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Phytosociological Analysis of Functional Components in Silvipastoral Land Use Systems of Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author SL contributed to the study's conception, design, review of literature, and writing the manuscript. Field data collection and analysis were performed by authors SP, VC and Varsha. All authors read and approved the final manuscript.

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ABSTRACT

Phytosociological studies are important for devising suitable conservation strategies of the plant genetic resources. Himachal Pradesh is a north-western Himalayan state with diverse landscape having rich and unique floristic diversity. Silvipastoral systems are one among the most prominent agroforestry land use systems which contributes significantly in productivity, ecological balance and livelihood of local communities. Thus, to know the status of floristic and phytosociological diversity in these land use systems, the present study has been conducted from April 2018 to March 2022 in 12 selected villages in Himachal Pradesh. Total number of plant species recorded in study area was 1046 (including 114 tree, 170 shrub and 762 herb species), belonging to 108 families and 538 genera. Poaceae, Asteraceae, Fabaceae, Rosaceae and Lamiaceae were the five most dominant families. Maximum tree density recorded for species *Myrica esculenta* (980 ind. ha^{-1}) at site 3,

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Grewia optiva (660 ind. ha^{-1}) at site 2 and *Grewia optiva* (640 ind. ha^{-1}) at Site 1 Naun, Mandi, followed by *Bauhinia variegata* (630 ind. $ha^{-1)}$ at Site 2 Banalgi, Solan in zone-II. On the basis of IVI, *Cedrus deodara* (252.30) was most dominant species followed by *Quercus oblongata* (193.11), *Pinus wallichiana* (164.68) and *Myrica esculenta* (149.10). Among the shrubs *Hippophae salicifolia* (119.24) was most dominant species followed by *Berberis lycium* (96.14) and *Berberis aristata* (90.98). However, *Achyranthus aspera* (107.66) was most dominant herb species followed by *Commelina benghalensis* (97.50) and *Sonchus asper* (44.01). The lowest value of IVI was observed for *Capsella bursa-pastoris* (9.63) and *Tanacetum dolichophyllum* (10.54). According to CAMP (Conservation Assessment and Management Prioritization), 2013 nine species viz., *Angelica glauca, Berberis aristata, Dioscorea deltoidea*, *Polygonatum cirrhifolium, Hyoscyamus niger, Bunium persicum, Ephedra gerardiana, Juniperus communis* and *Selinum vaginatum* are threatened and requires conservation and management efforts. In past no study was conducted on floristic and phytosociology diversity of silvipastoral systems of Himachal Pradesh. Hence, present study will definitely act as base line data for further in-depth studies on restoration of degraded lands and silvipastoral system management and improvement programs.

Keywords: Agroforestry; floristic diversity; important value index; North Western Himalaya; phytosociology; silvipastoral systems.

1. INTRODUCTION

Floristic composition refers to a measure of species diversity in a community [1]. Knowledge of the biodiversity of any area is required for sustainable utilization, management, and conservation of natural resources [2]. The floristic composition of different land use systems is liable to change with season besides biotic and abiotic factors [3]. Floristic composition enables scientists to understand differences among various land use systems, their role in biodiversity and the conservation of important vulnerable species [4,5]. The adaptation potential and gene pool of any community is reflected by the species diversity [6]. Nature has gifted Indian Himalayn Region with diverse landscapes which retains a variety of unique habitats having rich repository of plant wealth. But, with the modernization the forest genetic resources are highly affected due to their over exploitation and unsustainable utilization. These negative impacts are visible in all parts of Himalayas but, low and mid Himalayan regions are severely affected due to high human and livestock population.

Traditional Himalayan agroforestry systems are complex in nature and structural and functional attributes of constituent species of these systems are greatly affected by complex interactions. Performance of components are also determined by the associated components density and frequency. Phytosociological analyses of agroforesty systems help us to access the production potentials under specific site conditions [7]. Silvipastoral systems are one of the most important land use system type of agroforestry systems in which trees and shrubs are combined with livestock and pasture production on the same unit of land. Within this broad category, several types of systems and practices can be identified depending on the role of the tree/shrub component; viz. cut and carries system, live fences, browsing and grazing [8]. Functional unit's woody + grass/forbs components and/or livestock were considered to identify silvipastoral systems and system units. The Silvopastoral system consists of three fundamental components, namely Agriculture, Forestry, and Livestock. These components constitute two important systems together with livestock: a) Silvipastoral system (Forestry + Livestock) and; b) Agrisilvipastoral system (Agriculture + Forestry + Livestock) [9,10].

Silvipastoral systems are most common form of agroforestry [11]. Effect of altitudinal variation on structure and composition of the vegetation in natural Himalaya forest of Parshuram Kund area in Lohit district of Arunachal Pradesh was studied by [12] and they recorded higher shrub and herb species richness on middle altitude followed by lower and upper altitudes. A study on dominance, diversity and species richness of the species along an altitudinal gradient of Mandakani catchment of Garhwal Himalaya conducted by [13] and they recorded the values of the density (trees/ha) and total basal area (m^2/ha) of selected strands range between 2448 and 600 trees/ha and 53.44-29.36 m^2/ha. Tree diversity in the agroforestry systems of North-eastern part of Karnataka was studied by [14] and they reported 52 tree species with a mean species density 9.04 ha^{-1} and mean number of

trees 104.24 ha^{-1}. Phytosociological analysis of woody species in sub-montane, montane and sub-alpine zones of Garhwal Himalaya was done by [15] and in their study, they reported a total of 94 woody plant species belonging to 72 genera and 44 families and the density varied from 235±9 to 505±21 trees ha $^{-1}$ and 4,730±474 to 9,530±700 shrubs ha^{-1}.

Floristic diversity studies along an altitudinal gradient in Kinnaur district of Himachal Pradesh was studied by [1] and they reported 142 plant species belonging to 49 families and 105 genera from study area. They also found that the number of shrub and herb species decreased as elevation increased and the distribution of species at different elevation was contiguous. *Populus nigra* was the dominant tree species at 3000-3500 m asl and *Ephedra gerardiana* was dominant at 3000 to 4000 m asl. Floristic composition and distribution pattern of plant communities under different agroforestry systems in Kinnaur, Himachal Pradesh was studied by [16] and a total of 17 tree species belonging to 8 different families were recorded by them in agri-horticulture, agri-silviculture and agri-horti-silviculture systems. The apple tree (*Malus domestica)* was recorded to be dominant fruit tree species with highest IVI values. Among all shrubs, *Artemisia vulgaris* (426.67 plants ha^{-1}) was most dominant shrub species found in both climatic conditions with (87.39) IVI value. *Malus domestica* was most dominant tree species showed highest density (503.33 plants ha^{-1}) and highest IVI (287.58). Floristic composition and natural regeneration status of Chir pine forests in Sirmaur district of Himachal Pradesh was studied [17] and the maximum density (690 individuals ha^{-1}), abundance (6.9), basal area of 44.65 m^2 ha^{-1} and IVI of 269.95 was recorded for Chir pine tree species. Phytosociological analysis of woody and non-woody components under some agroforestry systems in Kuthar village of Kuthar forest range, district Solan of Himachal Pradesh was carried out by [18] and in their study they found that horti-silvipastoral system was more diversified with 12 tree, 4 shrubs, 7 herbs and 6 fruit species. *Acacia catechu, Grewia optiva, Celtis australis* and *Pyrus pashia* were dominant trees; *Murrya koenigii, Lantana camera* and *Berberis lycium* were dominant shrubs and *Lathyrus aphaca*, *Chrysopogon montanus* and *Cyperus rotundus* were dominant herb species in different agroforestry systems. The review of literature revealed that, in general, few studies are available on floristic and phytosociological analysis of different agroforestry systems in different parts of India as well as in Himachal Pradesh. However, phytosociological analysis silvipastoral land use systems have not been studied considering the whole Himachal Pradesh as a single unit although it caters various domestic needs viz., fuel, fodder etc., of the farming communities.

2. MATERIALS AND METHODS

The present study has been conducted in the state of Himachal Pradesh, India. As per the Census 2011, the total Population of Himachal Pradesh is 68.64602 Lacs forms 0.57 percent of India. The climate is temperate and consist of three distinct seasons i.e., winter, summer and rainy. In the present study firstly, the state was divided into four agroclimatic zones based on agroclimatic conditions of the state. Extensive field surveys were conducted in all four agroclimatic zones of Himachal Pradesh. Total 360 villages were surveyed form all four agroclimatic zones of Himachal Pradesh of which 12 villages viz., Zone I: Jogipanga (Una), Masiyana (Hamirpur), Bhakra (Bilaspur), Shiun Khas (Kangra); Zone II: Naun (Mandi), Banalgi (Solan), Keela Kalanj (Sirmour); Zone III: Ghiaghi (Kullu), Jarashi (Shimla), Kundi (Chamba); Zone IV: Roghi (Kinnaur), Muling (Lahaul-Spiti) representing all twelve districts and agroclimatic zones of Himachal Pradesh were selected for the present study (Fig. 1).

For the selection of villages, detailed information regarding the occurrence of silvipastoral systems and community dependency was obtained from forest officials of respective areas. Stratified classification of agroforestry practices given by Zou and Sanford (1990) was used to identify the silvopastoral systems and woody and herbaceous components are major functional components of silvopastoral systems [19]. Basic functional units of silvopastoral systems has been identified as combination of specific species within a component with the species from other components. The species composition of herbs, shrubs and trees were recorded in standard sample plots. In silvipastoral systems of all twelve selected villages of different agroclimatic zones three experimental plots (1ha each) were laid out for qualitative assessment of herbs, shrubs and trees following standard ecological methods [7,20,21,5]. In all 36 sampled plots, trees were sampled randomly by laying 10 quadrats of 10x10m, shrubs by 30 quadrats of 5x5m and herbs by 50 quadrats of 1x1m. The circumference at breast height (cbh) i.e., 1.37m

from ground level was measured for each individual tree. Individual with cbh>31.5 cm was considered tree. Shrubs were considered as woody species having several branches arising from the base [7] and herbs were considered as those species having aerial part surviving for one season through their underground parts i.e. roots, rhizomes, bulb etc., may remain alive during the other season. Samples of the species also collected from each site and identified with the help of available floras [22-28,3] and other published literature. Sampling of the population in each site will be done in a peak season of growth i.e., Mid-June to September. Data analysis was performed on the data using MS Excel 2016. Species diversity (H') was calculated by using the Shannon-Wiener information index (Shannon and Wiener 1963) as follows.

$$H' = \sum_{i=1}^{S} \text{pi} \ln \mathbf{pi}$$

Where, pi = the proportion of individuals of species i

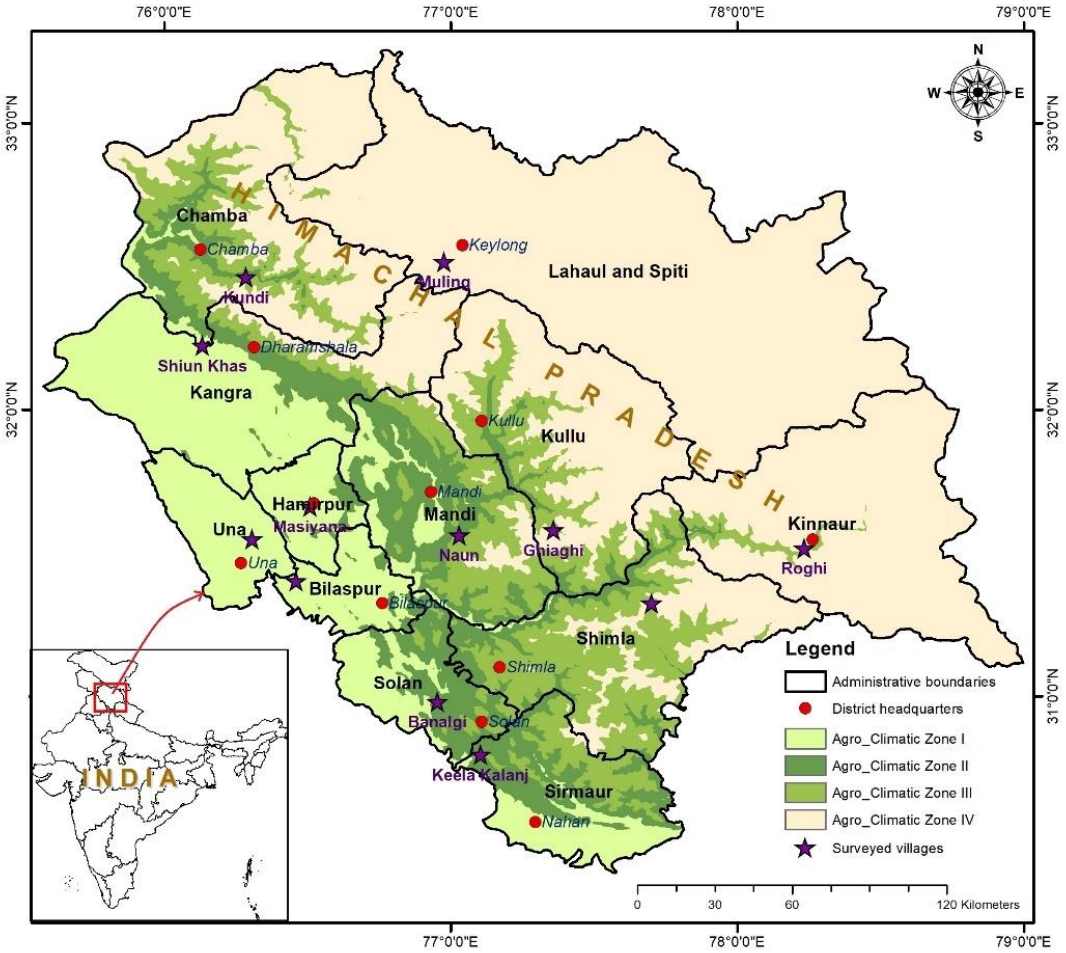


Fig. 1. Map of the study area

The Concentration of dominance (Cd) was calculated using Simpson's index (Simpson 1949) as follows.

$$D = \sum (n / N)^2 \qquad D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species
N = the total number of organisms of all species
(The value of D ranges between 0 and 1)

Basal area, Frequency, Density, Abundance, Relative Frequency, Relative Density and Relative dominance and Important Value Index [21,29] of the species were calculated as:

Basal area= πr^2, where 'r' is the radius of the species.

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Density} = \frac{\text{Total number of individual of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance} = \frac{Total\ number\ of\ individual\ of\ species}{Total\ number\ of\ quadrate\ of\ occurrence}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Density of all the species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Dominance

3. RESULTS AND DISCUSSION

Phytosociological studies for trees, shrubs and herbs were conducted in the selected villages of different agroclimatic zones of Himachal Pradesh. The range of altitude varied from 500m to 3080m. The total number of plant species recorded in the study area was 1046, belonging to 538 genera and 108 families. The dominant families included Poaceae, Asteraceae, Fabaceae, Rosaceae and Lamiaceae. Some photographs of plant species found in Silvipastoral systems of Himachal Pradesh is given in Plate 1. The comparative phytosociological status of tree, shrubs and herb species in silvipastoral systems of Himachal Pradesh are described as below:

Phytosociological studies on tree species in silvipastoral land use systems revealed that in Zone I, maximum IVI in Una was found in *Pinus roxburghii* (86.86), in Kangra *Acacia catechu* (59.54), in Hamirpur *Acacia catechu* (72.06), in Bilaspur *Acacia catechu* (60.74); Maximum TBA in Una was found in *Pinus roxburghii* (16.98), in Kangra *Mangifera indica* (17.72), in Hamirpur *Acacia catechu* (16.46), in Bilaspur *Mangifera indica* (10.92); Maximum Density in Una was found in *Pinus roxburghii* (400.00 Ind/ha), in Kangra *Acacia catechu* (320.00 Ind/ha), in Hamirpur *Acacia catechu* (560.00 Ind/ha), in Bilaspur *Acacia catechu* (260.00 Ind/ha); Maximum Species diversity in Una was found in *Pinus roxburghii* (0.36), in Kangra *Acacia catechu* (0.35), in Hamirpur *Acacia catechu* (0.36), in Bilaspur *Acacia catechu* (0.36); Maximum Concentration of dominance in Una was found in *Butea monosperma* (0.5540), in Kangra *Acacia catechu* (0.0846), in Hamirpur *Acacia catechu* (0.1176), in Bilaspur *Acacia catechu* (0.0958).

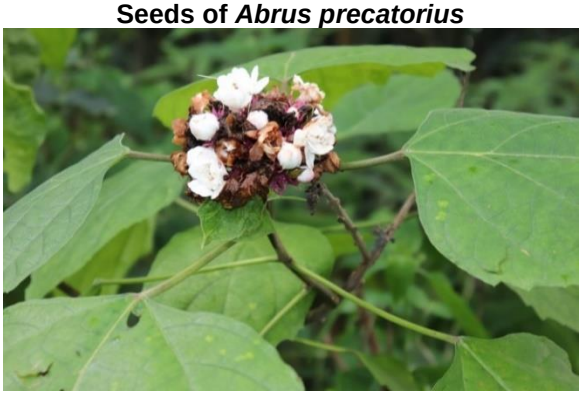
In Zone II, maximum IVI in Mandi was found in *Myrica esculenta* (149.10), in Sirmour *Pinus roxburghii* (83.56), in Solan *Phoenix sylvestris* (100.31); maximum TBA in Mandi was found in *Myrica esculenta* (26.31), in Sirmour *Melia azaderach* (9.33), in Solan *Albizia odoratissima* (92.30); maximum density in Mandi was found in *Myrica esculenta* (980.00 Ind/ha), in Sirmour *Pinus roxburghii* (310.00 Ind/ha), in Solan *Bauhinia variegata* (630.00 Ind/ha); maximum species diversity in Mandi was found in *Grewia optiva* (0.36), in Sirmour *Melia azaderach* (0.36), in Solan *Phoenix sylvestris* and *Bauhinia*

variegata (0.36, each); maximum concentration of dominance in Mandi was found in *Myrica esculenta* (0.2997), in Sirmour *Melia azaderach* (0.0942), in Solan *Phoenix sylvestris* (0.1233).

Flowers of *Mucuna pruriens*

Seeds of *Abrus precatorius*

Flowers of *Erythrina suberosa*



Flowers and leaves of *Clerodendrum chinense*

Flower of *Vigna vexillata*

Aerial part of *Zingiber chrysanthum*

Aerial part of *Evolvulus alsinoides*

Flower of *Bauhinia variegata*

Plate 1. Some photographs of plant species found in Silvipastoral systems of Himachal Pradesh

In Zone III, maximum IVI in Kullu was found in *Cedrus deodara* (138.31), in Shimla *Quercus oblongata* (193.11), in Chamba *Cedrus deodara* (109.87); Maximum TBA in Kullu was found in *Cedrus deodara* (20.56), in Shimla *Quercus oblongata* (99.74), in Chamba *Pinus wallichiana* (199.10); Maximum density in Kullu was found in *Cedrus deodara* (430.00 Ind/ha), in Shimla *Quercus oblongata* (610.00 Ind/ha), in Chamba *Cedrus deodara* (100.00 Ind/ha); Maximum species diversity in Kullu was found in *Quercus floribunda* (0.35), in Shimla *Quercus oblongata* (0.37), in Chamba *Cedrus deodara* (0.37); maximum concentration of dominance in Kullu was found in *Cedrus deodara* (0.5244), in Shimla *Quercus oblongata* (0.7262), in Chamba *Cedrus deodara* (0.3537).

In Zone IV, maximum IVI in Kinnaur was found in *Cedrus deodara* (252.30), in Lahaul and Spiti *Pinus wallichiana* (164.32); maximum TBA in Kinnaur was found in *Alnus nitida* (1027.66), in Lahaul and Spiti *Salix fragalis* (137.90); maximum Density in Kinnaur was found in *Alnus nitida* (620.00 Ind/ha), in Lahaul and Spiti *Salix fragilis* and *Pinus wallichiana* (190.00 Ind/ha); maximum species diversity in Kinnaur was found in *Pinus wallichiana* (0.37), in Lahaul and Spiti *Salix acmophylla* (0.36); maximum concentration of dominance in Kinnaur was found in *Cedrus deodara* and *Alnus nitida* (0.5000, each), in Lahaul and Spiti *Salix fragilis* (0.5278).

Phytosociological studies on shrub species in silvipastoral land use systems revealed that in Zone I, maximum IVI in Una was found in *Agave americana* (83.59), in Kangra *Dodonea viscosa* (55.19), in Hamirpur *Lanatana camera* (77.06), in Bilaspur *Lanatana camera* (76.36); maximum TBA in Una was found in *Dendrocalamus strictus* (128.98), in Kangra *Dendrocalamus strictus* (123.52), in Hamirpur *Reinwardia indica* (79.85), in Bilaspur *Jatropha ceroides* (238.75); maximum density in Una was found in *Dodonea viscosa* (6444.44 Ind/ha), in Kangra *Dodonea viscosa* (6481.48 Ind/ha), in Hamirpur *Murraya koenigii* (5074.07 Ind/ha), in Bilaspur *Jatropha ceroides* (8185.19 Ind/ha); maximum species diversity in Una was found in *Opuntia monocantha* (4.25), in Kangra *Euphorbia royleana* and *Dodonea viscosa* (0.30, each), in Hamirpur *Dendrocalamus strictus* (4.24), in Bilaspur *Indigofera cassioides* (4.30); maximum concentration of dominance in Una was found in *Agave americana* (0.2786), in Kangra *Dodonea viscosa* (0.1698), in Hamirpur *Lantana camera* (0.0660), in Bilaspur *Jatropha ceroides* (0.2721).

In Zone II, maximum IVI in Mandi was found in *Dodonea viscosa* (68.21), in Sirmour *Isodon rugosus* (68.55), in Solan *Mimosa rubicaulis* (44.54); maximum TBA in Mandi was found in *Indigofera heterantha* (183.02), in Sirmour *Euphorbia royleana* (403.08), in Solan *Rubus ellipticus* (541.32); maximum density in Mandi was found in *Dodonea viscosa* (4592.59 Ind/ha), in Sirmour *Isodon rugosus* (5148.15 Ind/ha), in Solan *Isodon rugosus* (3341.25 Ind/ha); maximum species diversity in Mandi was found in *Roylea cineara* (4.64), in Sirmour *Bauhinia vahlii* (4.00), in Solan *Isodon rugosus* and *Justicia adathoda* (3.70, each); maximum concentration of dominance in Mandi was found in *Dodonea viscosa* (0.0449), in Sirmour *Isodon rugosus* (0.0522), in Solan *Mimosa rubicaulis* (0.0220).

In Zone III, Maximum IVI in Kullu was found in *Sarcococca pruniformis* (89.56), in Shimla *Berberis lycium* (96.14), in Chamba *Daphne papyracea* (85.15); maximum TBA in Kullu was found in *Sarcococca pruniformis* (99.03), in Shimla *Berberis lycium* (153.28), in Chamba *Daphne papyracea* (91.05); maximum density in Kullu was found in *Sarcococca pruniformis* (12000.00 Ind/ha), in Shimla *Spirea canescence* (16925.93 Ind/ha), in Chamba *Desmodium elegans* (4592.59 Ind/ha); maximum species diversity in Kullu was found in *Sarcococca pruniformis* (0.36), in Shimla *Asparagus racemosus* and *Clematis grata* (3.85, each), in Chamba *Daphne papyracea* (0.36); maximum concentration of dominance in Kullu was found in *Sarcococca pruniformis* (0.2985), in Shimla *Berberis lycium* (0.3205), in Chamba *Daphne papyracea* (0.2838).

In Zone IV, maximum IVI in Kinnaur was found in *Berberis aristata* (90.98), in Lahaul and Spiti *Hippophae salicifolia* (119.24); maximum TBA in Kinnaur was found in *Sorbaria tomentosa* (613.97), in Lahaul and Spiti *Hippophae salicifolia* (79.79); maximum density in Kinnaur was found in *Rubus fruticosus* (7037.04 Ind/ha), in Lahaul and Spiti *Astragalus filicaulis* (3370.37 Ind/ha); maximum species diversity in Kinnaur was found in *Berberis arstata* and *Rubus fruticosus* (0.36, each), in Lahaul and Spiti *Hippophae salicifolia* (0.37); maximum concentration of dominance in Kinnaur was found in *Juniperus indica* (0.3033, each), in Lahaul and Spiti *Hippophae salicifolia* (0.3975).

Phytosociological studies on herb species in silvipastoral land use systems revealed that in

Zone I, maximum IVI in Una was found in *Saccharum spontaneum* (19.01), in Kangra *Alternenthera sessilis* (24.32), in Hamirpur *Achyranthes aspera* (107.66), in Bilaspur *Cymbopogon ambiguus* (38.39); maximum TBA in Una was found in *Fimbristylis cymosa* spp *cymosa* (4.27), in Kangra *Alternenthera sessilis* (0.0834), in Hamirpur *Achyranthes aspera* (13.38), in Bilaspur *Stellaria media* (112.11); maximum density in Una was found in *Commelina benghalensis* (17140.59 Ind/ha), in Kangra *Oplismenus compositus* (17100.00 Ind/ha), in Hamirpur *Paspalidium flavidum* (18200.00 Ind/ha), in Bilaspur *Veronica persica* (20400.00 Ind/ha); maximum species diversity in Una was found in *Cymbopogon martini* (0.17), in Kangra *Alternenthera sessilis* (0.32), in Hamirpur *Achyranthes aspera* (0.37), in Bilaspur *Cymbopogon ambiguus* (0.26); maximum concentration of dominance in Una was found in *Cymbopogon martini* (0.0618), in Kangra *Alternenthera sessilis* (0.1965), in Hamirpur *Achyranthes aspera* (0.3560), in Bilaspur *Cymbopogon ambiguus* (0.1252).

In Zone II, maximum IVI in Mandi was found in *Chrysopogon fulvus* (21.90), in Sirmour *Commelina benghalensis* (97.50), in Solan *Solanum manguivi* (25.47); maximum TBA in Mandi was found in *Apluda mutica* (13.48), in Sirmour *Commelina benghalensis* (4.81), in Solan *Xanthium strumarium* (563.56); maximum density in Mandi was found in *Thymus linearis* (21545.00 Ind/ha), in Sirmour *Senna tora* (18140.59 Ind/ha), in Solan *Tripogon filiformis* (18140.59 Ind/ha); maximum species diversity in Mandi was found in *Urtica dioica* (0.22), in Sirmour *Commelina benghalensis* (0.37), in Solan *Trichodesma indicum* (17.9); maximum concentration of dominance in Mandi was found in *Thymus linearis* (0.0904), in Sirmour *Commelina benghalensis* (0.3250), in Solan *Thalictrum foliolosum* (0.0838).

In Zone III, maximum IVI in Kullu was found in *Micromeria biflora* (15.15), in Shimla *Amaranthes spinosus* (13.43), in Chamba *Malva neglecta* (33.64); maximum TBA in Kullu was found in *Micromeria biflora* (2.85), in Shimla *Amaranthes spinosus* (4.04), in Chamba *Cymbopogon martini* (28.04); maximum Density in Kullu was found in *Ranunculus laetus* and *Dactylis glomerata* (10204.08 Ind/ha), in Shimla *Rumex hastatus* (19274.38 Ind/ha), in Chamba *Malva neglecta* (6462.85 Ind/ha); maximum Species diversity in Kullu was found in *Micromeria biflora* (0.16), in Shimla *Amaranthes spinosus* (0.14), in Chamba *Salvia canariensis* (0.31); maximum concentration of dominance in Kullu was found in *Micromeria biflora* (0.0505), in Shimla *Amaranthes spinosus* (0.0448), in Chamba *Malva neglecta* (0.0893).

In Zone IV, maximum IVI in Kinnaur was found in *Cannabis sativa* (29.22), in Lahaul and Spiti *Sonchus asper* (44.01); maximum TBA in Kinnaur was found in *Rubus fruticosus* (981.83), in Lahaul and Spiti *Sonchus asper* (29.24); maximum density in Kinnaur was found in *Cymbopogon pospischilii* (23809.52 Ind/ha), in Lahaul and Spiti *Geranium wallichianum* (6425.85 Ind/ha); maximum species diversity in Kinnaur was found in *Adiantum capillus veneris* (0.37), in Lahaul and Spiti *Sonchus asper* (0.28); maximum concentration of dominance in Kinnaur was found in *Adiantum capillus veneris* (0.3354), in Lahaul and Spiti *Sonchus asper* (0.1467).

Biodiversity is essential for human survival and economic well being and for the ecosystem function and stability [30]. As important part of life it acts as resource base of our daily needs and fate of future generation also depends on its sustainability [12]. Species diversity is one of the most important characteristics of community and its mechanism, which generates stability [8]. Maintenance and periodic assessment of diverse ecosystems and a whole of biological diversity therein are, therefore, crucial for long term survival of human beings [15,31]. The species diversity varies in particular forest area due to the varying altitudinal range, aspect, habitats, degree of prevailing abiotic and biotic pressures and adaptation of species [29] and elevation and aspect are major physiographic factors which influences distribution, growth form and structure of species and due to which the individual species has different value of density and basal cover [11]. According to Himachal Pradesh Forest Department Conservation Assessment & Management Prioritization (CAMP) report 57 species of medicinal plants are threatened but, in this study 9 threatened species were reported from silvipastoral systems [32]. Considering this knowledge of plant community, diversity, population, distribution etc., are essential for the sound management of Himalayan ecosystem [29]. The floristic composition results of present study are in conformity with the reports given by following workers [32, 18,33-37,1, 38, 39,15,40-46].

4. CONCLUSION

North western Himalaya occupies a special place in the mountain ecosystems of the world, mainly

because of its unique environmental conditions, flora, fauna and diverse demographic profile. In the present study 1046 woody and non-woody species, representing 108 families and 538 genera reported from silvipastoral land use systems of Himachal Pradesh, along with population status. *Angelica glauca, Berberis aristata, Dioscorea deltoidea*, *Polygonatum cirrhifolium, Hyoscyamus niger, Bunium persicum, Ephedra gerardiana, Juniperus communis* and *Selinum vaginatum* are threatened medicinal plants recorded in the silvipastoral land use systems of Himachal Pradesh and requires *in situ* and *ex situ* conservation and management efforts. In the past, there was no authentic data on the floristic composition and phyto-sociology of the silvipastoral systems of Himachal Pradesh. In view of the ecological, economic and social importance of silvipastoral systems the present study will definitely act as base line data for further in-depth studies on the development and introduction of suitable demonstration/silvipastoral models, tree-grass suitability and compatibility studies, quantitative and qualitative improvement in livestock, restoration of degraded lands and silvipastoral system management improvement programs.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Thakur NS, Gupta NK, Gupta B. Phytosociological analysis of woody and non-woody components under some agroforestry systems in western Himalaya. Indian Journal of Agroforestry. 2004;6(1):65-71.
2. Dansereau P. The origin and growth of plants in living systems, New York: Basic Books Inc; 1960.
3. Singh SK and Rawat GS. Flora of Great Himalayan National Park, Himachal Pradesh. Bishen Singh Mahendra Pal Singh, Dehradun, India; 2000.
4. Chytry M, Schaminee HJ, Schwabe A. Vegetation survey: A new focus for applied vegetation science. Applied Vegetation Science. 2011;14:435-439.
5. Gupta SR, Bhardwaj B. Biomass and productivity of forest ecosystems of Shiwaliks Hills, Journal of Tree Science. 1993;12(2):57-63.
6. Nair PKR. An Introduction to Agroforestry. Kluwer, Dordrecht; 1993.
7. Samant SS, Singh M, Lal M, Pant S. Diversity, Distribution and Prioritization of Fodder Species for Conservation in Kullu District, North western Himalaya, India. Journal of Mountain Science. 2007;4 (3): 259-274.
8. Malik ZA, Chand D, Bhatt AB. Community composition and tree population structure along a disturbance gradient in a protected area and its adjoining areas in Garhwal Himalaya, India. In: Change in cryosphere its impact on ecosystem services and rural livelihoods: Understanding local adaptation in the Himalayan region. (*Tandup* C, ed). University of Jammu, Bhaderwah, Doda, J&K, India; 2014a.
9. McNaughton, Samuel Joseph. Relationships among functional properties of Californian grassland. Nature. 1967;168-169.
10. Wikum DA, Wali MK. Analysis of North Dakota Gallery forest vegetation in relation to topographic and soil gradients. Ecological Monographs. 1974;44:441-464.
11. Whittakar RH. Communities and Ecosystem. McMillan Comp. New York; 1970.
12. Polunin O, Stainton A. Flowers of the Himalaya. Oxford University Press;1984.
13. Devlal R, Sharma N. Dominance, diversity and species richness of tree species along an altitudinal gradient of a catchment of Garhwal Himalaya. Indian Forester. 2010;136(7):943-950.
14. Doddabasawa, Murthy MM, Chittapur BM. Assessment of Tree Diversity in Agroforestry Systems under Irrigated Ecosystem. International Journal of Current Microbiology and Applied Sciences. 2017;6(10):2111-2127.
15. Malik ZA. Phytosociological behavoiur, anthropogenic disturbances and regeneration status along an altitudinal gradient in Kedarnath Wildlife Sanctuary (KWLS) and its adjoining areas. PhD

thesis, HNB Garhwal University, Srinagar Uttarakhand, India; 2014.
16. Rawat YS, Vishvakarma SCR, Oinam SS, Kuniyal JC. Diversity, distribution and vegetation assessment in the Jahlmanal watershed in cold desert of the Lahaul valley, north-western Himalaya, India. Bio geoscience and Forestry. 2010;3:65-71.
17. Attri V, Sharma DP, Dhiman R. Floristic Diversity and Natural Regeneration Status of Chir pine (*Pinus roxburghii* Sargent) Forest: a case study of Rajgarh Forest Division of Himachal Pradesh. Bulletin of Environment, Pharmacology and Life Sciences. 2017;6(9):01-06.
18. Singh PB. Flora of Mandi district Himachal Pradesh North West Himalaya. Bishen Singh Mahendra Pal Singh, Dehradun, India; 2018.
19. Zou X, Standford RL. Agroforestry systems in China: a survey and classification. Agroforestry Systems. 1990;11:85-94.
20. Singh H, Sharma M. Flora of Chamba district (Himachal Pradesh). Bishen Singh Mahendra Pal Singh, Dehradun, India; 2006.
21. Dhar U, Rawal RS, Samant SS. Structural diversity and representativeness of forest vegetation in a protected area of Kumaun Himalaya, India: implications for conservation. Biodiversity and Conservation. 1997;6:1045–1062.
22. Collett H. Flora Simlensis. Thacker Spink. & Co Calcutta and Shimla, Reprinted 1971. Dehradun; 1902.
23. Odum EP. Fundamental of Ecology. W.B. Saunders Co., Philadelphia; 1971.
24. Chowdhery HJ, Wadhwa BM. Flora of Himachal Pradesh, 3 Volumes. Botanical Survey of India, Howrah, Calcutta;1984.
25. Dhaliwal DS, Sharma M. Flora of Kullu district Himachal Pradesh. Bishen Singh Mahendra Pal Singh, Dehradun, India; 1999.
26. Singh M. Pattern, composition and vegetation dynamics of Agroforestry systems in Giri catchment, H.P. Ph.D. thesis, Dr. Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan, H.P; 2014.
27. Jyoti, Samant SS, Tewari LM, Paul S, Singh A, Bala K, Thakur P. Structural Diversity, Distribution Pattern and Regeneration of Forest communities in Shivalik Hills, Himachal Pradesh, North Western Himalaya. Biological Forum – An International Journal. 2023;15(5a):264-281.
28. Sharma N. GIS based land use planning for watershed management. Ph.D. thesis, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan, (HP), India; 2012.
29. Gairola S, Sharma CM, Suyal S, Ghildiyal SK. Species composition and diversity in mid-altitudinal moist temperate forests of the Western Himalaya. Journal of Forest Science. 2011;27:1-15.
30. Sharma VD, Gupta B. Interaction between trees and ground flora in different aged chir pine stands of sub-tropical region in India–I: Density of herbage and LAI. Indian Journal of Forestry. 2005; 28(1):28-36.
31. Malik ZA, Bhatt AB. Phytosociological analysis of woody species in Kedarnath Wildlife Sanctuary and its adjoining areas in Western Himalaya, India. Journal of Forest and Environmental Science. 2015;31(3):149-163.
32. Goraya GS, Jishtu, V, Rawat G.S, Ved DK. Wild Medicinal Plants of Himachal Pradesh: An Assessment of their Conservation Status and Management Prioritization. Himachal Pradesh Forest Department, Shimla; 2013.
33. Sharma SB, Pandey S, Upadhyaya SD, Agarwal R. Phyto-sociological Studies of Tree Species Outside Forest in Traditional Agroforesty of Chhattisgarh. Indian Journal of Agroforestry. 2006, 8(1).
34. Saxena AK, Singh JS. A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. Vegetation. 1982;50(1):3-22.
35. Salve A, Bhardwaj DR, Thakur CL. Floristic composition and distribution pattern of plant communities under different agro-forestry systems in Kinnaur, North western Himalaya. Journal of Chemical and Environmental Sciences. 2018;6(1):17-34.
36. Rana CS, Gairola S. Forest community structure and composition along elevation gradient of Parshuram Kund area in Lohit district of Arunachal Pradesh, India. Nature and Science. 2009;8(1): 44-52.
37. Singh JS. The biodiversity crisis: a multifaceted review. Current Science. 2002;82:638-647.
38. Kumari K, Verma RK, Kumar R, Thakur A. Study on Arboreal Floristic Diversity, Phytosociology and Conservation Strategy of Endangered Species in Chandi Beat of Majathal Wildlife Sanctuary, Himachal

Pradesh, Western Himalaya. International Journal of Environment and Climate Change. 2023;13(10):3263-3280.
39. Singh JS, Singh SP. Forests of Himalaya: Structure. Functioning and Impact of Man. Gyanodaya Prakashan, Nainital; 1992.
40. Kaur H, Sharma M. Flora of Sirmaur district (Himachal Pradesh). Bishen Singh Mahendra Pal Singh, Dehra Dun, India; 2004.
41. Joshi HC, Samant SS. Assessment of forest vegetation and conservation priorities of communities in part of Nanda Devi biosphere reserve, West Himalaya. Part I. International Journal of Sustainable Development and World Ecology. 2004;11:326–336.
42. Mahato D. Vegetation dynamics of chirpine forests along altitudinal gradient in Giri catchment of Himachal Pradesh. Ph.D. thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), India; 2013.
43. Nair PKR. Classification of agroforestry system. Agroforestry systems. 1985;3:92-128.
44. Pushpangadan P, Ravi K, Santosh V. Conservation and Economic Evaluation of Biodiversity. Vols.I-II, Oxford abd IBH publishing Co. Pvt. Ltd., New Delhi; 1997.
45. Verma RK, Kapoor KS. Floristic diversity along an altitudinal gradient in Namgia valley of cold desert in district Kinnaur, Himachal Pradesh. Indian Forester. 2013;130(3):202-211.
46. Zinkhan FC, Mercer DE. An assessment of agroforestry systems in the southern USA. Agroforestry Systems. 1997;35:303-321.

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