape or monoculture forests. Local communities through the devata institutions, aided by a system of beliefs that encompass the lives and livelihoods of these communities manage these forests. Such devaban are found in the study area.

These devabans today are traditional institutions that lie at the intersection of cultural and ecological practices. Changing religious beliefs, transmuting cultural practices, economic transition, and an emergent green consciousness have all left their mark on this traditional institution. They now lie in the discursive terrain of tradition, culture, modernity, markets, and conservation. They represent a religio-social system that is today isolated in small pockets, challenged continually by broader cultural and economic forces. On the other hand, they have entered the conservation discourse and politics since they represent unique ecological islands.

Sacred groves have generally been seen as examples of traditional conservation practices, repositories of indigenous knowledge, and models of community based biodiversity conservation. There are at least three major types of sacred forests that can be distinguished. First are forests that have been defined as sacred by some community of users. These forests are sacred and have religious/cultural/emotional value in local discourse and practice, irrespective of the actual legal ownership of the land or trees. Thus it is possible that what is a reserved forest in legal ownership documents, is considered in local discourse as a sacred grove. In this form of sacred grove, the entire forest ecosystem including the entire fauna and flora enjoy protection. Second, there are particular species of trees that have sacred value, and thus clusters of this species form a sacred forest. Here the value attached is to the particular species

and other coexisting species may not be protected. Specific deodar (cedar/*Cedres deodara*) trees in Kullu are often considered sacred, believed to hold the spirit of some devata. The Vanshira of Kullu is one example, where a particular deodar tree is believed to be the guardian of the forest. It is relatively common to find iron nails driven into trees, pieces of red cloth or old iron articles left below such a tree. Third, there are forests that are the legal property of the devata. In general, the property of the devata is sacred, although conversion from one form of property to another may be entirely acceptable. This is significant since sacredness is not embodied in the particular object or place; it is sacred mainly by way of ownership. This does not provide the same level of ecological protection as the earlier two types of sacred groves. Harvest or sale of forest produce for conversion into other forms of temple property could be legitimized more easily under this system. All three types of sacred forests are found in Himachal Pradesh, often with one type overlapping or intermixed with the other. The management of these sacred forests is closely interwoven with the entire devata system that forms the core of rural social life.

Devaban range in size from a few trees to forest tracts spread over several acres. They are managed on the basis of rules of use, which are specific to each devaban. There is a significant distinction made between using the forest for the devatas own use, such as in temple repairs and in communal cooking during *devata's* fairs, and the use for human needs like fuel-wood, fodder, poles and timber. Human use is believed to be determined according to devata's willingness and wishes. There is no one set of rules that is operative for all devaban or for all times. Generally in the forests of devatas like *Nag*, *Vanshiras*, and *Jognies*, which are manifestations of animistic and natural spirits, rules regarding use of their devaban are more stringent.

#### *Cultural fairs*

Melas held in honour of devatas are an important economic and cultural space in this area. They encompass religious rites and rituals, games and entertainment, trade, and cultural events. Melas serve an important social function in cementing social relations within the community and between neighbouring villages. These are occasions for social interaction. Since each community hosts its own mela, relations of reciprocity in hosting and visiting each other are established. The hospitality of particular families and communities are remembered and reciprocated. Thus even though two families may not meet during the year, relationships are maintained through close interaction during the melas. News from the entire valley circulates in the region. Melas are important locations and times when marriages are fixed and conducted. It is an opportunity for informal cross-gender interaction, where young people select their own partners. It is also a site where more formal marriages are arranged through interaction and agreement between families.

#### *Livestocks*

There is livestock population of within the study area mainly includes cattles (local dwarf breeds), sheeps, goats and poultry birds.

The characteristics of the physical setting gives rise to a variety of biogeo physical processes, which in juxtaposition with roads, agricultural land, settlements and infrastructure and people are hazardous. The details of topography, surficial deposits, landforms, and vegetation cover, as well as formal and informal field observations and historical records provide the basis for describing the processes of the study area. Earthquakes, floods and debris torrents, landslides and rockfalls, snow avalanches, snowstorms and cold spells and forest fire are the important processes.

In regard to seismic activity, the study area lies fully within Zones IV and V, which are characterized by frequent occurrences with Richter magnitudes varying from 5 to 8. Notable earthquake events in the general region include 1905 Kangra earthquake; 1975 Kinnaur-Spiti earthquake; and the 1991 Uttarkashi earthquake. This is seismically a very active region and there is no doubt that earthquakes must be factored into any consideration of risk from natural hazards.

Upstream from Manali, the channel morphology of the Beas River is indicative of periodic, high energy flooding. Occasionally, as in early July 1993, early monsoon rainfall coupled with late snowmelt at higher elevations produced a strong flood flow. Other high magnitude flood events occurred in late August and early September in each of 1994, 1995 and 1996. Likewise, coincident flood flows have occurred on major tributaries of the Beas, such as Manalsu stream. Torrents occur from time to time in most streams, including both those with perennial and ephemeral flows. The occurrence of several such events with disastrous consequences in August 1994 in the Kullu District led to suggestions that the frequency and magnitude of such events is on the increase as a consequence of deforestation (G. B. Pant Institute 1995). There is relatively little physical evidence to suggest this is the case. Indeed, examination of historical documents provides evidence of similar torrents in the same locations in the past. The disastrous consequences may have escalated however as a result of other factors.

Mass wasting processes, namely landslides and rockfalls, are common in high mountain environments. Physical evidence indicates that the study area is no exception. Recent history does not provide significant examples of specific events apart from minor slope failures associated with extreme bank erosion on the Beas River. Land surface features indicate large-scale landslide masses and scars in the vicinity of the villages of Chichoga and Solang. These appear to have developed in valley-side colluvial and/or glacial deposits and are probably progressive. The Chichoga feature is evident in photos taken in the early part of this century. It is less evident today, largely because of human alteration of the land surface for agricultural purposes. Nonetheless, progressive failure is likely still occurring. The Solang example is clearly evident today. Minor rockfall activity occurs from most vertical rock slopes throughout the area and, of course, is one of the ongoing processes that leads to the build-up of colluvial deposits. Physical evidence of large-scale rockfall activity is present on the approach to Rohtang Pass.

Snow avalanches are common throughout the upper Beas River watershed during the winter. High snowfall and the development of a deep snowcover makes the region, including parts of Spiti, Kinnaur, Lahul and adjacent Kashmir, one of the most avalanche-prone, inhabited areas of the Himalaya. Because of this and the hazard to habitation and transportation, the Indian government created the Snow and Avalanche Study Establishment at Manali. This is a world-class snow and avalanche research and forecasting center.

Snowstorms and cold spells occur from time to time in the region. From the hazard perspective, these events are most dangerous when they are least expected. The most recent example stemmed from the early July 1993 storm, which created flooding in the upper Beas River watershed. This event also resulted from an unusually late (in the year) occurrence of a strong westerly system, which brought a cold, continental air mass into contact with a warm, moist air mass, representing an early incursion of monsoonal air into the region. At elevations above 3,000 m in the upper Beas, Spiti, and north into Lahul, this system produced very heavy snowfall and an extended period of cold temperatures. This, in turn resulted in road closures and disruption of transhumance grazing activities.

Finally, historical information suggests that, from time to time, forest fires occur in the study area. This is not unusual in forested mountain areas generally. However, there is no evidence from the study area to indicate that extensive burns have occurred in the recent historical period.

### *Landslides*

Landslides are common events in the geodynamically sensitive Himalayas, especially during high intensity monsoon rains. Overstauration of slopes fractured by tectonic forces, compounded by anthropogenic interference leads to frequent slope failure in this high relief mountain system. Over the years, human activity has contributed to an increase in slope failures in the Himalayas because of the expansion of road networks, settlements, and other developmental activities. Apart from disruption to road transportation and high-sediment delivery into the river system, the landslides also contribute to loss of human lives.

A devastating landslide occurred on 12 September 1995 near Luggar Bhatti, Kulu, Himachal Pradesh, and killed 65 people. An estimated  $0.96 \times 10^6$  m<sup>3</sup> of unconsolidated mass slid down the terminal part of a thick alluvial fan, on the left bank of the Beas River. About  $0.03 \times 10^6$  m<sup>3</sup> of dislodged material formed a 15m high and 150m long hump at the bottom of the failed slope; a shallow sag pond developed in the rear. The slide occurred after heavy rains on 3-6 September in the region when the Beas rose to a bankfull position. Factors involved in this toppling debris slide included a steep slope, continuous seepage with high pore water pressure in unconsolidated material, a road-cut obliterating the foot of the fan slope, and impinging by the Beas River during the flood. A survey in the area showed that a variety of mass movement processes were triggered by the heavy rains in September; the most predominant being a series of slope failures on the outside of meander loops and bank erosion caused by turbulence of the overflowing Beas River. National Highway-21 (NH-21), a bridge ramp near Bhuntar, a suspension bridge at Kulu



and two other bridges upstream sustained extensive damage. Most damage occurred in the Manali area where massive buildings were washed away by the flash flood. Whereas some smaller events occurred in the early and middle part of this century, the recurrence and intensity of mass movements are recent phenomena attributed mainly to escalating socio-economic development, growth of tourism, and population pressure