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Comparative Study of Vegetation Status and Species Richness around Alakhnanda and Bhagirathi Valley under Kotli – Bhel Hydroelectric Power Projects (IA and IB), Uttarakhand, India

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Abstract - A comparative study was carried out in two different valleys of Ganga river system viz; Alaknanda and Bhagirathi. In both of valleys total 134 species with 118 genera and 56 families were recorded. Poaceae was the dominant family representing maximum (11) number of species followed by Asteraceae (10) Fabaceae (9) and Lamiaceae (9). In different vegetation strata a total of 39 species were encountered under tree layer, 36 species were under shrub layer and 59 species were under herb layer in both of the valleys. Out of them 31 tree species were recorded in Alaknanda valley and 27 were in Bhagirathi valley. In shrub layer 32 and 30 species were recorded in Alaknanda and Bhagirathi valley respectively. In the herb layer Bhagirathi valley showed highest (51) species richness in its influence zone and submergence zone (45). The proportion of family to species was recorded greater in both of valleys compare to the proportion of family to genus and genus to species.

Keywords : *alaknanda valley, bhagirathi valley, submer-gence zone, influence zone, species richness.*

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I. Introduction

Biodiversity has attracted world attention because of the growing awareness of its importance on the one hand and the anticipated massive depletion on the other (Singh 2002). India in general and Himalayan region in particular is known for its biological richness and has always been a botanist's paradise. Its diversified landforms, relief and environmental conditions support a wide range of vegetations (Rana *et al.* 2010). Biodiversity is considered an important aspect of ecosystem energy because it allows building complex trophical networks and it functions as insurance for ecosystem stability and resilience (Gaston and Spicer, 2004). The encroachment on the land by different development works by the people leads to various types of disturbance on the forest vegetation in Himalayan region. In man made landscapes, agricultural activities are the most frequent causes of species loss and, in addition to these deterministic causes of extinction, reductions in area and increases in isolation of semi natural habitats lead to further stochastic species losses (Saunders *et al.,* 1991; Rosenzweig, 1995). Loss of biodiversity may result in loss of stability and functioning of ecosystems (Lawton, 1994; Naeem *et al.,* 1995).

Although India is endowed with rich natural resources and considered as one of the important biodiversity pools for genetic, economic and ecological prudence, it suffers from a variety of problems, ranging from demographic pressure to accelerated land degradation. (Navalgund *et al.,* 2007). Floristic dynamics of landscape reflects variation in climatic conditions, habitat and physiography of the region. The study of natural biotic community is a prerequisite to understand the structural as well as functional attributes to locate for better landscape management (Thakur *et al.,* 2007). Human activities, such as agriculture and forestry, and natural disturbances, such as outbreaks of insects and diseases, can modify the physical environment of an ecosystem (i.e., the patterns of temperature, moisture, wind, and light) by altering structural features (Chen *et al.,* 1999).

II. Methodology

To analyze the plant diversity, phytosociological study was conducted at Alakhnanda and Bhagirathi valley in the Ganga river system under "Kotlibhel Hydroelectric Project (Stage-IA & Stage- IB). The "Kotlibhel H.E. Project (Stage I-A) was situated on river Bhagirathi near village Muneth which is at 3.80 km. upstream of the confluence of river and Alakhnanda at Devprayag in Distt. Tehri Garhwal. The Alakhnanda valley was start from the tail end of the proposed reservoir of Kotlibhel hydro electric power project (Stage I-B) in river Alakhnanda at Srinagar (Garhwal) to 5km. downstream of the proposed power house near confluence of Bhagirathi and Alakhnanda at Devprayag. This covered the total stretch of about 30 km long and 7 km wide.

The ecological survey was conducted during June 2005 to Feb 2006. Study area was divided into two categories, influence and submergence zone along the

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reservoir. A total of 8 transects were laid in the entire study area for both of the valleys. Each Transects were spatially distributed so as to minimize the autocorrelation among the vegetation. 'S' or species richness, was determined following Whittaker (1976) by tabulating the number of woody species in each plot. Biodiversity Pro (vers. 2) software (1997) was used to Bray-Curtis analysis.

III. Results and Discussion

After detailed ecological study in both valleys, a total of 134 species were recorded which were represented by 56 families and 118 genus. Out of 134 species, 39 species were under tree layer, 36 under shrub layer and 59 were found under herb layer. Taxonomically, among different vegetation layer of both valley Poaceae was most diverse family with maximum (11) number of species followed by Asteraceae (10), Fabaceae (9), Lamiaceae (9), Euphorbiaceae (6) and Caesalpinaceae (5) (Table-1, 2 and 3).

In Alakhnanda valley total 31 tree species were recorded in which 26 were in Influence zone and 21 in submergence zone. In Bhagirathi valley total 27 tree species were recorded in which 12 were in Influence zone and 27 were in the submergence zone. As far as shrub specie were concerned, 32 species were found in Alakhnanda valley in which 32 were in the influence zone and 24 were in submergence zone while in the Bhagirathi valley total 31 shrub species were recorded in which 30 were in the influence zone and 27 species were in the submergence zone. Herb layer of both valleys in both zones followed the same trend as for tree and shrub species. A total of 42 herb species were found in the Alakhnanda valley in which 41 were in the influence zone and 38 were in the submergence zone while in the Bhagirathi valley a total of 55 herb species were recorded in which 51 species were in the influence zone and 45 species were in the submergence zone (Table 4).

Between both of the valleys the species richness was greater in the influence zone, except for tree layer of Bhagirathi valley where it was fount higher (27 individuals) in the submergence zone. Adhikari *et al.,* (2009) explored the vegetation structure and community pattern of Tehri Dam submergence zone and reported maximum species richness in Bhagirathi submergence zone compare to the Bhilangana Submergence zone.

Maximum (48) and minimum (12) genera were occurred in the influence zone of Bhagirathi valley for the herb layer and tree layer respectively. In Alakhnanda valley, herb layer also occupied maximum (38) genera in the influence zone followed by (36) in submergence zone for herb layer, 32 for shrub layer in influence zone and 26 in influence zone for tree layer. Tree layer of submergence zone of Alakhnanda valley showed minimum (21) genera. In the Bhagirathi valley highest numbers (48) for genera were recorded for the herb layer followed by 41 for herb layer in the submergence zone, 30 for shrub layer in influence zone and same number (27) of genera recorded for shrub layer and tree layer in the submergence zone (Table-4).

The proportion of genus, species and family presents in table-5. The proportion of family to species was recorded higher compare to proportion of genus to species and family to genus in both of the zone in both valleys. While, maximum proportion (2.20) of family to species was recorded in the influence zone of Alkhnanda valley. In present study in both of the valley, the proportion among species, genus and family followed the trend as family to species > family to genus >genus to species. Pokhriyal *et al.,* (2009) reported the greater proportion of family to species and genera to species in a comparative study of *Annogeissus latifolius* mixed forest in Phakot and Pathri Rao watersheds of Garhwal Himalaya. In hilly districts of Garhwal Himalaya, Negi *et al.,* (2008) also found higher proportion of family to species followed by family to genus and genus to species in a comparative study between Panchayat and Reserve forests. Kharkwal *et al.,* (2005) found higher proportion between family and species with a little difference compare to genus to species and family to genus in three different Oak forests of Nainital district.

Bray-Curtis cluster analysis was used to find out the species assemblage in influence and submergence zone at both of the Alaknanda and Bhagirathi valley. Figure 1 – 3 represents different species assemblage in both of valleys. In the tree layer *Acacia catechu, Aegle marmelos, Cassia fistula, Haldinia cordifolia, Holoptelea integrifolia, Mallotus philippensis, Mangifera indica* and *Pinus roxburghii* formed separate cluster as these species assemblage was found in both of the zones as well as both valleys. While *Ougenia ooginansis, Grevillia robusta* and *Eucalyptus camaldulensis* were found only at submergence zone of Alaknanda valley (Figure 1). In the shrub layer *Adathoda zeylanica, Artemisia roxburghiana, Cajanus mollis, Cassia tora, Colebrookia oppositifolia, Debregeasia longifolia, Eupatorium adenophorum, Euphorbia royleana, Ficus hederaceae, Lantana camara, Murrya koenigii, Rhus parviflora, Tephrosia candida, Woodfordia fruticosa* and *Ziziphus oxyphylla* was distributed at both of the zones of Alaknanda and Bhagirathi valley. While *Agave americana, Berberis lycium, Pteracanthus angustigrons, Reinwardtia indica* and *Jatropa curcas* found only at the influence zone of Bhagirathi valley (Figure 2). In the herb layer out of total 59 species, 29 herb species were recorded at both zones of Alaknanda and Bhagirathi valley. Only 2 species viz; *Aster peduncularis* and *Bidens bipinata* were found at only submergence zone of the Bhagiratgi valley (Figure 3)

Table 1 : Tree species composition in submergence and influence zone of Alaknanda and Bhagirathi valley

S.No.	Species	Family	Alakhnanda valley		Bhagirathi valley	
			IZ	SZ	IZ	SZ
1	*Acacia catechu*	Mimosaceae	+	+	+	+
2	*Aegle marmelos*	Rutaceae	+	+	+	+
3	*Albizia lebbek*	Mimosaceae	+	+	-	-
4	*Anogeissus latifolius*	Combretaceae	-	-	+	+
5	*Bauhinia variegata*	Caesalpiniaceae	+	-	-	-
6	*Boehmeria rugulosa*	Urticaceae	-	-	-	+
7	*Bombax cieba*	Bombaceae	+	+	-	+
8	*Carica papaya*	Cacricaceae	+	-	-	+
9	*Cassia fistula*	Caesalpinaceae	+	+	+	+
10	*Celtis australis*	Ulmaceae	-	+	-	+
11	*Dalbergia sissoo*	Fabaceae	+	+	-	-
12	*Delonix regia*	Caesalpiniaceae	+	-	-	-
13	*Eucalyptus camaldulensis*	Myrtaceae	-	+	-	-
14	*Ficus benghalensis*	Moraceae	-	-	-	+
15	*Ficus palmata*	Moraceae	-	-	-	+
16	*Ficus religiosa*	Moraceae	-	+	+	+
17	*Grevillia robusta*	Proteaceae	-	+	-	-
18	*Grewia optiva*	Tiliaceae	-	-	+	+
19	*Haldinia cordifolia*	Rubiaceae	+	+	+	+
20	*Holoptelea integrifolia*	Ulmaceae	+	+	+	+
21	*Juglans regia*	Juglandaceae	+	-	-	-
22	*Lannea coromendelica*	Anacardaceae	+	+	-	+
23	*Leucaena leucocephala*	Mimosaceae	+	+	-	+
24	*Mallotus philippensis*	Euphorbiaceae	+	+	+	+
25	*Mangifera indica*	Anacardaceae	+	+	+	+
26	*Melia azedarach*	Miliaceae	+	+	-	+
27	*Morus alba*	Moraceae	+	-	-	-
28	*Musa paradisca*	Musaceae	+	-	-	+
29	*Ougenia ooginansis*	Fabaceae	-	+	-	-
30	*Phoenix humilis*	Arecaceae	-	-	-	+
31	*Phyllanthus emblica*	Euphorbiaceae	+	-	-	-
32	*Pinus roxburghii*	Pinaceae	+	+	+	+
33	*Prunus cerasoides*	Rosaceae	-	-	-	+
34	*Psidium guajava*	Myrtaceae	-	-	-	+
35	*Pyrus phasia*	Rosaceae	+	-	-	+
36	*Syzygium cumini*	Myrtaceae	+	-	+	+
37	*Tectona grandis*	Verbenaceae	+	-	-	-
38	*Terminalia chebula*	comberetaceae	+	+	-	-
39	*Toona hexandra*	Miliaceae	+	-	-	+

Table 2 : Shrub species composition in submergence and influence zone of Alaknanda and Bhagirathi valley

S.No.	Species	Family	Alakhnanda valley		Bhagirathi valley	
			IZ	SZ	IZ	SZ
1	*Adathoda zeylanica*	Acanthaceae	+	+	+	+
2	*Aerva sanquinolenta*	Amaranthaceae	+	+	-	-
3	*Agave americana*	Agavaceae	-	-	+	+
4	*Agave fastigata*	Agavaceae	+	+	-	-
5	*Artemisia roxburghiana*	Asteraceae	+	+	+	+
6	*Asparagus adscendens*	Liliaceae	+	-	+	+
7	*Bambusa arundinaceae*	Fabaceae	+	+	-	-

8	*Barleria cristata*	Acanthaceae	+	+	+	-
9	*Berberis lycium*	Berberidaceae	-	-	+	+
10	*Cajanus mollis*	Fabaceae	+	+	+	+
11	*Cannavis sativa*	Cannabinaceae	+	-	+	+
12	*Carrisa opeca*	Apocynaceae	+	+	+	+
13	*Cassia tora*	Caesalpiniaceae	+	+	+	+
14	*Colebrookia oppositifolia*	Lamiaceae	+	+	+	+
15	*Cotinus coggygria*	Anacardiaceae	+	+	-	-
16	*Debregeasia longifolia*	Urticaceae	+	+	+	+
17	*Eupatorium adenophorum*	Asteraceae	+	+	+	+
18	*Euphorbia royleana*	Euphorbiaceae	+	+	+	+
19	*Ficus hederaceae*	Moraceae	+	+	+	+
20	*Jatropa curcas*	Euphorbiaceae	-	-	+	-
21	*Lantana camara*	Verbenaceae	+	+	+	+
22	*Murrya koenigii*	Rutaceae	+	+	+	+
23	*Nyctanthes arbo-tritis*	Oleaceae	+	+	-	-
24	*Pteracanthus angustigrons*	Acanthaceae	-	-	+	+
25	*Pueraria tuberosa*	Fabaceae	+	+	+	-
26	*Pupalia lapaca*	Amaranthaceae	+	-	+	+
27	*Reinwardtia indica*	Linaceae	+	-	-	+
28	*Rhus parviflora*	Anacardaceae	+	+	+	+
29	*Ricinus communsis*	Euphorbiaceae	+	-	+	+
30	*Rubus ellipticus*	Rosaceae	+	-	+	+
31	*Sida cordifolia*	Malvaceae	+	-	+	+
32	*Tephrosia candida*	Fabaceae	+	+	+	+
33	*Urtica dioica*	Urticaceae	+	+	+	-
34	*Woodfordia fruiticosa*	Lythraceae	+	+	+	+
35	*Xanthium indicum*	Asteraceae	+	-	+	+
36	*Ziziphus oxyphylla*	Rhamnaceae	+	+	+	+

Table 3 : Herb species composition in submergence and influence zone of Alaknanda and Bhagirathi valley

S.No.			Alakhnanda valley		Bhagirathi valley	
	Species	Family	IZ	SZ	IZ	SZ
1	*Ageratum conyzoides*	Asteraceae	-	-	+	+
2	*Ajuga bracteosa*	Lamiaceae	+	+	+	+
3	*Alysicarpus bupleurifolius*	Fabaceae	+	+	+	+
4	*Anaphalis adnata*	Asteraceae	+	-	+	-
5	*Apluda mutica*	Poaceae	-	-	+	+
6	*Arisaema tortuosum*	Areceae	-	-	+	-
7	*Artimissia capalaris*	Asteraceae	+	+	+	+
8	*Arundinella nepalensis*	Poaceae	+	-	+	+
9	*Aster peduncularis*	Asteraceae	-	-	-	+
10	*Bidens bipinata*	Asteraceae	-	-	-	+
11	*Bidens pilosa*	Asteraceae	+	+	+	+
12	*Brachiaria ramosa*	Poaceae	+	+	+	+
13	*Brassica rapa*	Brassicaceae	-	-	+	+
14	*Bupleurum falctaum*	Apiaceae	-	-	+	-
15	*Carex myosuras*	Cyperaceae	-	-	+	+
16	*Cassia absus*	Caesalpiniaceae	+	+	+	+
17	*Celosia argentea*	Areceae	+	+	+	+
18	*Chenopodium album*	Chenopodiaceae	-	-	+	+

19	*Chrysopogon aciculatus*	Poaceae	+	+	+	+
20	*Chrysopogon fulvus*	Poaceae	+	+	+	+
21	*Commelina benghalensis*	Commelinaceae	-	-	+	+
22	*Crotolaria medicagina*	Fabaceae	+	+	+	+
23	*Cynadon dactylon*	Poaceae	+	+	+	+
24	*Cynoglosum glochidiatum*	Boraginaceae	+	+	+	+
25	*Cyperus comprsssus*	Cyperaceae	+	+	+	+
26	*Datura innoxia*	Solanaceae	+	+	-	-
27	*Datura stramonium*	Solanaceae	-	-	+	-
28	*Desmodium triflorum*	Fabaceae	+	+	+	+
29	*Digitaria ciliaris*	Poaceae	+	+	+	+
30	*Elusine coracana*	Poaceae	-	-	+	+
31	*Eragrostis minor*	Poaceae	+	+	+	+
32	*Euphorbia hirta*	Euphorbiaceae	+	+	+	+
33	*Evolvulus alsinoides*	Convolbulaceae	+	+	+	+
34	*Fumaria indica*	Fumariaceae	+	+	-	-
35	*Galium aprine*	Rubiaceae	+	+	-	-
36	*Geranium ocelatum*	Geraniaceae	+	+	+	+
37	*Heteropogon controtus*	Poaceae	+	+	+	+
38	*Heteropogon melanocarpus*	Poaceae	-	+	+	+
39	*Ipomoea hederifolia*	Convolbulaceae	+	+	+	+
40	*Leucas cephalotes*	Lamiaceae	+	+	+	+
41	*Leucas lanata*	Lamiaceae	+	+	+	+
42	*Malva sylvestris*	Malvaceae	+	+	+	+
43	*Micromaria biflora*	Lamiaceae	+	+	+	+
44	*Nepeta hindostana*	Lamiaceae	+	+	-	+
45	*Nicotiana plumbaginifolia*	Solanaceae	+	+	+	-
46	*Origanum vulgare*	Lamiaceae	+	-	+	-
47	*Oxalis corniculata*	Oxalidaceae	+	+	+	+
48	*Physalis divaricata*	Solanaceae	+	+	+	+
49	*Rumx hastatus*	Polygonaceae	+	+	+	+
50	*Scutellaria linearis*	Lamiaceae	-	-	+	-
51	*Scutellaria scandems*	Lamiaceae	+	+	-	+
52	*Sedum multicaule*	Crasulaceae	+	+	+	+
53	*Sida rhombifolia*	Malvaceae	+	+	-	-
54	*Sida cordata*	Malvaceae	+	-	+	+
55	*Stellaria media*	Caryophyllaceae	-	-	+	+
56	*Tagetus erecta*	Asteraceae	-	-	+	-
57	*Thalictrum foliolosum*	Ranunculaceae	-	-	+	-
58	*Verbascum thapsus*	Scrophulariaceae	-	-	+	+
59	*Viola canescens*	Violaceae	+	+	+	-

+ Presence and – Absence of species

Table 4 : Distribution of species, families and genus in both zone of Alakhnanda and Bhagirathi valley

Site	Alakhnanda valley Influence Zone			Alakhnanda valley Submergence Zone		
	Tree	Shrub	Herb	Tree	Shrub	Herb
Species	26	32	41	21	24	38
Family	19	23	19	15	18	19
Genus	26	32	38	21	24	36

	Bhagirathi valley Influence Zone			Bhagirathi valley Submergence Zone		
Species	12	30	51	27	27	45
Family	12	21	24	19	22	21
Genus	12	30	48	27	27	41

Table 5 : Proportion of Species, genus and family in both zone of Alakhnanda and Bhagirath valley

Zone	Genus: Species	Family: species	Family: Genus
Alakhnanda valley Influence Zone	1.09	2.20	2.02
Alakhnanda valley Submergence Zone	1.09	2.05	1.88
Bhagirathi valley Influence Zone	1.11	2.02	1.83
Bhagirathi valley Submergence Zone	1.14	1.98	1.74

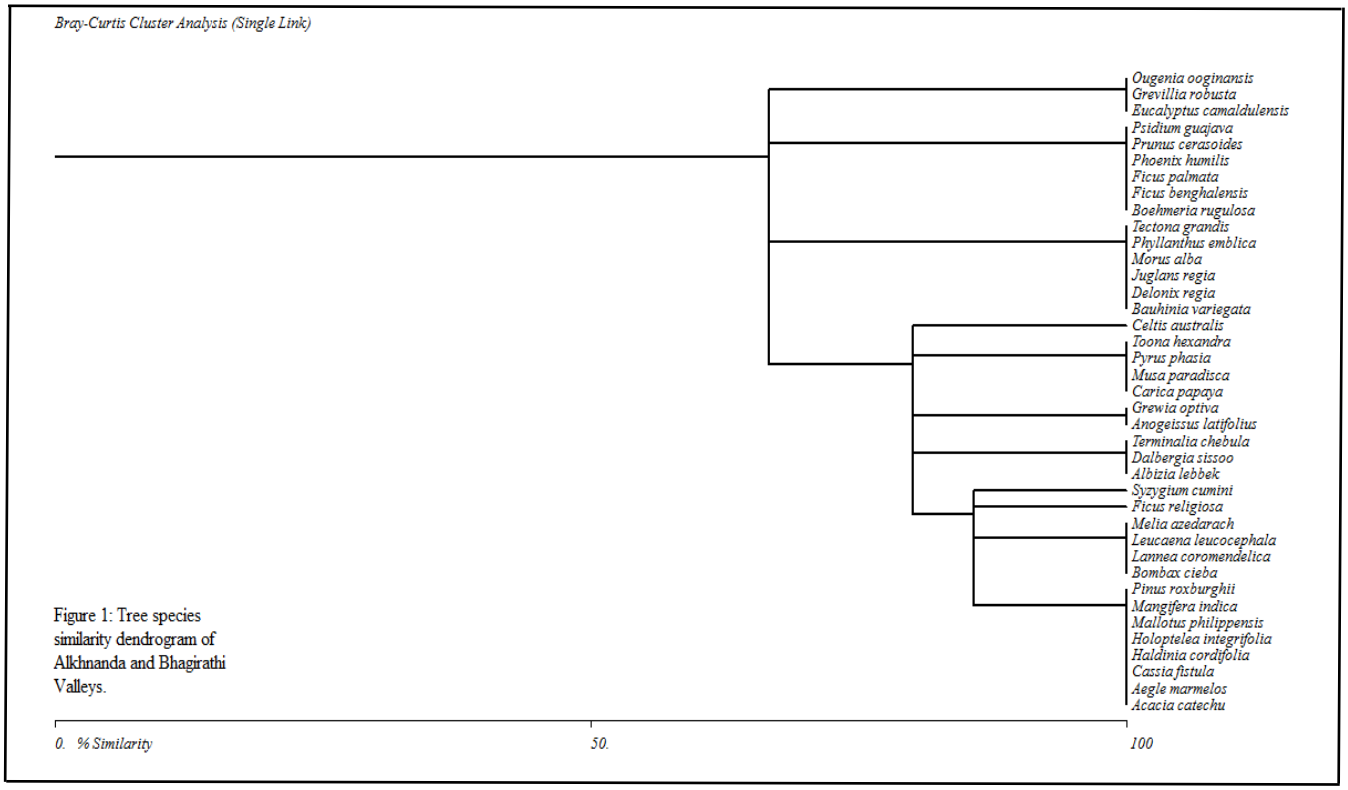

Figure 1: Tree species similarity dendrogram of Alkhnanda and Bhagirathi Valleys.

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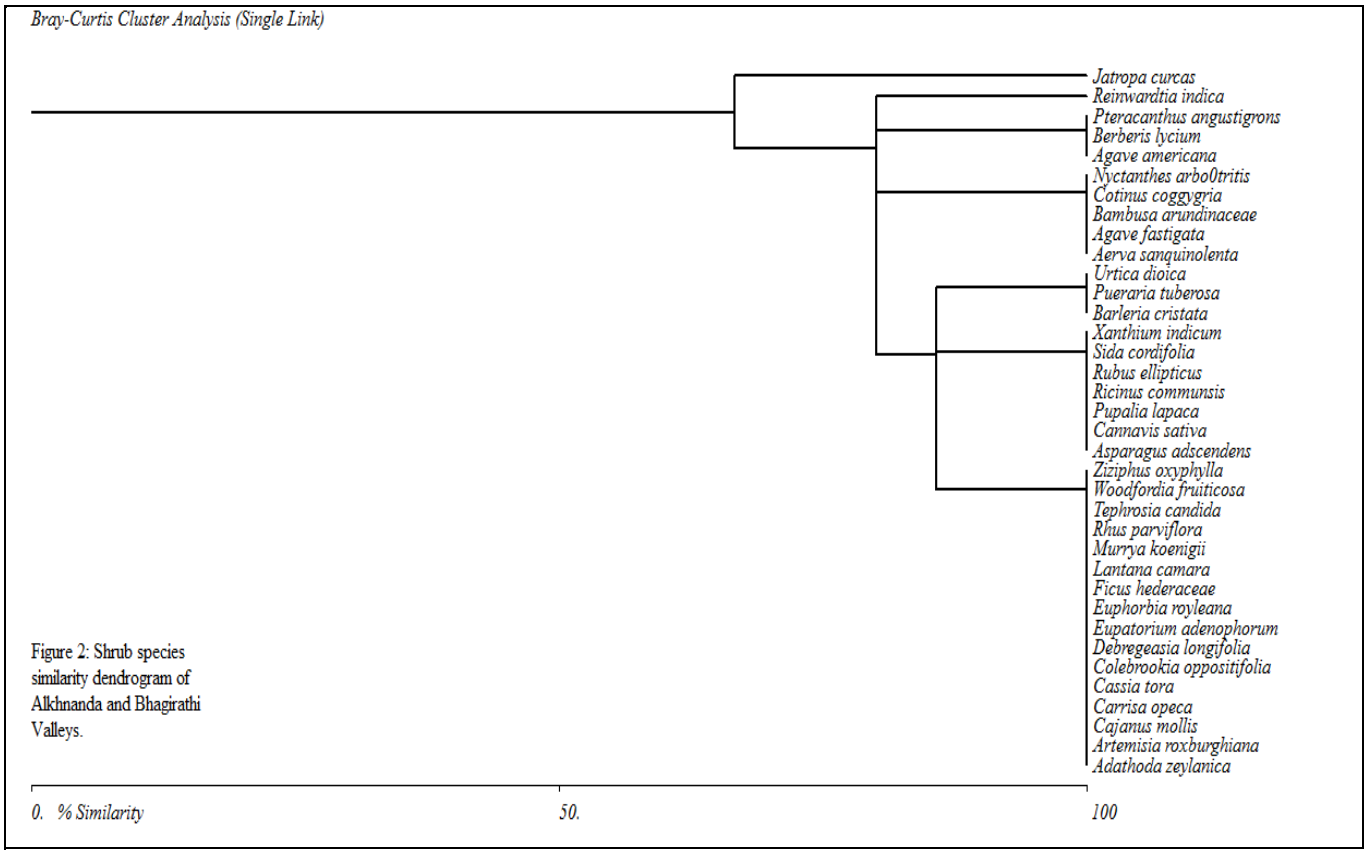

Figure 2: Shrub species similarity dendrogram of Alkhnanda and Bhagirathi Valleys.

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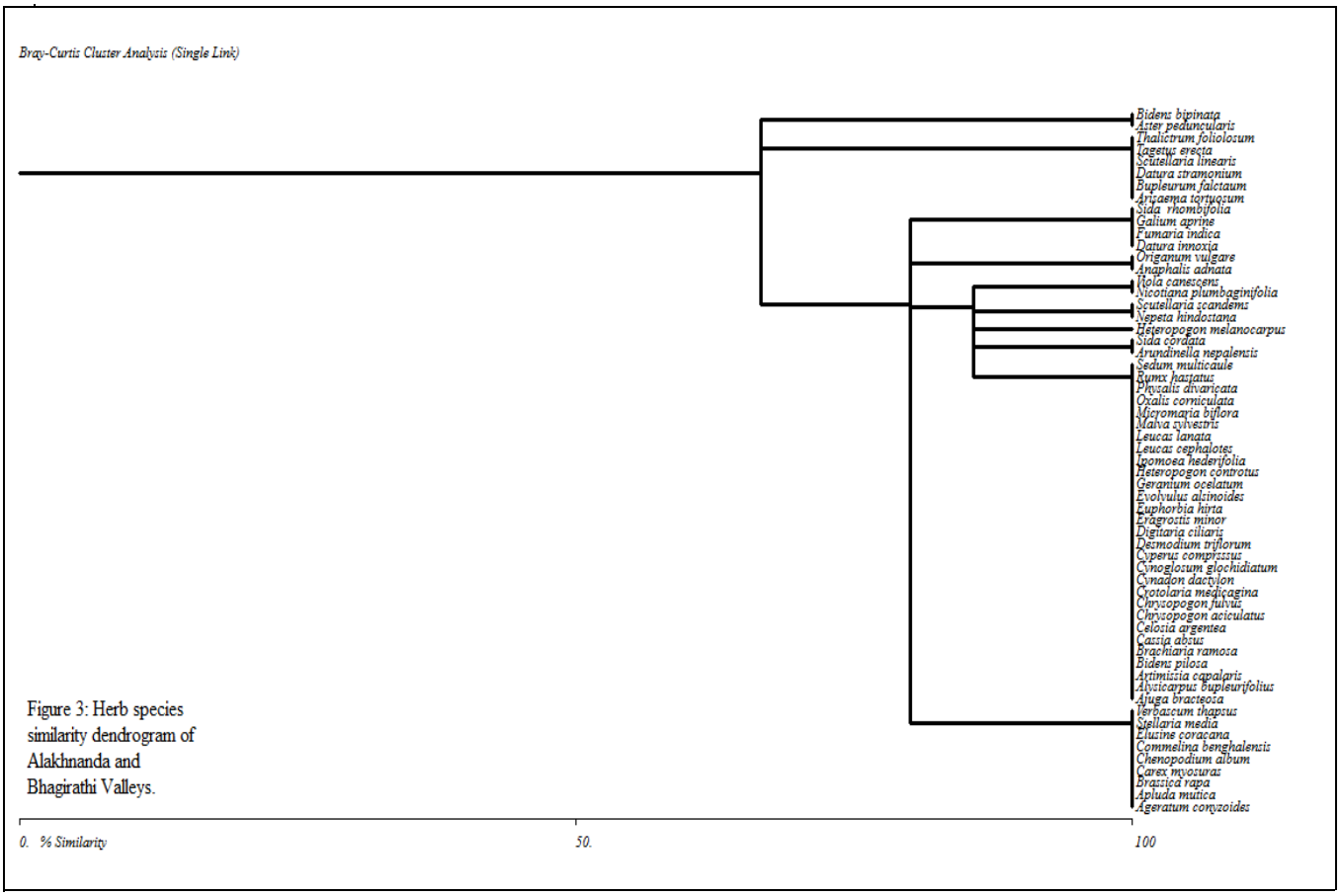

Figure 3: Herb species similarity dendrogram of Alakhnanda and Bhagirathi Valleys.

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IV. Conclusion

Comparing both of the valleys, tree species richness was high at the submergence zone of Bhagirathi valley. Number of shrub was higher at the influence zone of Alaknanda valley. While herb species richness was observed higher at Bhagirathi valley. In both valleys the vegetation composition both valleys was found almost in similar pattern, though species richness was greater in the Influence zone. Hence, it may be hypothesized that after construction of proposed hydropower projects there may be negligible effect on the species richness of the surrounding vegetation, but definitely a significant portion of the vegetation is going to be lost forever. All the plant species as well as their surrounding diversity are, in order to protect the whole range of biodiversity, these plant communities need to be conserved.

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