Indian Journal of Ecology (2023) 50(3): 566-574
DOI: https://doi.org/10.55362/IJE/2023/3936

Manuscript Number: 3936
NAAS Rating: 5.79

Structure, Composition and Distribution Pattern of Agroforestry Flora along Altitudinal Gradient in Kirtinagar Block of District Tehri Garhwal, Uttarakhand, India

Atul Negi, D.S. Chauhan and Jitendra Singh

Department of Forestry and Natural Resources
Hemvati Nandan Bahuguna Garhwal University Srinagar Garhwal-246 174, India
E-mail: atulnegiforestry13@gmail.com

Abstract: In this study, we investigated phytosociological attributes of traditional agroforestry systems in Kirtinagar Block of Tehri Garhwal, Uttarakhand, India. The objective of this study was to explore and compare phytosociological attributes along the altitudinal gradient of traditional agroforestry components species. Three different indigenous agroforestry systems *i.e.* agri-silviculture, silvi-pasture and homegarden were selected for documentation of agrobiodiversity through quadrat method. Further, density, frequency, IVI, and abundance-frequency ratio was calculated for each component of agroforestry system. The study reported that *Grewia optiva, celtis australis, Mallotus phillipensis, Citrus sinensis* and *Morus alba* were the most dominant tree species in the area.

Keywords: Agrobiodiversity, Altitudinal gradient, Traditional agroforestry systems, Himalaya

In India, agroforestry has been recognised as a traditional method of land usage and distributed over 11.54 m ha (3.39 %) of the total geographic area of country (FSI 2019). Numerous unsustainable farming, illicit tree felling, conversion of lands, encroachment are the principal factors have led to overexploitation of natural resources. In Indian mountainous regions, the loss of agricultural land attributed to alterations in rainfall patterns, landslides, runoff, nutrient leaching, the drying up of natural springs, and a lack of irrigation facilities has made farming unprofitable and unsubstantial. To address this, agroforestry is considered as an alternative approach to restore the environmental and livelihood security of the region. In such scenarios, integration of trees on farm boundaries, croplands, fallow lands, and village settlement *etc*. provides enhanced tree cover, biodiversity maintenance, improved soil health, delivery of multiple products and carbon sequestration benefits (FAO 2005). There are numerous traditional agroforestry systems in Garhwal Himalaya, Uttarakhand which is in the northern region of India. Under these systems, farmers have been cultivating a wide variety of annual, biennial, and seasonal crops. The fragile environment created by the terraced slopes and scattered agricultural land, which makes it difficult to conduct agricultural activities and even prohibits the annual demand of food grains by households (Kanwal et al 2022). Agroforestry systems are crucial for maintaining farm productivity and production, creating a resilient farming system, and improving livelihoods and employment prospects. Additionally, agroforestry might be a useful technology in regions with subsistence farming and delicate ecosystems. Agroforestry produced a considerable sum of money that is used by the farmers to provide subsistence income for their families. This has a major impact on improving the rural areas' economies (Sangeetha et al 2016).

Traditional agroforestry systems are practiced from many decades, which combines agriculture crops along with the trees species. A significant portion of Garhwal Himalaya constitutes diversified traditional agroforestry systems. The hilly regions of Uttarakhand are primarily consisting of agri-silviculture, agrihorticulture, and agri-silvi-horticulture systems. Each of these agroforestry systems has the potential to store significant amounts of carbon while also producing fuel, fruits, fodder, fibres, and organic fertilisers (Thakur et al 2007, Bijalwan et al 2015). Due to variable terrain and climatic conditions, vegetation is complex in nature, and its structure and composition changes from place to place (Raturi 2012). Vikrant et al (2016) documented traditional agroforestry systems from Tehri Garhwal i.e., Agrisilviculture, Agri-horticulture and Agri-hortisilvicultural system and it consists of total 22 forest tree species, 11 fruit tree species, and 15 crops species in studied area. The identification of available tree species, their compositions, structure, and functions are need of the hour to design the site-specific agroforestry models to address poverty, land degradation and climate change. Therefore, a study was

planned with objective to document the traditional agroforestry systems Kirtinagar Block of Tehri Garhwal.

MATERIAL AND METHODS

The study was conducted in Kirtinagar Block of district Tehri Garhwal (Uttarakhand). The studied Community Development Block covers total of 153 villages and covers an area of about 264.83 km^2, Latitude ranges from 30°12'38" to 30°23'17" North and Longitude ranges from 78° 55'19" to 78°37'15" East. The elevation ranges from 492 m to 2712 m throughout the block from mean sea level (Fig. 1). Three different indigenous agroforestry systems *i.e.* agri-silviculture, silvi-pasture and home garden were selected from 300-1200 m amsl (Lower Altitude) and 1200-2000 m amsl (Upper Altitude) for documentation of agrobiodiversity. Quadrat method was adopted to access the agrobiodiversity, in which 10×10 m, 5×5 m, 1×1 m quadrates were laid out for trees, shrubs, crops and herbs, respectively. Further, density, frequency, Important Value Index (IVI), and abundance-frequency ratio was calculated for each component of agroforestry system. The quantitative analyses for frequency, density, and abundance was done by following methodology developed by Curtis and MacIntosh (1950). Other parameters such as relative frequency, relative density, relative dominance was calculated by following Phillips (1959). The importance value index (IVI) at species level was calculated from the sum of relative frequency, relative density, and relative dominance (Curtis, 1959). The ratio of abundance to frequency is generally used to interpret the distribution pattern of species (Whitford 1949). The ratio of abundance to frequency indicates regular distribution if below 0.025, random distribution between 0.025-0.05 and contagious if it is >0.05 (Curtis and Cottam 1956).

RESULTS AND DISCUSSION

Agri-silviculture: Agri-silviculture system usually comprises of fuelwood and fodder trees, which are grown along the bunds of the farmlands. Total 14 tree, 6 agricultural crops and 6 species of different herbs were found in upper altitudinal zone (1200-2000 m amsl) of study area. Whereas, 13 tree, 8 agricultural crops and 7 species of herbs were found in lower altitudinal (below 1200 m amsl) zone of the study area (Table 1). In upper altitude total tree density was 514 trees/ha, in which *Grewia optiva* had maximum tree density (186 trees/ha) and frequency (85.71), whereas minimum tree density (7 trees/ha) and frequency (7.14) was of *Ficus palmata*. Maximum IVI (94.32) recorded for *Celtis australis* and minimum IVI (3.91) was of *Nyctanthes arbortristis*. *Melia azedarach* had highest abundance frequency ratio of 0.28 and *Ficus roxburghii* had lowest (0.02). In the lower altitudinal zone, the total tree density was 494 trees/ha, out of which *G. optiva* had maximum density (219 trees/ha) and frequency (100). Minimum tree density (6) and frequency (6.25) was of *Ficus hispida*. IVI of *G. optiva* was highest (110.39) and *Ficus cunia* had lowest IVI (3.66) among all trees. The highest and lowest abundance factor was observed for *Morus alba* (0.32) and *Grewia optiva* (0.02), respectively. The similar results were also reported by Manzoor and Jazib (2020). Vikrant et al (2018) found that the major agroforestry systems in same district were dominated by *Grewia oppositifolia*, *Celtis australis* and *Quercus leucotrichophora*.

Among agricultural crops total density was found 1000037/ha in upper altitude, in which *Eleusine coracana* had maximum density (523167), frequency (57.14) and IVI (111.31), while *Cajanus cajan* had minimum density (37038), frequency (7.14) and IVI (19.46). *Oryza sativa* had maximum abundance and frequency ratio (3.64) and *Amaranthus viridis* had minimum A/F (0.10). On the other hand, in lower elevation, crop density/ha was found 125625, in which *Eleusine coracana* had maximum density (46875), frequency (43.75) and IVI (82.13) and *Cajanus cajan* had minimum density (1875), Frequency (6.25) and IVI (10.48). Sesamum indicum had maximum abundance and frequency ratio (1.28) and *Amaranthus viridis* had minimum A/F (0.09). Mahato et al (2016) also found these species prominent in their study.

The total herb density was 80000 individuals/ha in upper altitude in which *Bidens Pilosa* had maximum density (31429), frequency (64.29), and IVI (96.14) and *Euphorbia*

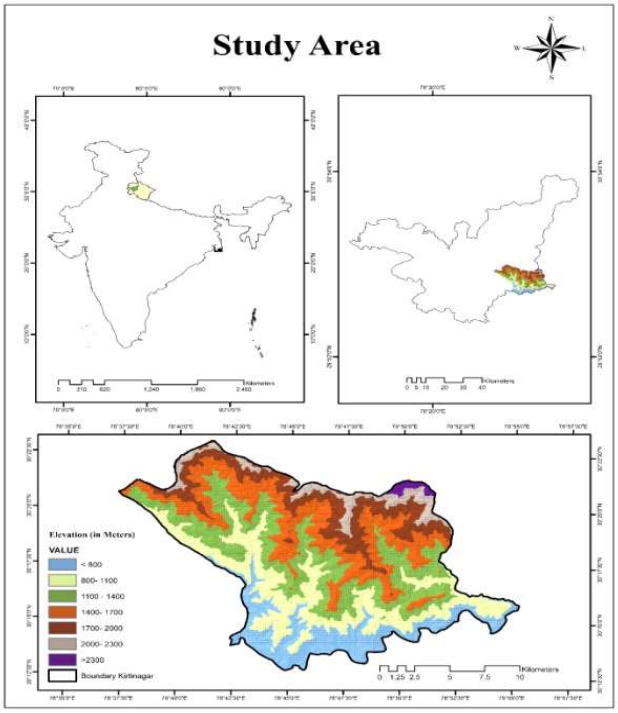

Fig. 1. Digital elevation map of study area

Table 1. Phytosociological attributes of different species in Agrisilviculture system

Trees in Agrisilviculture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Khair	*Acacia catechu*	0	0.00	0.00	0.00	13	12.50	7.67	0.08
Kachnar	*Bauhinia variegata*	21	14.29	11.03	0.11	0	0.00	0.00	0.00
Kharik	*Celtis australis*	136	71.43	94.32	0.03	113	56.25	68.27	0.04
Khinna	*Falconeria insignis*	7	7.14	4.01	0.14	0	0.00	0.00	0.00
Khaina	*Ficus cunia*	0	0.00	0.00	0.00	6	6.25	3.66	0.16
Cluster Fig	*Ficus hispida*	0	0.00	0.00	0.00	6	6.25	9.15	0.16
Dudhila	*Ficus neriifolia*	7	7.14	5.12	0.14	0	0.00	0.00	0.00
Bedu	*Ficus palmata*	7	7.14	3.98	0.14	0	0.00	0.00	0.00
Timla	*Ficus roxburghii*	43	42.86	32.58	0.02	19	18.75	15.23	0.05
Chanchri	*Ficus subincisa*	29	28.57	19.94	0.04	6	6.25	9.16	0.16
Bhimal	*Grewia optiva*	186	85.71	87.83	0.03	219	100.00	110.4	0.02
Subabool	*Leucaena leucocephala*	0	0.00	0.00	0.00	25	18.75	16.35	0.07
Ruina	*Mallotus phillipensis*	0	0.00	0.00	0.00	19	18.75	11.74	0.05
Dainkan	*Melia azedarach*	14	7.14	7.25	0.28	31	25.00	20.08	0.05
Sehtoot	*Morus alba*	21	14.29	9.99	0.11	13	6.25	5.53	0.32
Parijat	*Nyctanthes arbortristis*	7	7.14	3.91	0.14	0	0.00	0.00	0.00
Sandan	*Ougeinia oojeinense*	14	7.14	5.75	0.28	0	0.00	0.00	0.00
Panya	*Prunus cerasoides*	14	14.29	10.10	0.07	0	0.00	0.00	0.00
Asan	*Terminalia elliptica*	0	0.00	0.00	0.00	6	6.25	4.17	0.16
Toon	*Toona ciliate*	7	7.14	4.19	0.14	19	18.75	18.60	0.05
Crop in Agrisilviculture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Marcha	*Amaranthus viridis*	83336	35.71	38.17	0.10	13125	37.50	38.84	0.09
Toor Dal	*Cajanus cajan*	37038	7.14	19.46	1.12	1875	6.25	10.49	0.48
Jhangora	*Echinochloa esculenta*	157413	14.29	48.59	1.19	30000	18.75	63.21	0.85
Koda	*Eleusine coracana*	523168	57.14	111.31	0.25	46875	43.75	82.13	0.24
Geheth	*Macrotyloma uniflorum*	0	0.00	0.00	0.00	6250	12.50	21.20	0.40
Dhan	*Oryza sativa*	120375	7.14	51.99	3.64	0	0.00	0.00	0.00
Till	*Sesamum indicum*	0	0.00	0.00	0.00	5000	6.25	21.79	1.28
Urad	*Vigna mungo*	0	0.00	0.00	0.00	6875	12.50	22.58	0.44
Ranyas	*Vigna umbellata*	78707	21.43	30.49	0.26	15625	31.25	39.77	0.16
Herbs in Agrisilviculture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Billygoat herb	*Ageratum conyzoides*	24286	50.00	78.40	0.10	31875	21.57	66.67	0.21
Kumarr	*Bidens pilosa*	31429	64.29	96.14	0.08	13125	28.57	42.41	0.12
Kana	*Commelina benghalensis*	2857	7.14	22.42	0.56	5000	37.50	33.53	0.07
Ashthma plant	*Euphorbia hirta*	2143	7.14	17.90	0.42	8750	35.71	37.86	0.08
Oxalis	*Oxalis spp.*	7857	14.29	38.46	0.39	16875	11.11	58.03	0.81
Gaajar ghaas	*Parthenium hysterophorus*	0	0.00	0.00	0.00	2500	25.00	29.07	0.16
Yellow Foxtail	*Setaria pumila*	11429	21.43	46.67	0.25	0	0.00	0.00	0.00

hirta had minimum density (2143) frequency (7.14) and IVI (17.90). *Commelina benghalensis* had maximum abundance and frequency ratio (0.56) and *B. Pilosa* minimum A/F (0.08). In lower altitude total density of herbs was 79375 individuals/ha, in which *Ageratum conyzoides* had maximum density (31875) and *Setaria pumila* had minimum density of 1250 individuals/ha. *Setaria pumila* had maximum (50) and *Oxalis species* had minimum (11.11) frequency. *Ageratum conyzoides* had highest (66.66) and *Parthenium hysterophorus* had lowest (29.06) IVI. *Oxalis spp.* had maximum abundance and frequency ratio (0.81) and *Setaria pumila* had minimum A/F (0.04).

Silvi-pasture: In silvi-pastoral system, trees, grasses, shrubs, and herbs were found spread on the uncultivated land. This agroforestry system is being practiced for fuel, fodder and timber. Total 16 tree, 11 grass, 9 shrub and 8 herb species were encountered in upper altitudinal zone of study. On the other hand, 24 tree, 9 grass, 15 shrub and 13 species of herb were found in lower altitudinal zone of the study area (Table 2).

In upper altitudinal zone, total tree density was found 550 individuals/ha in which *Celtis australis* had highest density (143 trees/ha) and frequency (85.71). Whereas, *Melia azedarach* had minimum density (7 trees/ha) and frequency (7.14). Maximum IVI in *C. australis* (82.15) and minimum was of *Morus alba* (3.64). Maximum abundance and frequency ratio was of *Bauhinia retusa* (0.56) and minimum A/F was for *Celtis australis* (0.01). In lower altitudinal zone, total tree density was 569 individuals/ha in which the highest density (81 trees/ha) and frequency (43.75) was of *Mallotus phillipensis* and lowest density (6 trees/ha) and frequency (6.25) was recorded for *Madhuca indica*. IVI, was maximum (34.07) for *M. phillipensis* and minimum (2.95) of *Leucaena leucocephala*. Abundance and frequency ratio was found maximum (0.48) for *Adina cordifolia* and minimum (0.03) was of *Celtis australis*. The phytosociological attributes of *C. australis, G. optiva, Lantana camara* and associated species were recorded are similar to findings of Thakur et al (2004).

Total density of grasses in upper altitude was 106428 individuals/ha in which highest density (37857 individuals/ha), frequency (78.57) and IVI (79.31) was of *Apluda mutica* and lowest density (1428 individuals/ha), frequency (7.14) and IVI (8.69) was for *Brachypodium sylvaticum*. Abundance and frequency ratio was found maximum (0.98) for *Heteropogon contortus* and minimum (0.06) was of *Apluda mutica*. In lower altitudinal zone, the total density of grasses was 104375 individuals/ha in which highest density (33750 individuals/ha), frequency (56.25) and IVI (74.92) was of *Crysopogon montanus,* whereas lowest density (1857 individuals/ha), frequency (6.25) and IVI (12.48) was recorded for *Heteropogon contortus*. A/F was maximum for *Bothriochloa ischarmum* (0.48) and minimum was of *Crysopogon montanus* (0.10). In the Garhwal Himalayan region, there are many types of grasses that grow abundantly during the rainy season. Bagwari and Todaria (2011) observed same trend about range grasses under silvi-pasture systems.

Density of shrubs was 2542 individuals/ha in upper altitudinal zone of study area in which maximum density (743 individuals/ha), frequency (50) and IVI (68.24) was of *Eupatorium adenophorum* and minimum density (57 individuals/ha), frequency (7.14) and IVI (13) was of *Carissa spinarum*. Abundance and frequency ratio was maximum (0.42) for *Senna occidentalis* and minimum (0.07) was of *Eupatorium adenophorum*. In lower altitude, total density of shrubs was 2825 individuals/ha in which highest density (500 individuals/ha), frequency (43.75) and IVI (40.71) was recorded for *Rhus parviflora* and lowest density (50 individuals/ha), frequency (6.25) and IVI (9.39) was of *Carissa spinarum*. Maximum abundance and frequency ratio was found in *Colebrookea oppositifolia* (0.48) and minimum A/F found in *Lantana camara* (0.04).

In upper altitudinal zone, total density of herbs was 47857 individuals/ha in which maximum density (22142 individuals/ha), frequency (57.14) and IVI (102.28) was of *Bidens pilosa* and minimum density (2143 individuals/ha), frequency (7.14) and IVI (20.50) was noted for *Cynoglossum lanceolatum*. Abundance and frequency ratio was found maximum (0.70) in *Geranium lucidum* and minimum (0.06) in *B. Pilosa*. In lower altitude the total density of herbs was 48125 individuals/ha in which maximum density (13125 individuals/ha), frequency (43.75) and IVI (63.50) was observed for *B. Pilosa* and minimum density (625 individuals/ha), frequency (6.25) and IVI (7.81) was of *Thalictrum foliolosum.* Maximum abundance and frequency ratio was of *Synedrella nodiflora* (0.96) and minimum A/F found was recorded for *B. Pilosa* (0.06). Bijalwan (2013), also mentioned same species in his study carried out in district Tehri Garhwal of Uttarakhand, India.

Homegarden: In homegardens, tree and fruit crops were the main woody components whereas crops and vegetable were main understory components. Total 17 tree, 14 crops and 5 herb species were reported in upper altitudinal zone. On the other hand, 24 tree, 11 crop and 6 species of herbs were found in lower altitudinal zone of the study area (Table 3).

In upper altitude total tree density of 564 individuals/ha was recorded, in which *Citrus sinensis* had maximum density (107 individuals/ha), frequency (57.14) and IVI (48.20) and *Phyllanthus emblica* had minimum density (7 individuals/ha), frequency (7.14) and IVI (3.73). *Ficus roxburghii* had minimum abundance and frequency ratio (0.28) and

Table 2. Phytosociological attributes of different species in silvipasture system

Trees in Silvipasture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Khair	*Acacia catechu*	0	0.00	0.00	0.00	19	18.75	11.54	0.05
Haldu	*Adina cordifolia*	0	0.00	0.00	0.00	19	6.25	8.97	0.48
Dhaura	*Anogeissus latifolia*	0	0.00	0.00	0.00	13	6.25	8.04	0.32
Kandi	*Bauhinia retusa*	29	7.14	9.69	0.56	13	6.25	7.79	0.32
Kachnar	*Bauhinia variegata*	7	7.14	3.93	0.14	56	31.25	22.22	0.06
Amaltas	*Cassia fistula*	0	0.00	0.00	0.00	6	6.25	7.33	0.16
Kharik	*Celtis australis*	143	85.71	82.16	0.02	44	37.50	28.50	0.03
Shisham	*Dalbergia sissoo*	0	0.00	0.00	0.00	6	6.25	3.23	0.16
Khinna	*Falconeria insignis*	21	21.43	14.18	0.05	13	12.50	7.11	0.08
Khaina	*Ficus cunia*	0	0.00	0.00	0.00	19	12.50	13.94	0.12
Cluster Fig	*Ficus hispida*	0	0.00	0.00	0.00	6	6.25	3.52	0.16
Dudhila	*Ficus neriifolia*	21	7.14	12.73	0.42	0	0.00	0.00	0.00
Timla	*Ficus roxburghii*	50	42.86	31.43	0.03	38	25.00	16.91	0.06
Chanchri	*Ficus subincisa*	14	14.29	6.87	0.07	0	0.00	0.00	0.00
Bhimal	*Grewia optiva*	64	35.71	32.26	0.05	44	31.25	21.47	0.04
Jamun	*Syzygium cumini*	0	0.00	0.00	0.00	19	18.75	14.17	0.05
Bahera	*Terminalia bellirica*	0	0.00	0.00	0.00	13	12.50	10.13	0.08
Harad	*Terminalia chebula*	0	0.00	0.00	0.00	31	12.50	13.21	0.20
Toon	*Toona ciliata*	21	14.29	17.72	0.11	25	18.75	20.30	0.07
Indrjau	*Wrightia tinctoria*	0	0.00	0.00	0.00	6	6.25	3.78	0.16
Grasses in Silvipasture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Tachlu	*Apluda mutica*	37857	78.57	79.32	0.06	21250	37.50	53.01	0.15
Dhaddu	*Arundinella nepalensis*	17143	35.71	41.63	0.13	19375	37.50	49.94	0.14
Yellow bluestem	*Bothriochloa ischarmum*	5714	14.29	20.07	0.28	1875	6.25	12.49	0.48
False brome	*Brachypodium sylvaticum*	1429	7.14	8.69	0.28	10000	18.75	32.29	0.28
Salmu	*Bromus inermis*	2143	7.14	11.53	0.42	0	0.00	0.00	0.00
Gurla	*Crysopogon montanus*	7857	14.29	25.33	0.39	33750	56.25	74.93	0.11
Dub	*Cynodon dactylon*	0	0.00	0.00	0.00	3125	12.50	15.44	0.20
Nut Grass	*Cyprus rotundus*	1429	7.14	8.69	0.28	0	0.00	0.00	0.00
Finger grass	*Digitaria spp.*	2857	7.14	14.36	0.56	7500	18.75	26.49	0.21
Black speargrass	*Heteropogon contortus*	5000	7.14	22.85	0.98	1875	6.25	12.49	0.48
Daba	*Juncus inflexus*	1429	7.14	8.69	0.28	0	0.00	0.00	0.00
Birachu	*Pennisetum species*	22143	42.86	50.15	0.12	5625	12.50	22.94	0.36
Naru		1429	7.14	8.69	0.28	0	0.00	0.00	0.00
Shrubs in Silvipasture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Kingod	*Berberis aristata*	0	0.00	0.00	0.00	150	18.75	17.29	0.11
Khakshu	*Boehmeria macrophylla*	371	21.43	41.00	0.20	300	31.25	28.04	0.08

Cont...

Table 2. Phytosociological attributes of different species in silvipasture system

Trees in Silvipasture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Kharanu	*Carissa spinarum*	57	7.14	13.01	0.28	50	6.25	9.40	0.32
Bhindu	*Colebrookea oppositifolia*	0	0.00	0.00	0.00	75	6.25	13.01	0.48
Kala bansa	*Eupatorium adenophorum*	743	50.00	68.24	0.07	225	18.75	22.67	0.16
Sakina	*Indigofera tinctoria*	200	14.29	27.62	0.25	100	12.50	13.34	0.16
Lantana	*Lantana camara*	286	21.43	34.11	0.16	375	43.75	34.34	0.05
Chui Mui	*Mimosa pudica*	0	0.00	0.00	0.00	50	6.25	9.40	0.32
Kari Patta	*Murraya koenigii*	0	0.00	0.00	0.00	425	43.75	36.89	0.06
Tungla	*Rhus parviflora*	400	35.71	44.13	0.08	500	43.75	40.71	0.07
Hisalu	*Rubus ellipticus*	229	21.43	29.51	0.12	150	12.50	17.84	0.24
Ameda	*Rumex hastatus*	171	14.29	24.73	0.21	125	12.50	15.59	0.20
Chakunda	*Senna occidentalis*	86	7.14	17.66	0.42	0	0.00	0.00	0.00
Bala	*Sida cordifolia*	0	0.00	0.00	0.00	75	6.25	13.01	0.48
Bariyara	*Urena lobata*	0	0.00	0.00	0.00	50	6.25	9.40	0.32
Dhaud	*Woodfordia fruticosa*	0	0.00	0.00	0.00	175	18.75	19.08	0.12
Herbs in Silvipasture system		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Billygoat herb	*Ageratum conyzoides*	0	0.00	0.00	0.00	1250	6.25	11.47	0.32
Bukifool	*Anaphalis busua*	0	0.00	0.00	0.00	1875	6.25	15.12	0.48
Kunja	*Artemisia vulgaris*	5000	14.29	33.53	0.25	5000	12.50	28.14	0.32
Kumarr	*Bidens pilosa*	22143	57.14	102.28	0.07	13125	43.75	63.50	0.07
Kana	*Commelina benghalensis*	2143	7.14	20.50	0.42	0	0.00	0.00	0.00
Lechkumar	*Cynoglossum lanceolatum*	2143	7.14	20.50	0.42	0	0.00	0.00	0.00
Horseherb	*Erigeron canadensis*	0	0.00	0.00	0.00	2500	12.50	18.23	0.16
Kaliko plant	*Euphorbia heterophylla*	0	0.00	0.00	0.00	2500	6.25	18.77	0.64
Ashthma plant	*Euphorbia hirta*	2857	7.14	25.58	0.56	1875	6.25	15.12	0.48
Shining cranesbill	*Geranium lucidum*	3571	7.14	30.66	0.70	2500	6.25	18.77	0.64
Kharenti	*Malvastrum coromandelianum*	0	0.00	0.00	0.00	1875	6.25	15.12	0.48
Gaajar ghaas	*Parthenium hysterophorus*	0	0.00	0.00	0.00	8750	25.00	43.09	0.14
Yellow Foxtail	*Setaria pumila*	6429	21.43	39.99	0.14	0	0.00	0.00	0.00
Synedrella grass	*Synedrella nodiflora*	0	0.00	0.00	0.00	3750	6.25	26.08	0.96
Mamira	*Thalictrum foliolosum*	3571	14.29	26.96	0.18	625	6.25	7.82	0.16
Tridex daisy	*Tridex procumbens*	0	0.00	0.00	0.00	2500	6.25	18.77	0.64

Table 3. Phytosociological attributes of different species in Homegarden

Trees in Homegarden		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Dhaura	*Anogeissus latifolia*	0	0.00	0.00	0.00	6	6.25	3.91	0.16
Kathal	*Artocarpus heterophyllus*	0	0.00	0.00	0.00	6	6.25	6.70	0.16
Kachnar	*Bauhinia variegata*	21	21.43	13.18	0.05	0	0.00	0.00	0.00
Papeeta	*Carica papaya*	0	0.00	0.00	0.00	56	43.75	23.40	0.03
Yellow Kaner	*Cascabela thevetia*	0	0.00	0.00	0.00	6	6.25	2.60	0.16
Kharik	*Celtis australis*	43	35.71	36.78	0.03	13	12.50	6.35	0.08
Orange	*Citru aurantium*	14	7.14	5.09	0.28	6	6.25	3.00	0.16
Malta	*Citru sinensis*	107	57.14	48.20	0.03	38	25.00	14.04	0.06
Nimbu	*Citrus aurantiifolia*	0	0.00	0.00	0.00	25	25.00	10.64	0.04
Galgal	*Citrus limon*	14	14.29	7.80	0.07	6	6.25	2.63	0.16
Chabutra	*Citrus paradisi*	0	0.00	0.00	0.00	25	18.75	11.20	0.07
Bedu	*Ficus palmata*	14	7.14	5.62	0.28	0	0.00	0.00	0.00
Timla	*Ficus roxburghii*	14	7.14	6.84	0.28	0	0.00	0.00	0.00
Chanchri	*Ficus subincisa*	0	0.00	0.00	0.00	6	6.25	2.82	0.16
Phalsa	*Grewia asiatica*	0	0.00	0.00	0.00	6	6.25	8.88	0.16
Bhimal	*Grewia optiva*	57	28.57	28.31	0.07	13	12.50	6.86	0.08
Akhrot	*Juglans regia*	7	7.14	7.78	0.14	6	6.25	9.69	0.16
Subabool	*Leucaena leucocephala*	0	0.00	0.00	0.00	6	6.25	3.34	0.16
Mango	*Mangifera indica*	43	28.57	25.33	0.05	69	43.75	37.65	0.04
Dainkan	*Melia azedarach*	14	14.29	11.12	0.07	44	31.25	25.89	0.04
Sehtoot	*Morus alba*	7	7.14	5.14	0.14	88	62.50	39.56	0.02
Banana	*Musa paradisiaca*	57	28.57	28.76	0.07	56	31.25	26.40	0.06
Aonla	*Phyllanthus emblica*	7	7.14	3.74	0.14	0	0.00	0.00	0.00
Chulu	*Prunus armeniaca*	0	0.00	0.00	0.00	6	6.25	3.11	0.16
Aadu	*Prunus persica*	43	35.71	23.60	0.03	13	12.50	6.04	0.08
Guava	*Psidium guajava*	50	28.57	24.02	0.06	63	56.25	29.77	0.02
Anar	*Punica granatum*	50	28.57	18.71	0.06	25	25.00	10.15	0.04
Jamun	*Syzygium cumini*	0	0.00	0.00	0.00	6	6.25	5.41	0.16
Crops in Homegarden		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Bhindi	*Abelmoschus esculentus*	4286	14.29	20.77	0.21	1875	6.25	15.34	0.48
Marcha	*Amaranthus viridis*	714	7.14	6.88	0.14	1875	6.25	15.34	0.48
Patta Gobhi	*Brassica oleracea var. capitata*	714	7.14	6.88	0.14	0	0.00	0.00	0.00
Mirch	*Capsicum annum*	30000	64.29	75.69	0.07	39375	87.50	99.93	0.05
Arbi	*Colocasia esculenta*	18571	64.29	55.43	0.04	16250	68.75	55.76	0.03
Kaddu	*Cucurbita pepo*	1429	14.29	10.26	0.07	0	0.00	0.00	0.00
Haldi	*Curcuma longa*	0	0.00	0.00	0.00	9375	43.75	36.50	0.05
Lauki	*Lagenaria siceraria*	714	7.14	6.88	0.14	625	6.25	6.74	0.16

Table 3. Phytosociological attributes of different species in Homegarden

Trees in Homegarden		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Common name	Botanical name	Density/ha	Frequency	IVI	A/F	Density/ha	Frequency	IVI	A/F
Karela	*Memordica charantia*	714	7.14	6.88	0.14	625	6.25	6.74	0.16
Mentha	*Mentha spicata*	0	0.00	0.00	0.00	2500	6.25	19.65	0.64
Beans	*Phaseolus vulgaris*	2857	14.29	15.51	0.14	0	0.00	0.00	0.00
Mooli	*Raphanus sativus*	714	7.14	6.88	0.14	0	0.00	0.00	0.00
Tomato	*Solanum lycopersicum*	1429	14.29	10.26	0.07	0	0.00	0.00	0.00
Baingan	*Solanum melongena*	5000	21.43	21.81	0.11	3125	12.50	17.62	0.20
Makka	*Zea mays*	5714	21.43	23.86	0.12	1250	6.25	11.04	0.32
Adrak	*Zingiber officinale*	8571	21.43	32.04	0.19	1875	6.25	15.34	0.48
Herbs		Upper Altitude 1200-2000 m				Lower altitude <1200 m			
Billygoat weed	*Ageratum conyzoides*	14286	35.71	82.62	0.11	21875	56.25	91.71	0.07
Kumarr	*Bidens pilosa*	13571	50.00	86.49	0.05	9375	37.50	51.57	0.07
Kana	*Commelina benghalensis*	4286	14.29	36.42	0.21	5000	18.75	32.61	0.14
Ashthma plant	*Euphorbia hirta*	0	0.00	0.00	0.00	3750	12.50	27.89	0.24
Gallant soldier	*Gallinsoga parviflora*	4286	14.29	36.42	0.21	0	0.00	0.00	0.00
Oxalis	*Oxalis* spp.	5714	7.14	58.06	1.12	13750	25.00	64.56	0.22
Trifolium	*Trifolium* spp.	0	0.00	0.00	0.00	3125	6.25	31.66	0.80

maximum A/F was in *C. sinensis* (0.03). *C. sinensis* in the northern aspect showed the highest IVI value (48.84). The concomitant results was also found in for fruit trees in that area (Bijalwan 2012). In lower altitude total tree density was 594 individuals/ha out of which *Morus alba* had highest density (87 individuals/ha), frequency (62.50) and IVI (39.56) and *Cascabela thevetia* showed lowest density (6 individuals/ha), frequency (6.25) and IVI (2.59). Abundance and frequency ratio was found maximum in *Juglans regia* (0.16) and minimum in *Psidium guajava* (0.01).

Among crops, total density was 81429 individuals/ha in upper altitude out of which *Capsicum annum* had maximum density (30000 individuals/ha), frequency (64.28) and IVI (75.68). *Lagenaria siceraria* showed minimum density (714 individuals/ha), frequency (7.14) and IVI (6.87). Maximum abundance and frequency ratio (0.21) was for *Abelmoschus esculentus* and minimum (0.04) of *Colocasia esculenta*. In lower altitude the total density of crops was 78750 individuals/ha, in which *C. annum* had maximum density (39375 individuals/ha), frequency (87.50) and IVI (99.93) and *Memordica charantia* had minimum density (625 individuals/ha), frequency (6.25) and IVI (6.74). Maximum abundance and frequency ratio (0.64) was of *Mentha spicata* and minimum (0.03) was for *Colocasia esculenta* (0.03). Findings of Vibhuti et al (2018) also depicted maximum frequency in *C. annum* (100) and minimum in *C. esculenta* (33.33).

Total density of herbs in upper altitudinal zone was 42143 individuals/ha in which *Ageratum conyzoides* had maximum (14285 individuals/ha) and *Gallinsoga parviflora* had minimum density (4285 individuals/ha). *Bidens Pilosa* had maximum (50) and *Oxalis species* had minimum (7.14) frequency. IVI was maximum (86.48) for *Bidens pilosa* and minimum (36.41) was of *Gallinsoga parviflora*. Abundance and frequency ratio was found maximum (1.12) for *Oxalis* species and minimum (0.05) was recorded for *B. Pilosa* (0.05). In lower altitudinal zone the total density of herbs was 56875 individuals/ha in which *Ageratum conyzoides* had maximum density (21875 individuals/ha) and frequency (56.25) and *Trifolium* species had minimum density (3125) and frequency (6.25). IVI was maximum (91.70) for *Ageratum conyzoides* and minimum for *Euphorbia hirta* (27.89). Abundance and frequency ratio was maximum (0.80) for *Trifolium* species and minimum (0.06) was of *Bidens pilosa*.

CONCLUSION

The present findings indicated that, there are relatively few trees in agricultural fields. It is perceived that homegardens provided a variety of ecological services since they are rich in tree species or tree diversity. Trees like *Grewia optiva, Celtis australis, Mallotus phillipensis, Citrus sinensis* and *Morus alba* are the most prominent tree species and suitable for restoration programme. Considering that traditional agroforestry systems provide a variety of economic and ecological benefits; it is crucial to preserve their sustainability.

REFERENCES

Bagwari HK and Todaria NP 2011. Resource use pattern and agroecosystem functioning in Rawanganga micro watershed in Garhwal Himalaya, India. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* **112**(2): 101-112.

Bijalwan A 2012. Structure, composition and diversity of horticulture trees and agricultural crops productivity under traditional agri-horticulture system in mid hill situation of Garhwal Himalaya, India. *American Journal of Plant Sciences* **3**: 480-488.

Bijalwan A 2013. Vegetation status of agroforestry systems in Tehri District of Garhwal Himalaya, India. *Asian Journal of Science and Technology* **4**(12): 011-014.

Bijalwan A, Upadhyay AP and Dobriyal MJR 2015. Tree crop combinations, biomass and carbon sequestration in conventional agrisilviculture (Agroforestry) system along altitude and aspects in the hills of Uttarakhand Himalaya, India. *International Journal of Current Research in Bioscience and Plant Biology* **2**(6): 214-217.

Curtis JT 1959. *The Vegetation of Wisconsin: An ordination of plant communities*. Madison, WI: University of Wisconsin Press.

Curtis JT and Cottam G 1956. The use of distance measurement in phytosociological sampling. *Ecology* **37**: 451-460.

Curtis JT and McIntosh RP 1950. The interrelation of certain analytic and synthetic phytosociological characters. *Ecology* **31**: 434-455.

FAO 2005**.** *State of the world's Forest: Selected Current Issues in the Forest Sector. Realizing the economic* Benefits of Agroforestry: Experiences, Lessons and Challenges. Part II. pp. 85-95.

FSI 2019. *State of Forest Report*, Forest survey of India (Ministry of Environment & Forests), published by FSI, Dehradun 322 pp.

Kanwal MS, Yadava AK and Vishvakarma SCR 2022. Crop productivity and soil properties under agroforestry system in Kosi Watershed of Kumaun Himalaya. *Indian Journal of Ecology* **49**(1): 21-30

Mahato S, Dasgupta S, Todaria NP and Singh VP 2016. Agroforestry mapping and characterization in four districts of Garhwal Himalaya. *Energy, Ecology and Environment* **1**(2): 86-97.

Manzoor J and Jazib MJ 2020. Distribution pattern and phytosociological study of agroforestry trees in Poonch district of Jammu and Kashmir, India. *Journal of Biodiversity Conservation and Bioresource Management* **6**(2): 77-82.

Phillips EC 1959. Methods of Vegetation study. New York: Holt R and Winston. 105p.

Raturi GP 2012. Forest community structure along an altitudinal gradient of district Rudraprayag of Garhwal Himalaya, India. *Ecologia* **2**(3): 76-84.

Sangeetha R, Murugan VB and Nandhini SU 2016. Economic analysis of factors affecting adoption rate of agroforestry technologies in Tamil Nadu. *Indian Journal of Ecology* **43**(Special Issue-2): 785-788

Thakur NS, Gupta NK and Gupta B 2004. Phytosociological analysis of woody and non-woody components under some agroforestry systems in Western Himalaya: A case study. *Indian Journal of Agroforestry* **6**(1): 65-71.

Thakur NS, Verma KS and Gupta NK. 2007. Structural difference vis-à-vis economic utility of shrubs and forage in different agroforestry systems in sub-tropical Himalayan region. *Journal of Tree Sciences* **26**(2): 35-48.

Vibhuti, Bargali K, Bargali SS 2018. Effects of homegarden size on floristic composition and diversity along an altitudinal gradient in Central Himalaya, India. *Current Science* **114**(12): 2494-2503.

Vikrant KK, Chauhan DS and Rizvi RH 2016. Existing agroforestry system and its component in Tehri district of Garhwal Himalaya. *Forestry Ideas* **22**(2-52): 221–227.

Vikrant KK, Chauhan DS, Rizvi RH and Maurya A 2018. Mapping the extent of agroforestry area in different altitudes of Tehri District, North Western Himalaya, India through GIS and Remote Sensing Data. *Journal of the Indian Society of Remote Sensing* **46**(9): 1471–1480.

Whitford PB 1949. Distribution of woodland plants in relation to succession and clonal growth. *Ecology* **30**(2): 199-208.

Received 28 January, 2023; Accepted 15 May, 2023