Forest Research
Open Access

Saleem and Kumar, Forest Res 2015, 4:1
DOI: 10.4172/2168-9776.1000137

Research Article Open Access

Species Composition, Distribution Pattern and Soil Properties in Influenced Zone of Srinagar Hydroelectric Project of Garhwal Himalaya, India

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Abstract

The aim of the present study was to understand species composition, distribution pattern and soil characteristics in the influenced zone of hydroelectric project of Srinagar Garhwal Himalaya. The physical (soil moisture, texture, water holding capacity, bulk density) and chemical (soil pH, soil organic carbon, phosphorus, potassium) properties of soil was estimated using standard procedures. Vegetation analysis was carried out by using 10 quadrats on each site, of a size 10×10 m^2 for trees, 5×5 m^2 for shrubs and 1×1 m^2 for herbs. The results showed that average moisture content, water holding capacity and bulk density of the zone reported 7.26%, 30.26% and 1.47 g m^{-3} respectively. The average value of soil pH was 7.32 which was slightly basic, however, average value of Soil Organic Carbon (SOC) was 0.24%, which reduced with increasing soil depths in each site. The average values of phosphorus (P) and potassium (K) reported 13.06 kg ha^{-1} and 104.21 kg ha^{-1} respectively. In tree, shrub and herb layers all the species were distributed contagiously in all sites. The average values of diversity reported were H=2.65 (trees), H=2.70 (shrubs) and H=3.18 (herbs). The average values of Concentration of Dominance (CD) for trees, shrubs and herbs were reported of CD=0.22, CD=0.22 and CD=0.15 respectively.

The results of the study indicated that influenced zone in present form rich in soil and plants resources and providing many requirements i.e., fuel, fodder, minor timber, medicinal and religious purposes to the villagers.

Keywords: Influenced zone; Forest composition; Distribution pattern; Hydroelectric project

Introduction

The river Alaknanda originates in the glacial region (Alkapuri glacier) of Himalaya in the district Chamoli of Uttarakhand state and enters in district Pauri Garhwal. The human influence on biodiversity and ecosystem functioning have largely taken in the form of rapid, large and frequent changes in land and resource use, increased frequency of biotic invasion, reduction in species number, creation of stresses and the potential for changes in climatic systems [1]. Such changes have a direct impact through habitat destruction and over exploitation of resources affect biodiversity [2] of that particular place. Gauthier et al. [3] described that the vegetation dynamics of forest systems are controlled by numerous factors such as the available pool of species, the physical characteristics of the land, soil fertility, climate and disturbance regime characteristics. Anthropogenic disturbances occur in chronic form involving removal of a small amount of biomass at any given time, but persisting all the year, without any respite for recovery [4].

Depletion of biodiversity is today's alarming problem all over the world. Extinction rate has been enhanced by human intervention resulting into habitat loss and climate change. Many species have eliminated from areas dominated by human influences [5]. The loss of biodiversity actually hampers and contrasts economic development [6], is an alarming problem of the world. The rate of extinction has been enhanced by human-related habitat loss and climate change [7]. Dam constructions in Himalayan rivers are considered one of the major sources of economy generation and fulfil the need of country's electricity. Although construction of dams are affecting the biodiversity of surrounding areas and also affecting needs of local villages which are closely linked with biodiversity for several daily requirement . It has been observed that in the several areas, local forest community are the source of different needs to the local villagers including their culture attachment.

Keeping in view the importance of biodiversity, the resources used by local villagers and their consequent losses due to human activities especially for dam constructions, the present study was taken with the aim to assess the vegetation and soil resources in influenced zone of Hydroelectric Project in Srinagar valley with the following objectives that:

i) Estimation of soil attributed of the influenced zone.

ii) Forest composition and distribution pattern of species in the influenced zone.

iii) Documentation the resources used by the local inhabitant.

iv) Consequences of anthropogenic pressure on inhabitant future requirement.

Materials and Methods

Study area

The soil and vegetation study in influenced zone of hydroelectric

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Received October 22, 2014; **Accepted** January 09, 2015; **Published** january 15, 2015

Citation: Saleem S, Kumar M (2015) Species Composition, Distribution Pattern and Soil Properties in Influenced Zone of Srinagar Hydroelectric Project of Garhwal Himalaya, India. Forest Res 4: 137. doi:10.4172/21689776.1000137

was carried out between the villages of Supana and Dhari Devi which cover the distance of approximately 12 km. The study was done in the right side forest area between the selected villages towards the stream flow. The area falls under sub-tropical region. The area is located between 30^0 14.472′ N latitude and 78^0 49.953′ E longitude at an elevation ranges between 535-630 m. The total height of dam is expected 93 m (submergence zone) which is marked from the initial river flow (winter season) at an elevation 535 m above sea level and the study was taken above the area of 100 m from 535 to 635 (Figure 1).

Climate and vegetation

The climate of the study area is of monsoon type and has three

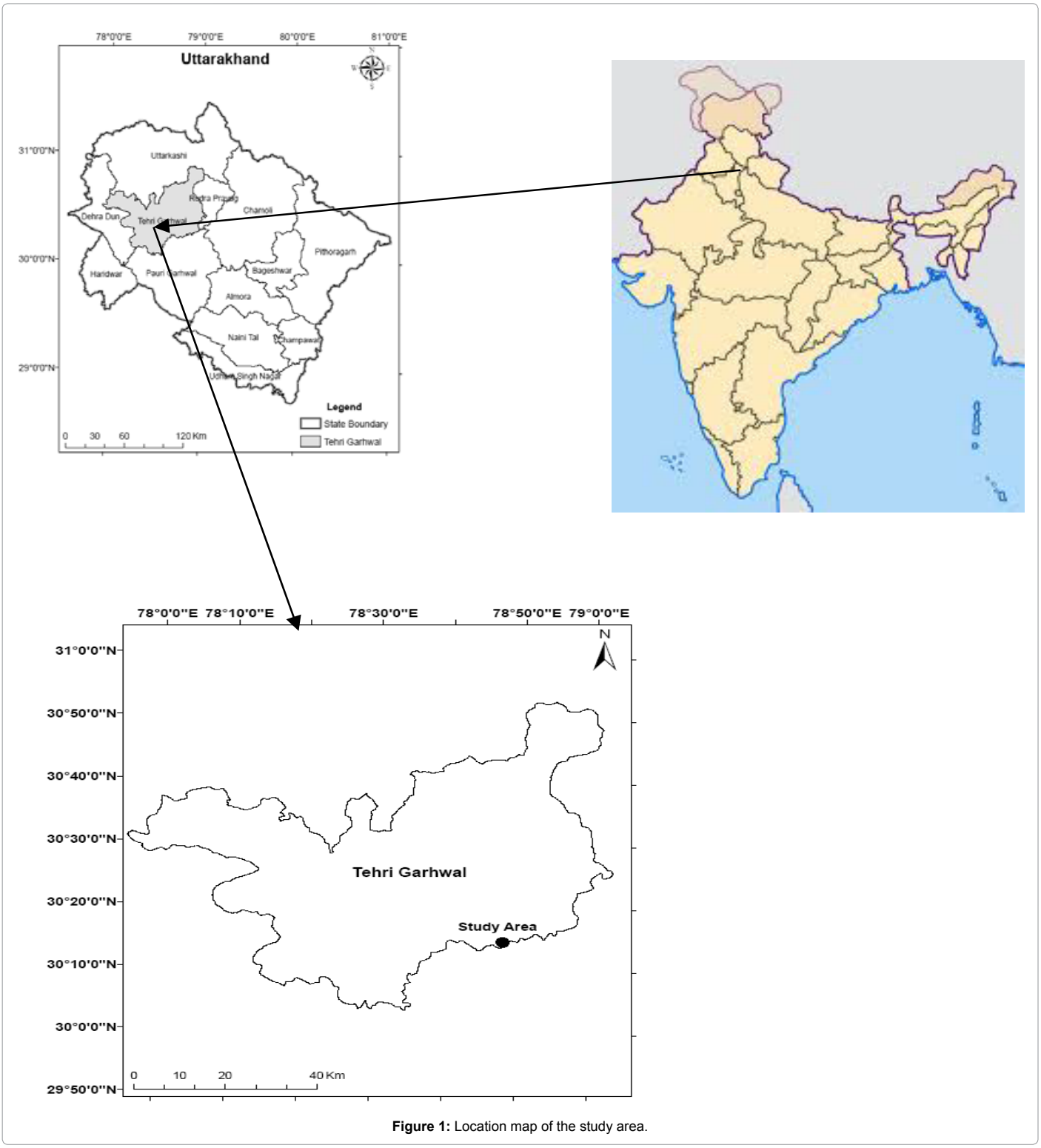

Figure 1: Location map of the study area.

different marked seasons in a year, viz.; rainy, winter and summer. The mean annual temperature ranges between 17°C to 23°C and the mean annual rainfall 960 mm. In tree layer the dominant species observed was *Anogeissus latifolia* with associated species of *Lannea comandelica Mallotus philippensis Aegle marmelos* however, in shrub layer dominant species reported *Adhatoda vasica* and other associated species were *Lantana camara Randia, tetrasperma Rhus parviflora*. The cropping pattern was both rain fed and irrigated. The main occupation of the villages is agriculture with small land holding.

Soil sampling

The soil sampling in the influenced zone was done based on sites selection. The total area was categorized for sampling into five sub-sites based of variability observed in the vegetations pattern in influenced zone. The soil analysis was done by collecting three samples randomly from each site using two different depths i.e. 0-30, 30-60 cm. Thus, from entire five sites and two depths of influenced zone, total 30 samples were collected for analysis.

Soil analysis

The soil samples were mixed well before use. The samples were air dried at 20 to 25°C and 20% to 60% relative humidity [8] for further use. Moisture percentage was calculated by samples placed in oven at 100 ± 2°C till their successive weights constant. Water Holding Capacity (WHC) and texture% of soil was determined according Misra [9]. Bulk Density (BD) of soil was determined by taking known volume of soil without disturbing the natural soil structure, dried to remove the water and weight the dry mass. Soil (1:2.5, soil: water) suspension was used to measure pH with the help of dynamic digital pH meter. Soil Organic Carbon (SOC) was determined by Walkley and Black's rapid titration method [10]. Exchangeable phosphorus (P) and available potassium (K) was determined as methods described by Jackson [8].

Vegetation sampling and analysis

The vegetation analysis was done by using fifty (50) quadrats from entire influenced zone. A total of 10 randomly placed quadrats were used in each sub-sites, each a size of 10×10 m^2 for trees, 5×5 m^2 for shrubs and 1×1 m^2 for herbs. The size and number of quadrats were determined based on species area curve [9] and the runnings mean methods [11]. In each quadrat, tree ≥30 cm girth (at 1.37 m from the ground) was considered.

In case of trees Importance Value Index (IVI) was calculated as sum of the relative frequency + relative density + relative dominance [12] however, the herbs only Importance Value (IV) was calculated as sum of relative frequency + relative density. Abundance to frequency ratio (A/F ratio) was determined for different species as regular (<0.025), random (0.025-0.05) and contagious (>0.05), as follows [13]. Diversity index (H) was calculated as method described by Shannon and Wiener [14], as: $H' = -\Sigma (Ni/N) \log_2 (Ni/N)$, where 'Ni' is total number of species 'i' and 'N' is the number of individuals of all species in that site. Concentration of Dominance (CD) was also calculated as per Simpson [15], as: $CD=\Sigma (Ni/N)^2$, where 'Ni' and N is the same as Shannon and Wiener information index.

Dominance-Diversity (D-D) curve for trees and shrubs plotted between importance value index and species rank of trees (Figure 2) and shrubs (Figure 3). The curves indicate relationship among different species which shows their importance value of the site. The flora of Chamoli [16] and Flora of Western Himalayas [17] were consulted for the identification of species. The details of species, their uses and part used for different purposes is based on secondary data Table 1.

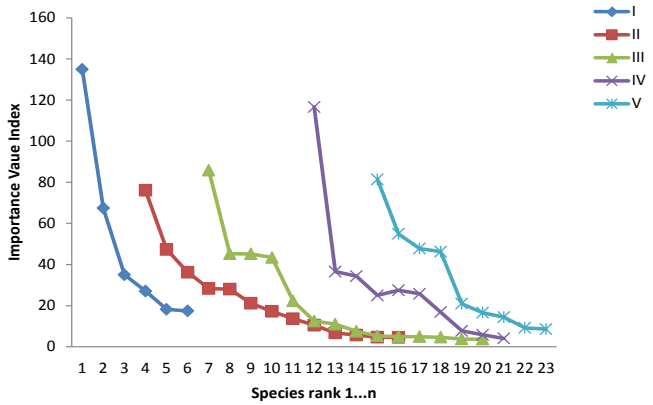

Figure 2: D-D curve of trees (IVI and species rank 1…n) on different sites.

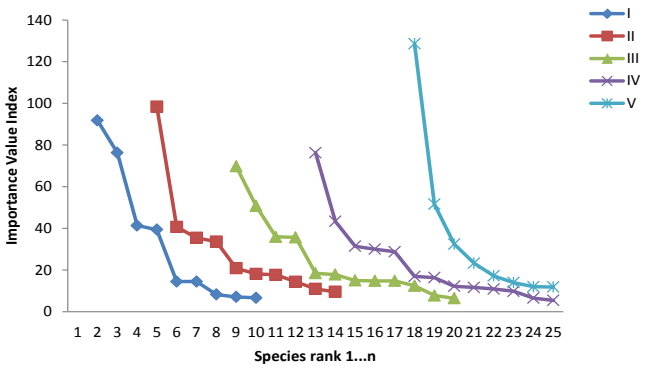

Figure 3: D-D curve of shrubs (IVI and species rank 1...n) on different sites.

Results and Discussion

Soil characteristics

The moisture content of the soil among the sites was highest on site-I followed by site-V, site-III, site-IV and lowest on site-II. The water holding capacity was highest on site-III and lowest on site-IV. The bulk density was reported highest on site-IV followed by site-II, site-V and lowest on site-III. In the texture%, maximum proportion was contributed by sand particles in all sites, however, silt was lowest on site-I, site-II and site-IV and clay reported lowest on site-III and site-I. (Table 2) A study carried out by Kumar et al. [18] in the *Anogessius latifolia* of this region, reported the range values of SOC phosphorus and potassium were from 0.47 to 0.68%, 9.67 to 10.56 kg ha^{-1}, 141.87 to 172.48 kg ha^{-1} respectively. The values of SOC and potassium of present study was lower than Kumar et al. [18] which might be due to biotic pressure and disturbances created on vegetation by dam construction activities.

Community structure and distribution pattern

Site-I: On this site, 6 trees, 9 shrubs and 15 herbs were reported. Among the trees, *Anogessius latifolia* was most dominant and *Leucena leucocephala* least dominant. The total basal cover, frequency and density were also highest for *Anogeissus latifolia*. Other associated species shown in Table 3. The distribution pattern of *Acacia catechu* and *Adina cordifolia* was contagiously and other species were distributed randomly except *Delonix region* which was distributed regularly (Table 4). In shrubs, the most dominant was *Mimosa himalayana* and least dominant *Agave americana*.. The highest total

Tree Species	Family	Status	Life form	Uses	Part used	Ailment
Acacia catechu (L.f.) Willd.	Mimosaceae	Fairly Common	T	Medicinal	Bark	Diarrhoea Dysentery Bronchitis Menstrual disorders
Adina cordifolia (Roxb.) Hook.f. ex Brandis	Rubiaceae	Common	T	Medicinal, Construction Furniture, Agricultural implements	Bark Roots	Diabetes Dysentery
Abrus precatorius L.	Fabaceae	Common	S	Medicinal	Roots Seed Powder and Paste	Bone fracture Oboritifacient Fever, Cough Rheumatic Arthritis Dysentery
Achyranthes aspera L.	Amaranthaceae	Fairly common	H	Medicinal Beverage	Roots Leaf	Malarial fever Dropsy Bronchitis
Adhatoda vasica Nees	Acanthaceae	Fairly Common	S	Medicinal Vegetable	Roots, Leaves Flowers	Cough, Cold Pulmonary infections Bronchitis and Fever
Adiantum incisum Forsk	Adiantaceae		H	-	-	-
Aegle marmelos (L.) Corr.	Rutaceae	-	T	Medicinal	Fruit Pulp	Digestive disorders
Aerva sanguinolenta (L.) Blume	Amaranthaceae	Common	S	Medicinal	-	Diuretic and Demulcent
Agave americana L.	Agavaceae	Common	S	Wicker works, planted in places to check soil erosion and Land slides		
Andropogon munroi C.B Clarke	Poaceae	Not common	H	Fodder	-	-
Anisochilus carnosus (L.f.) Wall. ex Benth	Lamiaceae	Fairly common	H	Medicinal	Plant extract	Cough Cold
Anogeissus latifolia (Roxb. ex DC.)	Combretaceae	Common	T	Construction Agricultural implements Tannin Black dye	-	-
Asparagus racemosus Willd.	Liliaceae	-	H	Medicinal	Roots	Antiseptic and Refrigerant
Barleria cristata L.	Acanthaceae	Fairly common	H	Medicinal Beverage	Roots Leaves	Bronchitis Pneumonia Wound Swelling
Barleria strigosa Willd.	Acanthaceae	Common	H	Medicinal Apiculture	Roots	Cough
Bauhinia variegata L.	Caesalpiniaceae	Common	T	Medicinal, Construction Agricultural implements	Dried Leaves	Cough
Bidens pilosa L.	Asteraceae	Common	H	Medicinal Fodder	Plant extract	Cough Bronchitis Leucoderma
Bombax ceiba L.	Bombacaceae	Common	T	Flower buds as Vegetables, Medicinal, Packing cases	Stem (Gum exude)	Aphrodisiac and Digestive disorders
Cannabis sativa L.	Cannabaceae	Common	H	Ropes, Sacs, fuelwood, Seeds as condiment and leaves and flowers as intoxicating agents		
Cynoglossum zeylanicum Thunb. ex Lehm.	Boraginaceae	Common	H	Medicinal	Leaf decoction	Bronchitis and Asthma
Delonix regia (Bojer ex Hook. F.) Rafin.	Caesalpiniaceae		T	Stem yields Fibre for pulp		
Evolvulus alsinoides L.	Convolvulaceae	Common	H	Medicinal	Plant extract, Leaf powder and flower extract	Tonic, Cough and Cold, Chronic bronchitis and Asthma
Launaea acaulis (Roxb.) Babcock ex Kerr.	Asteraceae	Common	H	Medicinal	Root juice	Diarrhoea (Infants)
Oropetium thomaeum (L.f.) Trin.	Poaceae	Common	H	-	-	-
Solanum verbascifolium auct. Non. L.	Solanaceae	Common	H	Medicinal	Roots , Leaves and Fruits	Wounds and burns, Urinary troubles and Skin Diseases
Borreria articularis (L,f.) F.N Williams	Rubiaceae	Common	H	Medicinal	Seeds Leaves	Diarrhoea, Dysentery Haemorrhoids
Carissa opaca Stapf ex Haines	Apocyanaceae	Frequent	S	Edible	-	-
Cassia fistula L.	Caesalpiniaceae	Common	T	Medicinal	Bark Fruit pulp	Antiseptic, Asthama, Bronchitis, Skin Diseases
Chenopodium album L.	Chenopodiaceae	Common	H	Vegetable	-	-
Cissampelos pareira L.	Menispermaceae	Common	H	Medicinal	Leaves Roots	Constipation Gastric troubles, Psychotherapy Cough Urinary troubles
Colebrookia oppositifolia J.E. Smith	Lamiaceae	Common	S	Medicinal	Leaf	Wounds

Cryptolepis buchananii Roem. and Schult.	Asclepiadaceae	Frequent	H	-	-	-
Cymbopogon martinii (Roxb.) Wat.	Poaceae	Common	H	-	-	-
Cynodon dactylon (L.) Pers.	Poaceae	Common	H	Medicinal	Roots	Fever and Internal injury
Debregeasia longifolia (Burm.f.) Wedd.	Urticaceae	Common	H	Fodder and Fibre	-	-
Emblica officinalis Gaert.	Euphorbiaceae	-	T	Medicinal Tannin	Fruit	Source of Vitamin C
Eupatorium adenophorum Spreng.	Asteraceae	Common	S	Medicinal	Leaves	Wounds
Euphorbia hirta L.	Euphorbiaceae	Common	H	Medicinal	Plant extract	Bronchial infection Asthama
Euphorbia royleana Boiss.	Euphorbiaceae	Fairly Common	S	Medicinal	Latex	Antiseptic and Germicidal
Ficus benghalensis L.	Moraceae	Fairly Common	T	Medicinal, Tent Poles Cart Yokes, Boats	Latex	Antidiabetic
Ficus religiosa L.	Moraceae	Common	T	Medicinal, Charcoal and Packing Cases	Bark Figs	Bronchitis and Skin ailments
Gnaphalium luteo-album L.	Asteraceae	Common	H	-	-	-
Grewia opositifolia Buch.-Ham. ex D. Don	Tiliaceae	Common	T	Medicinal and Edible Ropes, Nets, Sacs Brushes and brooms	Fruit	-
Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae	Abundant	T	Medicinal, Charcoal Construction and Fuel	Bark	Rheumatic Pain
Ipomoea nil (L.) Roth	Convolvulaceae	Common	H	Medicinal	Decoction of seeds	Fever Constipation
Lamium amplexicaule L.	Lamiaceae	Fairly common	H	-	-	-
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	-	T	Medicinal, Tannin Fuel, Fodder and Agricultural Implements	Bark	Diarrhoea
Lantana camara L.	Verbenaceae	Common	S	Medicinal and Fuel	Leaves	Insecticidal, Germicidal and Skin Ailments
Leptadenia reticulata (Retz.) Wight and Arn.	Asclepiadaceae	Rare	H	Medicinal	Leaves Roots and Plant extract	Skin ailments Antiseptic and Useful to control abortion
Leucaena leucocephala (Lam.) De Wit.	Mimosaceae	Not uncommon	T	Planted for soil conservation	-	-
Mallotus philippensis (Lam.) Muell.-Arg.	Euphorbiaceae	-	T	Dye, Anthelmintic, Purgative, Fuel and Match Boxes	-	-
Mangifera indica L.	Anacardiaceae	Abundant	T	Medicinal Edible and Construction	Bark, Seeds and Resin	Haemorrhage and Diarrhoea
Mimosa himalayana Gamble	Mimosaceae	Common	S	Medicinal and Fodder	Leaves	Cough, Cold Bronchitis and Urinary Complaints
Murraya koenigii (L.) Spreng.	Rutaceae	Common	S	Medicinal Flavouring	Bark, Leaves Roots	Insecticide and Pisicide
Nepeta hindostana (Roth.) Haines	Lamiaceae	Common	H	Medicinal	Plant extract	Cardiac tonic Fever and Gonorrhoea
Oxalis corniculata L.	Oxalidaceae	Common	H	Vegetable	-	-
Parthenium hysterophorus L.	Asteraceae	Common	H	-	-	-
Peristrophe bicalyculata (Retz.) Nees	Acanthaceae	Common	H	Medicinal	Plant paste	Wounds
Plumbago zeylanica L.	Plumbaginaceae	-	H	Medicinal	Roots	Skin diseases Wounds
Poa annua L.	Poaceae	Common	H	-	-	-
Randia tetrasperma (Roxb.) Poir.	Rubiaceae		S	-	-	-
Reinwardtia indica Dumort.	Linaceae	Common	H	Apiculture and Mouth wash	Petals	Mouth wash
Rhus parviflora Roxb.	Anacardiaceae	Abundant	S	Medicinal Edible and Fuel	Leaves	Cholera
Ricinus communis L.	Euphorbiaceae	-	S	Castor oil	Seeds	Purgative and Laxative
Rubia manjith Roxb. ex Fleming	Rubiaceae	Common	H	Medicinal and Dye	Roots, Stem Flowers	Tonic, Astringent and Bacillary dysentery
Sida acuta Burm.f.	Malvaceae	Common	H	Medicinal and Fibre	Leaves Roots Stem	Demulcent Diuretic and Leucorrhoea

Sida cordifolia L.	Malvaceae	Common	H	Medicinal and Fibre	Roots Seed powder	Astringent, Diuretic, Tonic and Dyspepsia
Solanum nigrum L.	Solanaceae	Common	H	Medicinal and Edible	Fruit Plant extract	Liver, Piles Dysentery Diarrhoea, Fever Eye ailments
Thysanolaena maxima (Roxb.) O. Kuntze	Poaceae	Common	H	Fodder and Brooms	-	-
Toona ciliata M. Roem.	Meliaceae	Common	T	Construction Furniture and Dye	-	-
Tridax procumbens L.	Asteraceae	Common	H	Medicinal and Vegetable	Plant paste	Wounds and Cuts
Woodfordia fruticosa (L.) Kurz	Lythraceae	Common	S	Medicinal and Dye	Leaves Bark and Dried flowers	Febrifuge, Tonic and Haemorrhoids
Ziziphus mauritiana Lam.	Rhamnaceae	Fairly Common	S	Edible, Construction, Agricultural implements ,Apiculture	-	-

Table 1: Plant species, part used and uses in influenced zone of hydroelectric project. T: Tree, S: Shrub, H: Herb.

Site	Depth (cm)	Moisture (%)	WHC (%)	BD (g cm^3)	Sand (%)	Silt (%)	Clay (%)	PH	SOC (%)	Phosphorus (kg/ha)	Potassium (kg/ha)
Site-I	0-30	9.20 ± 2.88	32.29 ± 2.85	1.34 ± 0.27	68.91 ± 11.53	14.15 ± 4.65	16.93 ± 6.89	7.2 ± 0.1	0.22 ± 0.08	11.75 ± 2.22	139.26 ± 16.09
	30-60	9.14 ± 3.43	29.08 ± 1.24	1.40 ± 0.43	70.14 ± 12.20	13.08 ± 4.63	16.78 ± 8.00	7.5 ± 0.21	0.13 ± 0.02	7.31 ± 1.04	68.69 ± 14.00
Site-II	0-30	6.07 ± 1.81	28.64 ± 1.34	1.56 ± 0.03	64.29 ± 2.78	14.33 ± 3.30	21.38 ± 0.56	7.2 ± 0.17	0.27 ± 0.09	14.01 ± 2.75	128.8 ± 16.50
	30-60	4.10 ± 0.81	34.50 ± 0.80	1.53 ± 0.08	64.67 ± 4.90	14.87 ± 4.16	20.46 ± 3.05	7.7 ± 0.15	0.13 ± 0.06	6.31 ± 0.62	183.68 ± 14.62
Site-III	0-30	8.39 ± 3.14	33.50 ± 0.90	1.24 ± 0.19	58.78 ± 12.21	20.81 ± 8.10	20.41 ± 6.18	7.0 ± 0.25	0.31 ± 0.05	40.85 ± 4.27	143.36 ± 27.50
	30-60	7.53 ± 2.14	35.23 ± 2.66	1.21 ± 0.18	58.24 ± 8.69	20.34 ± 5.84	21.42 ± 5.46	7.5 ± 0.35	0.12 ± 0.01	6.91 ± 1.49	56.093 ± 11.24
Site-IV	0-30	5.25 ± 2.17	25.22 ± 2.66	1.74 ± 0.11	67.91 ± 7.78	13.06 ± 1.55	19.03 ± 6.48	7.0 ± 0.15	0.36 ± 0.08	16.18 ± 5.57	150.08 ± 10.26
	30-60	5.88 ± 2.27	26.82 ± 2.34	1.82 ± 0.12	71.26 ± 10.04	12.84 ± 3.37	15.90 ± 6.70	7.4 ± 0.2	0.47 ± 0.02	8.58 ± 2.63	54.51 ± 6.17
Site-V	0-30	9.14 ± 2.71	24.07 ± 2.78	1.48 ± 0.30	70.89 ± 4.54	15.30 ± 3.62	13.81 ± 1.98	7.1 ± 0.06	0.28 ± 0.04	12.73 ± 3.98	130.29 ± 10.88
	30-60	7.88 ± 3.23	33.18 ± 1.78	1.32 ± 0.25	70.59 ± 12.26	15.46 ± 5.71	13.94 ± 6.90	7.6 ± 0.21	0.11 ± 0.02	5.92 ± 1.65	53.76 ± 8.89

Table 2: Soil characteristics in different sites of submergence zone of hydroelectric project.

basal cover was of *Mimosa himalayana* and lowest of *Achyranthes aspera*. However the highest density was of *Adhatoda vasica*. All the shrub species were distributed contagiously (Table 4). In herb layer, the highest importance value was *Solanum nigrum* and lowest of *Ipomoea nil*. The highest density was of *Peristrophe bicalyculata* and lowest of *Sida acuta*. Other species reported on the site is shown in Table 5. All the species on this site were distributed contagiously, except *Solanum nigrum* which was distributed randomly (Table 5).

Site-II: A total of 13 trees, 10 shrubs and 10 herbs were encountered on this site. The dominant tree was *Ficus religiosa* and least dominant *Holoptelea integrifolia*. The highest total basal cover and density was reported of *Mangifera indica* and *Anogeissus latifolia* respectively. Other species on the site is shown in the Table 2. The most species of trees on this site were distributed contagiously, three randomly and two regular in distribution (Table 3). In shrub layer *Adhatoda vasica* was the dominant and *Colebrookia oppositifolia* least dominant. The highest total basal cover, density and frequency were reported for *Adhatoda vasica*. The other associated species is shown in Table 5. All the species were distributed contagiously (Table 4). Among the herbs, the highest importance value was of *Andropogon munroi* and lowest of *Lamium amplexicaule*. The other associated species on the site is shown in Table 5.

Site-III: A total of 14 trees were found, *Adina cordifolia* was the most dominant and *Emblica officinalis* least dominant. Among the trees mostly species were distributed contagious, few random and only *Anogeisuss latifolia* was distributed regularly (Table 3). In shrub layer, 12 species were reported, *Adhatoda vasica* was dominant and *Colebrookia oppositifolia* least dominant. However, the highest total basal cover was reported of *Euphorbia royleana* and lowest of *Colebrookia opositifolia*. Among the 21 herbs, *Chenopodium album* was the dominant and *Poa annua* least dominant. All the herbs distributed contagiously. The other associated species of trees, shrubs and herbs have been shown in Tables 3, 4 and 5 respectively.

Site-IV: On this site, total 10 trees, 13 shrubs and 15 herbs reported. *Anogeissus latifolia* was dominant and *Holoptelea integrifolia* least dominant. In the distribution pattern *Mallotus philippensis, Holoptelia integrifolia* and *Lannea coromandelica* were distributed contagious, few species distributed random and were distributed regularly (Table 3). In shrub layer, *Adhatoda vasica* was dominant and *Plumbago zeylanica* least dominant. All the species of shrubs were distributed contagiously (Table 4). In herb layer, the highest importance value was of *Parthenium hysterophorus* and lowest of *Evolvulus alsinoides*. All the species were distributed contagiously (Table 5). The associated species on the site of trees, shrubs and herbs is shown in Tables 3, 4 and 5 respectively.

Site-V: In tree layer 9 species were recorded. The dominant tree was *Anogeissus latifolia* and least dominant *Toona ciliata*. Most of the species were distributed contagiously. *Ficus bengalensis* and *Acacia catechu* were distributed randomly. In shrub layer again 9 species were encountered. The most and least dominant species were *Adhatoda vasica* and *Eupatorium adenophorum*. All the species were distributed contagiously (Table 4). In herb layer, a total of 19 species were reported. Among these species the highest importance value was reported of *Chenopodium album* and lowest of *Oxalis annua*. All the species on this site were distributed contagiously (Table 5). The other associated species of trees, shrubs and herbs is shown in Tables 3, 4 and 5 respectively.

Among the sites, the average tree density and total basal cover of trees was 728 plants ha^{-1} and 25.19 m^2 ha^{-1} respectively. In shrub layer

Species	Site-I			Site-II			Site-III			Site-IV			Site-V		
	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio
Adhatoda vasica	5.9	0.091	0.073	4.2	0.036	0.066	4.7	0.036	0.096	7.2	0.01	0.072	9.4	0.1	0.094
Mimosa himalayana	5.3	0.162	0.053	-	-	-	0.8	0.007	0.2	0.8	0.02	0.8	0.9	0.01	0.225
Murraya koenigii	-	-	-	1.2	0.014	0.133	3.5	0.015	0.071	1.6	0.03	0.1	0.8	0.01	0.8
Carissa opaca	2.9	0.043	0.081	0.4	0.008	0.1	2	0.021	0.125	2.1	0.04	0.233	3.1	0.04	0.124
Abrus precatorius				0.4	0.008	0.4	0.2	0.019	0.2	0.8	0.01	0.8			
Lantana camara	0.5	0.008	0.5	1.8	0.012	0.113	-	-	-	1.2	0.01	0.3	1.8	0.02	0.113
Sida cordifolia	-	-	-	0.3	0.005	0.3	1.2	0.009	1.2	-	-	-	-	-	-
Randia tetrasperma	-	-	-	-	-	-	-	-	-	0.4	0.01	0.1	-	-	-
Euphorbia royleana	1.7	0.112	0.425	0.6	0.007	0.15	1	0.044	0.25	1.1	0.11	0.275	-	-	-
Eupatorium adenophorum	0.8	0.021	0.2	-	-	-	-	-	-	-	-	-	0.5	0.01	0.5
Woodfordia fruiticosa	-	-	-	-	-	-	-	-	-	0.2	0.01	0.2	0.4	0.02	0.4
Ricinus communis	1	0.004	0.111				0.9	0.007	0.1	0.7	0.01	0.077	0.3	0.02	0.3
Plumbago zeylanica	-	-	-	1.2	0.009	0.048	0.3	0.005	0.3	0.2	0.004	0.2	-	-	-
Rhus parviflora	-	-	-	0.8	0.004	0.09				0.5	0.07	0.125	1	0.02	0.11
Ziziphus mauritiana	-	-	-	-	-	-	0.6	0.011	0.6	0.4	0.02	0.4	-	-	-
Colebrookia oppositifolia	-	-	-	0.3	0.004	0.3	0.2	0.004	0.2	-	-	-	-	-	-
Aerva sanguinolenta	-	-	-	-	-	-	1.3	0.007	0.325	-	-	-	-	-	-
Achyranthes aspera	0.5	0.001	0.125	-	-	-	-	-	-	-	-	-	-	-	-
Agave americana	0.4	0.008	0.4	-	-	-	-	-	-	-	-	-	-	-	-

Table 3: Density (Ind. ha^{-1}), TBC (m^2 ha^{-1}), A/F ratio of trees on different sites in influenced zone of hydroelectric project.

Species	Site-I			Site-II			Site-III			Site-IV			Site-V		
	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio	Density	TBC	A/F ratio
Adhatoda vasica	5.9	0.091	0.073	4.2	0.036	0.066	4.7	0.036	0.096	7.2	0.01	0.072	9.4	0.1	0.094
Mimosa himalayana	5.3	0.162	0.053	-	-	-	0.8	0.007	0.2	0.8	0.02	0.8	0.9	0.01	0.225
Murraya koenigii	-	-	-	1.2	0.014	0.133	3.5	0.015	0.071	1.6	0.03	0.1	0.8	0.01	0.8
Carissa opaca	2.9	0.043	0.081	0.4	0.008	0.1	2	0.021	0.125	2.1	0.04	0.233	3.1	0.04	0.124
Abrus precatorius				0.4	0.008	0.4	0.2	0.019	0.2	0.8	0.01	0.8			
Lantana camara	0.5	0.008	0.5	1.8	0.012	0.113	-	-	-	1.2	0.01	0.3	1.8	0.02	0.113
Sida cordifolia	-	-	-	0.3	0.005	0.3	1.2	0.009	1.2	-	-	-	-	-	-
Randia tetrasperma	-	-	-	-	-	-	-	-	-	0.4	0.01	0.1	-	-	-
Euphorbia royleana	1.7	0.112	0.425	0.6	0.007	0.15	1	0.044	0.25	1.1	0.11	0.275	-	-	-
Eupatorium adenophorum	0.8	0.021	0.2	-	-	-	-	-	-	-	-	-	0.5	0.01	0.5
Woodfordia fruiticosa	-	-	-	-	-	-	-	-	-	0.2	0.01	0.2	0.4	0.02	0.4
Ricinus communis	1	0.004	0.111				0.9	0.007	0.1	0.7	0.01	0.077	0.3	0.02	0.3
Plumbago zeylanica	-	-	-	1.2	0.009	0.048	0.3	0.005	0.3	0.2	0.004	0.2	-	-	-
Rhus parviflora	-	-	-	0.8	0.004	0.09				0.5	0.07	0.125	1	0.02	0.11
Ziziphus mauritiana	-	-	-	-	-	-	0.6	0.011	0.6	0.4	0.02	0.4	-	-	-
Colebrookia oppositifolia	-	-	-	0.3	0.004	0.3	0.2	0.004	0.2	-	-	-	-	-	-
Aerva sanguinolenta	-	-	-	-	-	-	1.3	0.007	0.325	-	-	-	-	-	-
Achyranthes aspera	0.5	0.001	0.125	-	-	-	-	-	-	-	-	-	-	-	-
Agave americana	0.4	0.008	0.4	-	-	-	-	-	-	-	-	-	-	-	-

Table 4: Density (ind. $25m^2$), TBC (cm^2 25 m^{-2}) of shrubs on different sites in influenced zone of hydroelectric project.

Species	Site-I			Site-II			Site-III			Site-IV			Site-V		
	Density	IV	A/F ratio	Density	IV	A/F ratio	Density	IV	A/F ratio	Density	IV	A/F ratio	Density	IV	A/F ratio
Solanum nigrum	1.15	36.6	0.046	-	-	-	0.65	4.8	0.289	0.45	6.6	0.113	0.4	4.3	0.400
Reinwardtia indica	0.1	3.5	0.400	-	-	-	-	-	-	-	-	-	0.45	5.9	0.200
Parthenium hysterophorus	1	30.4	0.063	-	-	-	2.65	12.6	0.294	8	52.4	0.125	-	-	-
Tridax procumbens	0.6	16.6	0.150	-	-	-	0.3	2.9	0.300	0.85	8.3	0.213	2.95	19.3	0.328
Euphorbia hirta	-	-	-	1.2	36.1	0.133	2	15.5	0.080				1.4	12.2	0.224
Oxalis corniculata	-	-	-	-	-	-	-	-	-	1.25	11.1	0.200	0.1	2.0	0.600
Bidens pilosa	0.75	18.6	0.188	-	-	-	0.15	2.5	0.150	-	-	-	-	-	-
Gnaphalium luteo-album	0.45	12.4	0.200	-	-	-	0.6	5.7	0.150	-	-	-	0.4	2.1	0.600
Peristrophe bicalyculata	1.35	33.1	0.110	-	-	-	0.5	3.3	0.500	-	-	-	-	-	-
Leptadenia reticulata	0.1	3.5	0.400	-	-	-	0.45	3.2	0.450	-	-	-	-	-	-
Andropogon munroi	-	-	-	1.6	42.3	0.178	10.4	32.6	0.650	1.65	11.6	0.413	5.25	30.5	0.328
Barleria strigosa	-	-	-	-	-	-	0.4	3.1	0.400				0.3	2.3	1.000
Nepeta hindostana	-	-	-	-	-	-	-	-	-	0.35	3.8	0.350	0.75	4.2	3.000
Cryptolepis buchananii	-	-	-	0.15	5.2	0.600	0.55	5.6	0.138	-	-	-	-	-	-
Borreria articularis	-	-	-	-	-	-	0.4	3.1	0.400	-	-	-	-	-	-
Debregeasia longifolia	-	-	-	-	-	-	0.8	6.2	0.200	0.75	7.9	0.188			
Poa annua	-	-	-	-	-	-	0.1	1.3	0.400	0.2	2.0	0.800	0.45	4.5	0.450
Blepharis maderaspatensis	-	-	-	0.75	26.2	0.120	-	-	-	-	-	-	0.3	3.4	0.150
Lamium amplexicaule	-	-	-	0.1	4.5	0.400	0.85	6.3	0.213	-	-	-	-	-	-
Chenopodium album	0.3	8.3	0.300	0.9	25.6	0.225	13.2	42.3	0.436	4.4	36.1	0.078	-	-	-
Adiantum incisum	-	-	-	0.8	24.1	0.200	4.75	21.8	0.190	2.4	19.5	0.150	4.1	23.5	0.456
Parthenium hysterophorus				0.6	21.0	0.150							1.15	9.9	0.288
Sida acuta	0.05	2.8	0.200	-	-	-	-	-	-	-	-	-	1.15	11.3	0.184
Thysanolaena maxima	0.55	11.7	0.550	-	-	-	0.25	2.7	0.250	-	-	-	-	-	-
Asparagus racemosus	-	-	-	-	-	-	-	-	-	-	-	-	0.25	5.2	0.111
Cynodon dactylon	-	-	-	-	-	-	2.9	13.2	0.322	1.55	19.5	0.051	0.7	11.1	0.078
Chenopodium album	-	-	-	-	-	-	-	-	-	-	-	-	6.45	37.7	0.258
Barleria cristata	0.3	6.2	1.200	-	-	-	0.95	7.6	0.152	-	-	-	-	-	-
Cissampelos pareira	-	-	-	0.15	8.2	0.150	-	-	-	-	-	-	-	-	-
Ipomoea nil	0.05	2.6	0.200	-	-	-	-	-	-	0.7	6.5	0.311	-	-	-
Rubia manjitha	0.1	3.5	0.400	0.25	6.8	1.000	-	-	-	-	-	-	-	-	-
Anisochilus carnosus	-	-	-	-	-	-	-	-	-	-	-	-	1.2	7.0	1.150
Oropetium thomaeum	0.45	10.3	0.450	-	-	-	-	-	-	-	-	-	-	-	-
Launaea acaculis	-	-	-	-	-	-	0.65	3.7	0.650	-	-	-	-	-	-
Evolvulus alsinoides	-	-	-	-	-	-	-	-	-	0.1	1.6	0.100	-	-	-
Cynoglossum zeylanicum	-	-	-	-	-	-	-	-	-	0.45	5.4	0.200	-	-	-
Cannabis sativa	-	-	-	-	-	-	-	-	-	0.7	7.6	0.175	-	-	-
Solanum verbascifolium	-	-	-	-	-	-	-	-	-	-	-	-	0.2	3.6	0.200

Table 5: Density (ind. m^2), IV (importance Value) and A/F ratio herbs on different sites in influenced zone of hydroelectric project.

the average density and total basal cover values were 16.45 plant 25 m^2 and 0.27 cm^2 25 m^{-2} respectively. A study carried out by Kumar et al. [19], in sub-tropical forests of the Garhwal Himalaya, reported total density and total basal cover ranged from 832 to 884 trees ha^{-1} and 14.30 to 24.83 m^2 ha^{-1} respectively. These values of density were higher than the present study, because the influenced zone is under biotic pressure. Kumar et al. [18] also conducted a study on different aspect of *Anogeissus latifolia* forest, the density ranged for trees from 260 to 380 trees ha^{-1} and density for shrub ranged from 970 to 1790 shrubs ha^{-1}. In this study the values of density were quite lower because of higher biotic pressure especially by the villagers for their daily needs i.e., fuel, fodder, grazing and browsing animals.

Among the vegetation layers, the distribution pattern of trees was contagious, random and regular. Although contagious distribution pattern of the species was common and in shrub layer mostly species were distributed contagiously. While in herbs all the species on all sites were distributed contagiously. Odum [20] stated that contagious distribution is the comments pattern in nature and random distribution found only in very uniform environment and the regular distribution occurs where sever competition between the individuals exist [18,21]. Regular and random distribution pattern of the species reflect the high biotic pressure though grazing and lopping.

Species richness

The richness of trees, shrubs and herbs is shown in Figure 4. The species richness was maximum (14) on site-III and minimum (6) on site-I. In the shrub layer, the highest number of species was on site-IV and lowest on site-I and site-V. A study carried out by Yadav and Gupta [22] in Rajasthan, suggested that anthropogenic disturbances have adverse impact on the woody vegetation. He also suggests that

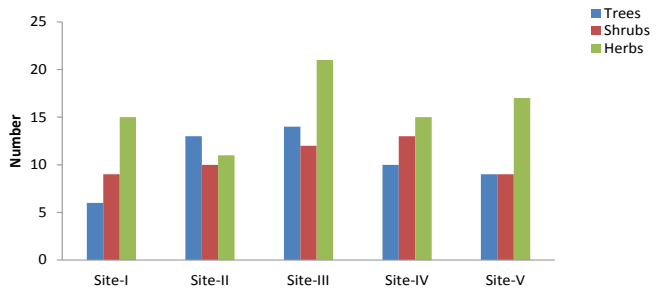

Figure 4: Species richness of trees, shrubs and herbs on different site in influenced zone.

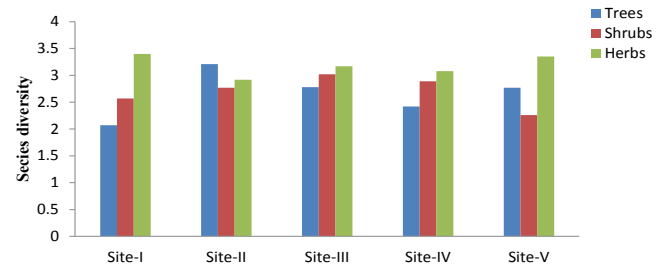

Figure 5: Diversity (H) of trees, shrubs and herbs on different site in influenced zone.

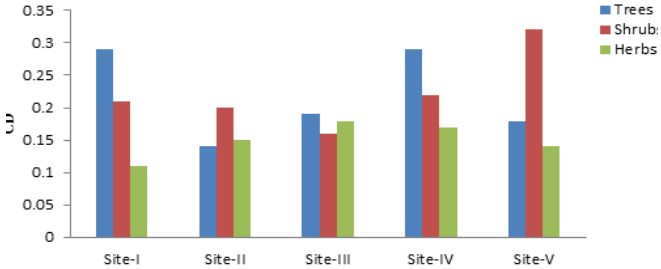

Figure 6: Concentration of dominance (CD) richness of trees, shrubs and herbs on different site in influenced zone.

species richness was higher in undisturbed forest as compared to partially disturbed forest and relatively higher in highly disturbed forest area. Kumar et al. [23] conduct a study in the same site of the dam project for conservation strategies of *Anogeissus latifolia* showed that various disturbance agents such as grazing and browsing, over-exploitation and major dam construction work in this valley is affecting the growth of *Anogeissus latifolia* . The dominant forest cover of this valley area is covered by *Anogeissus latifolia* which is the main source of villager's requirement for fuel, fodder and minor timber which is highly disturbing by developing activities of dam and road construction work. Boring et al. [24] emphasized the positive role of mild disturbances in improving the regeneration of tree. Levin [25] also indicated sever disturbance has deleterious effect on regeneration. Khan et al [26] reported that erosion action of torrential rains on slopes can also cause a decreased in the number of seedling during the rainy season. The long history of human interaction with plants, animals and environmental factors in the mountain region has a significant impact upon the biological diversity at different levels. The topography, soil, climate and geographical location also influenced the vegetation diversity of forest. In modern time Himalayan forest ecosystems have witnessed great natural and biotic disturbances. Yadav and Gupta [22] reported that the number of shrubs reduced with increasing level of anthropogenic disturbance on the forest sites.

Species diversity (H') and Concentration of dominance (CD)

The diversity was highest on site-II (H=3.21) and minimum on site-I (H=2.07). In shrub layer the maximum and minimum diversity was on site-III (H=3.02) and site-V (H=2.26) respectively. In herb layer the highest diversity was on site-I (H=3.4) and minimum (H=2.92) on site-II (Figure 5). Kumar et al. [19] also reported diversity value of 2.76 for the sub-tropical forest of *Anogeissus latifolia* of this region in Garhwal Himalaya. These reported values were within the range of present study. Kumar et al. [18] carried study in *Anogeissus latifolia* forest reported diversity values H=0.846 to 1.710 for trees and H=1.943 to 2.847 for shrubs are within the ranged values of the present study. The CD ranged values for trees, shrubs and herbs were CD=0.14 to 0.29, CD=0.16 to 0.32 and CD=0.11 to 0.18 respectively (Figure 6). Riser and Rice [27] and Knight [28] ranged from CD=0.326 to 0.693 for trees and CD=0.185 to 0.719 for shrubs. These reported values of CD for trees are with the range of present study but shrub values were higher for the present study.

The present study revealed that the collected data information in influenced zone is rich in vegetation and soil resources. Although the developmental activities in the dam is going on and soon after completion of project work the submergence zone will be covered under reservoir which will affect the existed pressure of villagers on influenced zone for several daily needs (fuel, fodder, timber etc). The severe pressure of villagers may affect the vegetation and further degradation of resources for villagers needs in future. The sustainability and efficiency of forest ecosystem being influenced by the hydroelectric projects in river valleys which can be restored by strengthening the knowledge on sustainable plant utilization. Therefore, local communities should aware about the submergence of valuable resources and subsequently pressure increasing in influenced zone, so community awareness may help to conserve the resource for sustainable long term out.

References

1. Bargali K, Bisht P, Khan A, Rawat YS (2013) Diversity and regeneration status of tree species at Nainital Catchment, Uttarakhand, India. International Journal of Biodiversity and Conservation 5:270-280.
2. Heywood VH (1995) Global Biodiversity Assessment. UNEP, Cambridge University press, Cambridge, UK.
3. Gauthier S, Grandpre LD, Bergerony (2000) Differences in forest composition in two Boreal forest eco-regions of Quebec. Journal of vegetation Science 11: 781-790.
4. Singh SP (1998) Chronic disturbance, a principle cause of environmental degradation in developing countries. Environmental conservation.
5. ChapinIII FS, Zavaleta ES, Eviner VT, Naylor RL, Vitousek PM, et al. (2000) Consequences of changing biodiversity. Nature 405: 234-242.
6. Kim KC, Weaver RD (1994) Biodiversity and landscapes. Cambridge University Press, New York, USA, 3-27.
7. Singh JS, Kushwaha SPS (2008) Forest biodiversity and conservation in India. International Forestry Review 10: 292-304.
8. Jackson ML (1958) Soil chemical analysis Prentice Hall, Inc., Engle Wood Cliffs, New Jersey, USA.
9. Misra R (1968) Ecology Work Book, Oxford and IBM Publishing co. Calcutta, 244.
10. Walkley AE, Black JA (1934) An examination of the Degtiga vett. method for determining soil organic matter and proposed modification of the chronic acid titration method. Soil Science 37: 29-38.
11. Kershaw KK (1973) Quantitative and Dynamic Plant Ecology, (2ndedn.) FLBS.

12. Curtis JT (1959) The vegetation of Winconsin. An Ordination of plant communities, University Winconsin Press, Madision Winconsin, 657.

13. Curtis JT, Cottam G (1956) Plant Ecology Work book laboratory field reference manual, Burgers publication co., Minnesota, 193.

14. Shannon CE, Wiener W (1963) The Mathematical Theory of Communication, University of Illinois press, Urbana.

15. Simpson EH (1949) Measurement of Diversity. Nature 163: 688.

16. Naithani BD (1984) Flora of Chamoli. Botnaical Survey of India. Raje Printers, New Delhi.

17. Gaur RD (1999) Flora of the district Garhwal Horth West Himalaya, Transmedia Srinagar (Garhwal), UP, India.

18. Kumar M, Joshi M, Todaria NP (2010a) Regeneration status and plant bio-diversity in a sub-tropical forest of Garhwal Himalaya. Journal of Forestry Research 21: 439-444.

19. Kumar M, Sharma CM, Rajwar GS (2004) A study on the community structure and diversity of a sub-tropical forest of Garhwal Himalayas. Indian Forester 130: 207-214.

20. Odum EP (1971) Fundamentals of ecology, (3rdedn.) Philadelphia: Saunders, 574.

21. Panchal NS, Pandey AN (2004) Analysis of vegetation of Rampara forest in Saurashtra region of Gujarat state of India. Tropical Ecology 45: 223-23.

22. Yadav AS, Gupta SK (2005) Effect of micro-environment and human disturbance on thr diversity of woody species in the Sariska Tiger Project in India. Tropical Ecology 48: 125-128.

23. Kumar M, Sheikh MA, Rajwar GS (2010b) Consevation strategies for Anogeissus latifolia in the Srinagar Valley of Uttarakhand, India. International Journal of Conservation Science 1: 191-198.

24. Boring LR, Monk CD, Swank WT (1981) Early regeneration of a clear-cut southern Appalachian forest. Ecology 62: 1244-1253.

25. Levin SA (1976) Population dynamics models in heterogeneous environments. Annual Review of Ecology and Systematics 7: 227-310.

26. Khan ML, Raj JPN Tripathi RS (1986) Regeneration and survival of tree seedlings and sprouts in tropical deciduous and sub-tropical forests of Meghalaya, India. Forest Ecology and Management 14: 293-304.

27. Risser PG, Rice EL (1971) Diversity in tree species in Oklahoma Upland forests. Ecology 52: 876-880.

28. Knight DH (1975) A phytosociological analysis of species rich tropical forest on Barro Colorado Island, Panama. Ecological Monographs 45: 259-289.