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Floristic Composition and Distribution of Plant Communities Under different Traditional Agroforestry Systems in Takoli Gad Watershed of Garhwal Himalayas

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Abstract: The study was carried out in Lower (300-1200 masl) and Middle (1200-2000 masl) altitudinal ranges of the Takoli Gad Watershed of Garhwal Himalaya. Quadrats of 10×10 m, 5×5 m and 1×1 m were randomly laid out for trees, shrubs, crops and herbaceous plants in each system, respectively. Agri-silviculture, silvi-pasture, and homegardens were recognized as traditional Agroforestry systems. A total of 19 tree species, 10 agricultural crops and 6 herb species were recorded in Agri-silvicultural system, whereas 23 tree species, 15 agricultural crops which include cash crops and 6 herb species were recorded in home garden. In silvi-pastoral systems, 19 tree, 13 shrubs, 9 herb and 10 grass species were documented. Maximum diversity was in the home garden system owing to the inclusion of fruit trees and other multipurpose tree species. Agri-silviculture systems are generally utilized for food production, whereas home garden systems are mostly used for subsistence purposes and silvi-pasture systems are mostly used for fodder and fuelwood production. From the current study it can be conclude that the traditional agroforestry systems are important for the livelihood support of local people and biodiversity conservation to protect the depletion of natural resources.

Keywords: Traditional Agroforestry, Agri-silviculture, Home garden, Silvipasture, Phytosociology

Recent population development has put more strain on natural resources, such as land availability for maintaining lifestyles. Additionally, due to overuse and extraction of natural resources, ecosystems are becoming unstable and fragile (Sundriyal and Sharma 1996). In this context, agroforestry plays an important role not only to sustain the natural balance but also providing livelihood securities to the local people. Agroforestry is commonly considered as 'a low-hanging fruit" due to its multifarious outputs such as tangible benefits (food, timber, fuelwood, fertilizer, NTFPs) and intangible (ecosystem services controlling soil erosion, water conservation, carbon sequestration, increasing climate resiliency, etc.) benefits, with the 6Fs, i.e. food, fruit, fodder, fuel, fertilizer, and fiber (Chavan et al 2015, 2016, 2022). Agroforestry has potential to enhance livelihoods in India, where people have a long history and have gathered local knowledge. India is notably noteworthy for its ethnoforestry practices and indigenous tree-growing knowledge systems. Shifting cultivation, taungya, and homegardens are three significant traditional systems that have changed through time (Sharma et al 2007, Newaj et al 2016). Several traditional Agroforestry practices from Himachal Pradesh and Uttarakhand, one of India's Himalayan regions, have been recorded (Arunachalam et al 2019, Thakur et al 2005, Thakur et al 2007). In Himachal, these practices include the three most often used Agroforestry systems: Agri-silviculture, agri-horticulture, and gri-horti-silviculture (Singh and Dagar 1990). Similarly, in the Mussoorie hills of Western Himalayas identified an Agri- silviculture system, Agri-horticulture system, Agri-horti- silviculture system, Silvi-pastoral system and Homesteads.

The production potentials in Agroforestry systems can be accessed under particular site circumstances through phytosociological study. The top layer has a bigger influence on the structure of understory species. When there is no competition, a species reacts to external stimuli differently than when there is competition. The abandonment of conventional, regionally appropriate crop types and intercropping in favor of high-yielding monocultures may have an impact on the biodiversity of the agroecosystem (Chappell and LaValle 2011, Sunderland 2011). Guillerme et al (2011) observed that introduction of exotic fast-growing multipurpose trees and the conversion of agroforestry systems (including home gardens or their parts) to monocropping production systems has resulted in a decline in the diversity of native multipurpose trees and shrubs as well as herbaceous components like traditional vegetable crops and ornamental plants. Therefore, by preserving tree species in their natural habitat on farms, easing pressure on remnant forests, and providing optimal habitat for plant and

animal species on fields, traditional agroforestry methods promote biodiversity. Keeping the potential of traditional agroforestry in view, the present study was conducted with objective of to assess the biodiversity of traditional agroforestry systems.

MATERIAL AND METHODS

Study area: The current study was conducted in the 'Takoli Gad Watershed' of Uttarakhand's Tehri District. The digital elevation map of study area is shown in the Figure 1 (located between 30° 14' to 30° 23' N latitude and 78° 37' to 78° 46' E longitude). This watershed consists of 67 villages on an area of approximately 131.43 km^2. The region is in the Garhwal of the lesser Himalaya and is distinguished by gentle and mature landscape (Parmar et al 2012). Two altitudes *viz*. lower altitude (300-1200 m) and middle altitude (1200-2000 m) were taken for present study (Fig. 1). The soil of the study area is mostly acidic to neutral in nature with pH range from 6.4 to 7.3 (Parmar and Negi 2017).

Community analysis: Thorough reconnaissance field survey was carried out for identifying Traditional Agroforestry systems and species distribution. Different useful parameters viz village, altitudes, GPS locations, existing agroforestry systems, tree species, DBH, agricultural crops, grasses and weeds were recorded in each Agroforestry systems. Quadrats of 10×10m, 5×5m and 1×1m quadrats were laid out randomly for trees, shrubs, agricultural crops and herbaceous plants respectively in each system.

Quantitative analysis: The Important Value Index (IVI) which is an integrated measure of the relative frequency, relative density and relative dominance/abundance was calculated for each species. The ratio of abundance to frequency indicates regular random (<0.050), contagious (0.050-1.00) and clump (>1.00) distribution patterns. The quantitative analyses for frequency, density, and abundance were 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). The basal area of trees was calculated using the formula Basal area = $\pi d^2/4$ or $G^2/4\pi$ or πr^2 (Chaturvedi and Khanna1984).

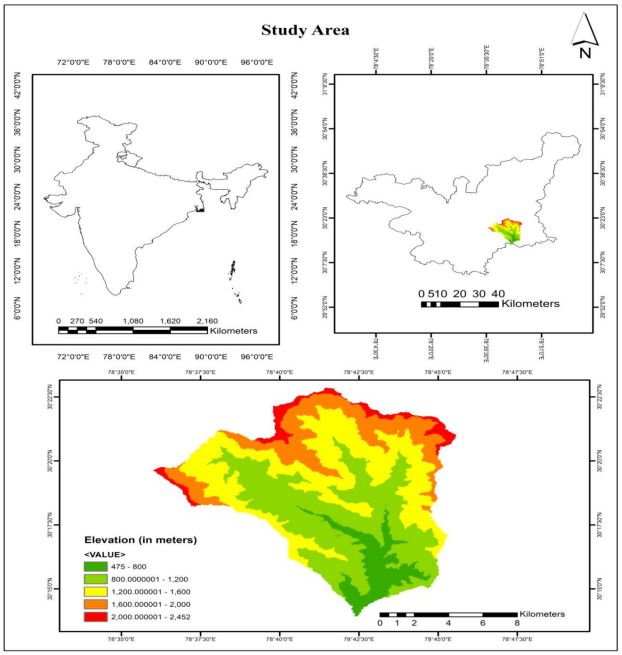

Fig. 1. Digital elevation map of study area

RESULTS AND DISCUSSION

Among the different traditional agroforestry models, the three most common in the study area were agri-silviculture, silvi-pasture and homegardens. Bijalwan (2013) and Vikrant et al (2016, 2018) also reported agri-silviculture, agri-horticulture and agri-hortisilviculture in Tehri district of Garhwal Himalaya, Uttarakhand. Similarly, Kumari et al (2008) reported agri-horticulture, agri-silviculture, agri-silvi-pastoral, silvi-pastoral and horti-pastoral systems in the similar climatic conditions of Kinnaur district, Himachal Pradesh. A total of 19 tree species, 10 agricultural crops and 6 herb species were present in agri-silvicultural system whereas 23 tree species, 15 agricultural crops which include cash crops too and 6 herb species were recorded in aomegarden and 19 tree species, 13 species of shrubs, 9 herb species and 10 grass species were recorded in silvi-pastoral systems. Lower altitude shows more plant diversity than the middle altitude.

Agri-silvicultural system: In agri-silvicultural system, lower altitude has more biodiversity with 13 tree species, 5 herb species and 10 agricultural species than the middle altitude which has 12 trees, 4 herb and 6 agricultural species (Table 1). In both altitudes, the most abundant tree species were *G. optiva* and Celtis australis. Manzoor and Jazib (2020) also reported *G. optiva* as the most frequent tree species followed by *Pyrus persica* and *C. australis* in the agroforestry systems of Poonch District of Jammu & Kashmir. Farmers grow these species on the farm bunds because of their high fodder value. Middle altitude contains more density of trees, agricultural crops and herbs per hectare. Highest IVI for trees in middle and lower altitude was recorded for *G. optiva* in both lower

Table 1. Phytosociological attributes of Agri-silviculture system

Trees	Botanical name	Lower altitude (300-1200 masl)				Middle altitude (1200-2000 masl)			
		Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F	Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F
Trees									
Bhimal	*Grewia optiva*	191	41815.27	102.63	0.02	200	15652.00	87.25	0.03
Kharik	*Celtis australis*	118	40240.00	75.17	0.03	78	8571.44	40.34	0.04
Toon	*Toona ciliata*	36	17792.27	29.73	0.05	11	972.67	6.97	0.09
Khaina	*Ficus cunia*	9	560.18	5.14	0.11	0	0	0	0
Timla	*Ficus roxburghii*	9	765.91	5.30	0.11	33	6482.44	25.54	0.03
Kachnar	*Bauhinia variegata*	18	2412.91	8.43	0.22	22	5381.22	18.40	0.05
Subabool	*Leucaena leucocephala*	18	8077.45	15.66	0.06	0	0	0	0
Khair	*Acacia catechu*	18	1729.91	10.75	0.06	0	0	0	0
Sandhan	*Ougeinia oojeinense*	9	2541.09	6.67	0.11	22	1383.78	9.63	0.18
Dainkan	*Melia azaderach*	27	6937.36	16.63	0.08	0	0	0	0
Ruina	*Mallotus phillipensis*	18	3873.91	12.41	0.06	0	0	0	0
Kathgular	*Ficus hispida*	9	1193.09	5.63	0.11	0	0	0	0
Asan	*Terminalia elliptica*	9	1471.55	5.85	0.11	0	0	0	0
Mulberry	*Morus alba*	0	0	0	0	33	6482.44	15.52	0.07
Chanchari	*Ficus subincisa*	0	0	0	0	11	1680.33	7.89	0.09
Panyan	*Prunus cerasoides*	0	0	0	0	33	5300.89	24.00	0.03
Banj	*Quercus leucotrichophora*	0	0	0	0	33	5156.89	16.67	0.27
Phalsa	*Grewia asiatica*	0	0	0	0	11	17819.89	28.90	0.09
Jamun	*Syzygium cumini*	0	0	0	0	33	6863.89	18.89	0.27
Herbs									
Kumarr	*Bidens pilosa*	5455	18.18	34.65	0.17	20000	55.56	75.87	0.06
Tipatti	*Oxalis spp.*	13636	18.18	70.84	0.41	28889	33.33	98.98	0.26
Billygoat weed	*Ageratum conyzoides*	28182	81.82	110.01	0.04	30000	66.67	99.25	0.07
Kana	*Commelina benghalensis*	10909	36.36	53.87	0.08	0	0	0	0
Asthma plant	*Euphorbia hirta*	4545	18.18	30.63	0.14	0	0	0	0
Yellow foxtail	*Setaria pumila*	0	0	0	0	3333	11.11	25.90	0.27
Agricultural crops									
Toor	*Cajanus cajan*	2727	9.09	11.37	0.33	11111	22.22	31.17	0.23
Chaulai	*Amaranthus viridis*	18182	45.45	45.17	0.09	23333	44.44	53.79	0.12
Mandua	*Eleusine coracana*	39091	36.36	66.37	0.30	63333	44.44	100.30	0.32
Himalayan Navrangi	*Vigna umbellata*	9091	18.18	24.27	0.28	17778	33.33	43.29	0.16
Jhangora	*Echinochloa esculenta*	20000	9.09	51.72	2.42	20000	11.11	56.48	1.62
Till	*Sesamum indicum*	7273	9.09	21.99	0.88	3333	11.11	14.97	0.27
Gahat	*Macrotyloma uniflorum*	10909	18.18	27.12	0.33	0	0	0	0
Arvi	*Colocasia esculenta*	3636	9.09	13.49	0.44	0	0	0	0
Urad	*Vigna mungo*	10909	18.18	27.12	0.33	0	0	0	0
Soyabean	*Glycine max*	2727	9.09	11.37	0.33	0	0	0	0

Table 2. Phytosociological attribute of Silvi-pasture system

Trees	Botanical name	Lower altitude (300-1200 masl)				Middle altitude (1200-2000 masl)			
		Density (Plants/ha)	Total basal cover (cm²/ha)	IVI	A/F	Density (Plants/ha)	Total basal cover (cm²/ha)	IVI	A/F
Plants									
Kharik	*Celtis australis*	36	8464.09	24.42	0.03	89	15110.22	45.17	0.03
Banj	*Quercus leucotrichophora*	9	2033.36	6.03	0.11	100	23912.00	57.07	0.03
Timla	*Ficus roxburghii*	36	4854.45	18.57	0.05	89	11227.78	40.71	0.03
Bhimal	*Grewia oppositifolia*	36	2995.64	19.25	0.03	67	11750.89	35.03	0.03
Toon	*Toona ciliata*	45	22467.18	39.31	0.03	22	4018.11	10.89	0.18
Kachnar	*Bauhinia variegata*	36	6706.82	17.88	0.11	0	0.00	0.00	0.00
Harad	*Terminalia chebula*	27	8351.82	17.77	0.08	56	4924.22	19.99	0.11
Aonla	*Phyllantus emblica*	9	339.73	4.43	0.11	22	879.22	9.99	0.05
Sandhan	*Ougeinia oojeinense*	55	4215.91	21.30	0.07	33	2200.11	13.29	0.07
Khair	*Syzygium cumini*	55	8557.64	25.40	0.07	0	0.00	0.00	0.00
Amaltas	*Cassia fistula*	18	1962.64	10.07	0.06	0	0.00	0.00	0.00
Haldu	*Haldina cordifolia*	45	10706.36	25.76	0.06	0	0.00	0.00	0.00
Ruina	*Mallotus phillipensis*	64	7212.91	28.24	0.05	11	1347.67	6.04	0.09
Kanndi	*Bauhinia retusa*	36	8011.27	21.55	0.05	0	0.00	0.00	0.00
Khaina	*Ficus cunia*	36	8987.55	20.03	0.11	22	1112.22	7.55	0.18
Chanchari	*Ficus subincisa*	0	0	0	0	22	858.00	9.96	0.05
Khinna	*Falconeria insignis*	0	0	0	0	44	6403.22	25.31	0.02
Panyan	*Prunus cerasoides*	0	0	0	0	22	2091.22	11.38	0.05
Jamun	*Syzygium cumini*	0	0	0	0	22	1160.44	7.61	0.18
Shrubs									
Hisalu	*Rubus ellipticus*	73	9.09	14.94	0.22	356	33.33	40.58	0.08
Kingora	*Berberis aristata*	218	27.27	27.58	0.07	222	22.22	29.23	0.11
Lantana	*Lantana camara*	255	27.27	30.50	0.09	178	11.11	27.91	0.36
Tungla	*Rhus parviflora*	255	27.27	30.50	0.09	400	44.44	46.06	0.05
Sakina	*Indigofera tinctoria*	73	9.09	14.94	0.22	133	11.11	22.25	0.27
Dhaud	*Woodfordia fruticosa*	400	45.45	42.57	0.05	89	11.11	16.59	0.18
Kari patta	*Murraya koenigii*	509	54.55	50.95	0.04	89	11.11	16.59	0.18
Khakshu	*Boehmeria macrophylla*	327	27.27	36.36	0.11	0	0	0	0
Kharanu	*Carissa spinarum*	218	27.27	27.58	0.07	0	0	0	0
Mimosa bush	*Vachellia farnesiana*	73	9.09	14.94	0.22	0	0	0	0
Ber	*Ziziphus jujuba*	36	9.09	9.14	0.11	0	0	0	0
Kala bansa	*Eupatorium adenophorum*	0	0	0	0	800	55.56	72.88	0.06
Ameda	*Rumex hastatus*	0	0	0	0	178	11.11	27.91	0.36
Herbs									
Kumarr	*Bidens pilosa*	14545	66.67	74.29	0.07	16667	44.44	89.35	0.08
Mamira	*Thalictrum foliolosum*	909	33.33	46.08	0.16	5556	22.22	41.51	0.11
Billygoat weed	*Ageratum conyzoides*	4545	11.11	23.13	0.45	5556	11.11	45.53	0.45

Cont...

Table 2. Phytosociological attribute of Silvi-pasture system

Herbs	Botanical name	Lower altitude (300-1200 masl)				Middle altitude (1200-2000 masl)			
		Density (plants/ha)	Frequency (%)	IVI	A/F	Density (plants/ha)	Frequency (%)	IVI	A/F
Herbs									
Lechkumar	*Cynoglossum lanceolatum*	7273	44.44	58.07	0.12	5556	22.22	41.51	0.11
Ashthma plant	*Euphorbia hirta*	2727	22.22	29.03	0.18	7778	22.22	51.45	0.16
Gaajar ghaas	*Parthenium hysterophorus*	9091	11.11	23.13	0.45	0	0	0	0
Kaliko plant	*Euphorbia heterophylla*	3636	11.11	30.28	0.63	0	0	0	0
Tridex daisy	*Tridex procumbens*	7273	11.11	15.98	0.27	0	0	0	0
Kunja	*Artemisia vulgaris*	0	0	0	0	3333	11.11	30.65	0.27
Grasses									
Tachlu	*Apluda mutica*	8182	18.18	28.40	0.25	32222	66.67	74.29	0.07
Birachu	*Pennisetum species*	8182	18.18	28.40	0.25	17778	33.33	46.08	0.16
Dhaddu	*Arundinella nepalensis*	18182	36.36	47.74	0.14	24444	44.44	58.07	0.12
Gurla	*Crysopogon montanus*	44545	72.73	92.89	0.08	8889	22.22	29.03	0.18
False brome	*Brachypodium sylvaticum*	9091	27.27	30.29	0.12	5556	11.11	23.13	0.45
Black speargrass	*Heteropogon contortus*	2727	9.09	14.92	0.33	7778	11.11	30.28	0.63
Yellow bluestem	*Bothriochloa ischarmum*	2727	9.09	14.92	0.33	3333	11.11	15.98	0.27
Finger grass	*Digitaria spp.*	3636	9.09	18.50	0.44	0	0	0	0
Naaru		6364	18.18	23.94	0.19	0	0	0	0
Nut grass	*Cyprus rotundus*	0	0	0	0	5556	11.11	23.13	0.45

(102.63) and middle altitude (87.25) followed by *C. australis* (75.17 in lower and 40.34 in middle altitude). While lowest IVI was recorded for *Ficus cunia* (5.14) in lower and *Toona ciliata* (6.97) in middle altitude. Among the herb species, highest IVI was recorded for *Ageratum conyzoides* in lower altitude (110.01) as well as in middle altitude (99.25) while the minimum IVI was recorded for *Euphorbia hirta* (30.63) in lower altitude and *Setaria pumila* (25.90) in middle altitude. Maximum IVI for agricultural crop was recorded for *Eleusine coracana i.e.* 66.37 for lower altitude and 100.30 for middle altitude. While minimum IVI value was recorded for *Glycine max* (11.37) in lower altitude and *Sesamum indicum* (14.97) in middle altitude.

Silvi-pasture system: A total of 15 tree, 11 shrub, 8 herb and 9 grass species were recorded in lower altitude and 14 tree, 9 shrub, 6 herbs and 8 grass species were found in middle altitude in silvi-pasture system (Table 2). In tree layer, highest IVI was recorded for *Toona ciliata* (39.31) in lower altitude and for *Quercus leucotrichophora* (57.07) in middle altitude while the lowest IVI was recorded for *Phyllanthus emblica* (4.43) in lower altitude and for *Mallotus phillipensis* (6.04) in middle altitude. In shrub layer, *Murraya koenigii* (54.55) showed highest IVI value in lower altitude and *Eupatorium adenophorum* (72.88) showed highest IVI in middle altitude. Among the herb layer, highest IVI value was recorded for *Bidens pilosa* in both altitudes *i.e.* 74.29 in lower and 89.35 in middle altitude while the minimum IVI was recorded for *Tridex procumbens* (15.98) in lower altitude and for *Artemisia vulgaris* (30.65) in middle altitude. Among grasses maximum IVI was recorded for *Crysopogon montanus* (92.89) in lower altitude and for *Apluda mutica* (74.29) in middle altitude while the least (14.92) was recorded for *Heteropogon contortus* and *Bothriochloa ischarmum* simultaneously in lower altitude and 15.98 for *Bothriochloa ischarmum* in middle altitude. Dominance of *Murraya koenigii* in shrubs and *Crysopogon montanus* in herbs was also documented by Thakur et al (2004, 2005) in the silvi-pastoral system of Western Himalayas.

Home garden: Home garden consists of higher biodiversity than other agroforestry systems. It is due to the presence of fruit (horticultural) trees and multipurpose trees. Home garden is the system used to meet the subsistent requirements of the households in study area. As Linger (2014) suggested that the home gardens, ecologically sustainable and diversifies sustainability of local community and therefore, considered as exceptional tools for

Table 3. Phytosociological attributes of homegarden

Trees	Botanical name	Lower altitude (300-1200 masl)				Middle altitude (1200-2000 masl)			
		Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F	Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F
Tree									
Mango	*Mangifera indica*	118	18800.00	59.99	0.02	56	3622.33	25.60	0.05
Malta	*Citrus sinensis*	55	2819.18	20.33	0.04	156	12110.56	71.08	0.02
Mulberry	*Morus alba*	36	2563.45	16.94	0.03	22	1131.78	12.13	0.04
Guava	*Psidium guajava*	73	6770.27	33.94	0.02	89	6755.11	40.30	0.04
Kagzi Nimbu	*Citrus aurantiifolia*	9	771.91	4.39	0.11	0	0.00	0	0
Bhimal	*Grewia optiva*	9	1868.27	5.72	0.11	67	6888.89	33.73	0.06
Banana	*Musa paradisica*	55	7596.27	26.09	0.04	100	12974.89	50.99	0.09
Peach	*Prunus persica*	9	505.91	4.07	0.11	33	2358.22	19.46	0.03
Papaya	*Carica papaya*	73	5998.27	31.08	0.02	11	527.89	5.99	0.09
Phalsa	*Grewia asiatica*	9	7491.45	12.50	0.11	0	0.00	0	0
Chanchari	*Ficus subincisa*	9	498.73	4.06	0.11	0	0.00	0	0
Chulu	*Prunus armeniaca*	9	835.45	4.47	0.11	11	219.78	5.40	0.09
Anaar	*Punica granatum*	18	414.55	7.42	0.06	0	0.00	0	0
Kathal	*Artocarpus heterophyllus*	9	4981.27	9.47	0.11	0	0.00	0	0
Dainkan	*Melia azaderach*	27	8951.00	19.26	0.08	22	3069.67	15.86	0.04
Chabutra	*Citrus paradisi*	27	1984.91	10.86	0.08	11	896.78	6.70	0.09
Dhaura	*Anogeissus latifolia*	9	1756.82	5.58	0.11	0	0.00	0	0
Akhrot	*Juglans regia*	9	4346.82	8.71	0.11	0	0.00	0	0
Pear	*Pyrus communis*	9	1931.09	5.79	0.11	0	0.00	0	0
Nimbu	*Citrus limon*	9	1090.18	4.78	0.11	0	0.00	0	0
Apple	*Mallus domestica*	9	892.00	4.54	0.11	0	0.00	0	0
Kharik	*Celtis australis*	0	0	0	0	11	1208.33	7.30	0.09
Narangi	*Citrus aurantium*	0	0	0	0	11	249.67	5.46	0.09
Herbs									
Kumarr	*Bidens pilosa*	9091	27.27	49.85	0.12	10000	33.33	75.59	0.09
Tipatti	*Oxalis spp.*	8182	18.18	49.13	0.25	12222	22.22	83.52	0.25
Billygoat weed	*Ageratum conyzoides*	20909	63.64	91.96	0.05	7778	22.22	61.23	0.16
Gallant soldier	*Galinsoga parviflora*	1818	9.09	19.14	0.22	4444	11.11	43.93	0.36
Kana	*Commelina benghalensis*	10000	36.36	53.66	0.08	3333	11.11	35.72	0.27
Asthma plant	*Euphorbia hirta*	5455	18.18	36.26	0.17	0	0	0	0
Agricultural crops									
Mirch	*Capsicum annuum*	39091	81.82	92.91	0.06	32222	77.78	72.81	0.05
Baingan	*Solanum melongena*	1818	9.09	13.04	0.22	7778	33.33	26.77	0.07
Lauki	*Lagenaria siceraria*	909	9.09	8.08	0.11	1111	11.11	8.14	0.09
Maize	*Zea mays*	4545	18.18	21.33	0.14	4444	22.22	18.63	0.09
Maize	*Zea mays*	4545	18.18	21.33	0.14	4444	22.22	18.63	0.09
Adrak	*Zingiber officinale*	5455	18.18	24.35	0.17	13333	33.33	38.51	0.12

Cont...

Table 3. Phytosociological attributes of homegarden

Trees	Botanical name	Lower altitude (300-1200 masl)				Middle altitude (1200-2000 masl)			
		Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F	Density (Plants/ha)	Total basal cover (cm^2/ha)	IVI	A/F
Arvi	*Colocasia esculenta*	14545	63.64	47.95	0.04	16667	66.67	47.12	0.04
Haldi	*Curcuma longa*	10000	45.45	35.99	0.05	5556	22.22	21.56	0.11
Karela	*Memordica charantia*	909	9.09	8.08	0.11	0	0	0	0
Tomato	*Solanum lycopersicum*	1818	18.18	12.28	0.06	0	0	0	0
Bhindi	*Abelmoschus esculentus*	2727	9.09	18.00	0.33	0	0	0	0
Sugarcane	*Saccharum officinarum*	2727	9.09	18.00	0.33	0	0	0	0
Beans	*Phaseolus vulgaris*	0	0	0	0	4444	22.22	18.63	0.09
Rai	*Brassica juncea*	0	0	0	0	2222	11.11	12.82	0.18
Reddish	*Raphanus sativus*	0	0	0	0	1111	11.11	8.14	0.09
Pudina	*Mentha spicata*	0	0	0	0	5556	11.11	26.89	0.45

biodiversity conservation. Lower altitude reported 21 trees, 6 herb and 11 agricultural species, whereas middle altitude recorded 13 trees, 5 herb, and 11 agricultural species (Table 3). Plant density was higher at the middle altitudes of the tree layer and agricultural crop layer. The highest IVI value was recorded for *Mangifera indica* (59.99) in lower altitude and for *Citrus sinensis* (71.08) in middle altitude. While the minimum value of IVI was found for *Prunus persica* (4.07) in lower altitude and for *P. armeniaca* (5.40) in middle altitude. *A. conyzoides* (91.96) in lower altitude and *Oxalis* spp. (83.52) in middle altitude had the highest IVI values in the herb layer. Minimum IVI value for herbs was recorded for *Galinsoga parviflora* (19.14) in lower altitude and *Commelina benghalensis* (35.72) in middle altitude. *Capsicum annuum* was the most prominent agricultural crop in both altitudes, with an IVI value of 92.91 in lower altitude and 72.81 in middle altitude.

CONCLUSION

Traditional agroforestry systems found in the study area support a diverse range of vegetation. People manage these systems based on their requirements. The home garden supports maximum tree density. Trees are cultivated on agricultural bunds in agri-silviculture systems, whereas in homegardens, they are grown during the farm. However, the density of herbs in the home garden is lower due to constant weeding by households. Agri-silviculture systems showed higher density of agricultural crops than homegardens owing to difference in structural compositions. Silvi-pasture system includes trees and grasses with high fodder value. The system, altitudinal gradient and climatic conditions influence the kind of species and their distribution. The current study reveals that traditional Agroforestry systems are essential not just for meeting people's basic needs for livelihood support, but also for conserving the area's biodiversity.

REFERENCES

Arunachalam A, Chavan SB, Handa AK, Kumar A, Bhaskar S, Alagusundaram K and Mohapatra T 2019. Agroforestry Systems for the Indian Himalayan Region. *Indian Council of Agricultural Research, New Delhi;* pp 19.

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.

Chappell MJ and LaValle LA 2011. Food security and biodiversity: Can we have both? An agroecological analysis. *Agriculture and Human Values* **28**(1): 3-26.

Chaturvedi MD and Khanna LS 1984. Forest Mensuration. *International Book Distributers, Dehradun*. Pp.86-94.

Chavan SB, Dhillon RS, Ajit; Rizvi RH, Sirohi C, Handa AK, Bharadwaj KK, Johar V, Kumar T, Singh P, Daneva V and Kumari S 2022. Estimating biomass production and carbon sequestration of poplar-based agroforestry systems in India. *Environment, Development and Sustainability* **24**: 13493-13521.

Chavan SB, Keerthika A, Dhyani SK, Handa AK, Newaj R and Rajarajan K 2015. National Agroforestry Policy in India: a low hanging fruit. *Current Science* **25**: 1826-1834.

Chavan SB, Uthappa AR, Sridhar KB, Keerthika A, Handa AK, Newaj R, Kumar N, Kumar D, Chaturvedi OP 2016. Trees for life: Creating sustainable livelihood in Bundelkhand region of central India. *Current Science* **25:** 994-1002.

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.

Guillerme S, Kumar BM, Menon A, Hinnewinkel C, Maire E and Santhoshkumar AV 2011. Impacts of public policies and farmer preferences on Agroforestry practices in Kerala India. *Environmental Management* **48**(2): 351-364.

Kumari A, Sehgal R and Kumar S 2008. Traditional Agroforestry Systems Practiced in Lahaul (Lahaul & Spiti) and Kinnaur Districts of Himachal Pradesh. *Indian Forester* 1003-1010.

Linger E 2014. Agro-ecosystem and socio-economic role of home garden Agroforestry in Jabithenan District, North-Western Ethiopia: Implication for climate change adaptation. *Springer Plus* **3**: 1-9.

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): 77-81.

Newaj R, Chavan SB, Kumar D, Uthappa AR, Singh M and Sridhar KB 2016. Agroforestry research in India: Relevance in livelihood and climate change. *Agroforestry Research Development* (Editors: JC Dagar and JC Tiwari) Nova Science Publisher, New York.

Parmar MK and Negi RS 2017. Physico chemical analysis of soil: A case study of Takoli Gad Watershed, Garhwal Himalaya. *International Journal of Applied and Pure Science and Agriculture* **3**(7): e-ISSN: 2394-5532, p-ISSN: 2394-823X.

Parmar. MK, Negi RS and Purohit K 2012. Implications of GIS application for the sustainable watershed development in Garhwal Himalaya: A case study of Takoli Gad Watershed, District Tehri Garhwal, Uttarakhand. *International Journal of Basic and Applied Sciences* **1**(3): 227-234.

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

Sharma, R, Xu J and Sharma G 2007. Traditional Agroforestry in the eastern Himalayan region: Land management system supporting ecosystem services. *Tropical Ecology* **48**: 1-12.

Singh VP and Dagar JC 1990. Agroforestry systems for Mussoorie Hills in Western Himalayas. *Indian Forester* **115**(7) 610-614.

Sunderland TCH 2011. Food security: Why is biodiversity important? *International Forestry Review* **13**(3): 265-274.

Sundriyal RC and Sharma E 1996. Anthropogenic pressure on tree structure and biomass in the temperate forest of Mamlay Watershed in Sikkim. *Forest Ecology and Management* **81**: 1-3.

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, Gupta NK and Gupta B 2005. An appraisal of biological diversity in agroforestry systems in North-Western Himalaya. *Indian Journal of Ecology* **32**(1): 7-12.

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.

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

Vikrant KK, Chauhan DS, Rizvi RH and Maurya A 2018. Mapping the extend of agroforestry area in different altitudes of Tehri district, North Western Himalaya, India through GIS and remote sensing. *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.

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