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Study on Arboreal Floristic Diversity, Phytosociology and Conservation Strategy of Endangered Species in Chandi Beat of Majathal Wildlife Sanctuary, Himachal Pradesh, Western Himalaya

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Authors' contributions

This work was carried out in collaboration among all authors. All the authors were actively involved in basic research structure development, research designing, methodology adoption, defining of intellectual content, benefit to society, and literature research. Author KK collected and analysed data, and prepared manuscript. Authors RKV and RK has edited and reviewed the manuscript. Author AT assisted in data analysis and in manuscript framing. All authors read and approved the final manuscript.

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ABSTRACT

Himachal Pradesh, a land of snow-abode mountains is significant for its natural wealth and unique habitat, flora, and fauna. Majathal Wildlife Sanctuary, the site of the present study was located in Solan and Shimla districts (Wildlife Division, Shimla) of Himachal Pradesh spread over an area of 37.71 sq km. Phytosociological studies for arboreal flora were conducted in the Chandi beat, of the sanctuary by using the quadrature method and quantitative analysis. The altitude of this beat varied from 625m to 1960m amsl. Total number of plant species recorded in the study area was 155, belonging to 46 families and 97 genera. The dominant families included Fabaceae, Moraceae, Asteraceae, Malvaceae, Lamiaceae, and Rosaceae. *Pinus roxburghii* recorded the highest value of IVI and is the most dominant tree species in the forest followed by *Quercus leucotrichophora*. Results revealed that the range of Concentration of dominance (C) 0.04-0.06, Index of Diversity (H) 2.55-3.58, Richness index (R) 3.47-7.78 and Evenness Index (E) 0.84-0.93 was for trees and range of Concentration of dominance (C) 0.03-0.04, Index of Diversity (H) 3.37-3.86, Richness index (R) 6.22-6.12 and Evenness Index (E) 0.91-0.93 for shrubs at different elevation in Chandi beat. There were three woody plant species found as threatened category plant according to CAMP, 2013 i.e., *Pleurolobus gangeticus*, *Oroxylum indicum* and *Zanthoxylum armatum* which require conservation efforts suggested except *Zanthoxylum armatum* which has shown a good population in nature. Phytosocial and floristic diversity study on woody plants was not done before in this sanctuary so it will provide baseline information on the biodiversity status of the woody vegetation of the sanctuary and encourage conservation efforts, sustainable utilization of resources, and bio-perspective.

Keywords: Biodiversity; conservation; density; floristic; frequency; threatened.

1. INTRODUCTION

India is one of the 17 mega-diverse countries of the world with a huge variation in the climate, altitude, rainfall pattern, and vegetation. It covers an area of 32,87,263 km², out of which nearly 8,09,537 km² (24.62%) geographical area of India is forest and tree cover, and 1,73,629.52 km² (5.28%) is included under a protected area network [1]. A network of 998 PAs has been established in India, comprising 106 National Parks (1.36%), 567 Wildlife Sanctuaries (3.73%), 105 Conservation Reserves (0.16%), and 220 Community Reserves (0.04%) [2]. A wildlife sanctuary is an area of major ecological, floral, faunal, or natural significance, which is notified by State Governments and protected by the Forest Department under the provisions of the Wildlife (Protection) Act, 1972.

The Himalayas is one of the youngest mountain ecosystems on this planet Earth with magnificent beauty uniqueness and endemism in life forms [3,4]. With a wider range of climates and unique habitat types, this gigantic system of mountain chains supports highly diverse flora and fauna [5-7]. Indian Himalayan Region (IHR) provides unique habitat to 18,940 species of plants, 8,500 species (40% endemics) are represented by Angiosperms; 44 species (15.91% endemics) by Gymnosperms, 600 species (25% endemics) of Pteridophytes; 1737 species (32.53% endemics)

of Bryophytes, 1,159 species (11.22% endemics) of Lichens; and 6,900 species (27.39% endemics) of Fungi [8,9]. Himachal Pradesh, a north Indian state, is located in the western part of the Himalayan range. Vast geographical spread (55,673 km²) and remarkable altitudinal variation (350-7,000 m amsl) have blessed this state with rich biodiversity. Himachal Pradesh has 37033 km² (66.52 percent of the total geographical area) total forest area out of which 1898 km² area comes under the Reserve forest, 33130 km² area protected forest and 2005 km² area under un-classed forest [1]. Conservation of biodiversity is one of the most important concerns, and the state ranks third in the country in terms of the percentage of total area under protected area coverage. There are 5 National Parks, 28 Wildlife Sanctuaries, and 3 conservation reserves that occupy about 8391.4231 km² area 15.07 percent of the state's geographical area [10]. Many researchers find the Himalayan flora to be fascinating to study because it exhibits the region's distinctiveness due to its particular environment, habitat suitability, and endemism [6]. Species cannot be studied under isolation, being at the basic level of ecological hierarchy, they play very important roles in the concerned community, ecosystem, and finally the biosphere. Dominance and diversity of any species depend upon habitat diversity, seasonal variation, edaphic factors, and anthropogenic disturbances [11]. Biotic

community refers to an assemblage of populations occurring in a prescribed area or physical habitat. It is a well-organized unit that possesses its characteristic features in addition to its components and functions through coupled metabolic transformations [12]. Owing to its high importance in explaining and predicting the vegetation structure of a community, phytosociology has been considered a basic biological science with applied importance in plant resource management [13]. Phytosociological studies allow ecologists to analyze the diversity, richness, and abundance of plants in an ecosystem. They help in depicting the rate of succession and climate change and play an important role in monitoring rare or endangered plants [14].

Knowledge of the biodiversity of an area is of paramount importance for sustainable utilization, management, and conservation of natural resources. Such a measure of plant species diversity in an area is referred to as floristic composition and diversity [15]. It is one of the major distinguishing characteristics of a community reflecting its gene pool, genetic worth, variability, and adaptation potential [16]. Floristic composition enables scientists to understand differences among various ecosystems, their role in biodiversity, and the conservation of important vulnerable species [17,18] and provides them with a tangible tool for the management of different ecological patterns and processes. Such information has its importance in the management, utilization, and conservation of plant resources for the fruitful future of mankind [6]. The present study site has a specific biodiversity and forest with grassland land use which is not explored yet and has a great potential for conservation and utilization. The sanctuary is also known for its beautiful fauna like Cheer pheasant, Ghoral, Leopard, Black Bear, Barking deer, griffon vultures, etc. which depends directly or indirectly on the diverse flora. With this information, the present study objective was refined to carry out the field survey for baseline information on arboreal plant diversity and conservation strategies for threatened plants.

2. MATERIALS AND METHODS

2.1 Study Area

Majathal Wildlife Sanctuary, the site of the present study, was located in Solan and Shimla district (Wildlife Division, Shimla) of Himachal Pradesh spread over an area of 37.71 sq km. It

is located within the Geo-coordinates North 31°18'4" N and 76°58'21"E, East 31°16'12"N and 77°02'25"E, South 31°15'03"N and 77°02'17"E and West 31°18'07" North and 77°56'26"E which falls on Survey of India toposheet No. 53A/15 and 53E/3 on scale 1: 50000. The Sanctuary was established in the year 1962, later re-notified as a wildlife sanctuary. It experiences variation with respect to altitude (600 to 1972 m amsl). The sanctuary has four beats namely as Chandi beat, Matrech beat, Harsang Bhaji, and Kangari beat. The average annual precipitation is 1,525 mm and temperature ranges between 1 °C to 35°C. Monsoon fog also persists for small duration, and high-elevation areas usually experience high-velocity winds [19]. There are two major forest types in this sanctuary viz; Himalayan Subtropical Pine Forests and Ban Oak Forests. The present study was done in the Chandi beat i.e 769 ha area of the sanctuary.

2.2 Methodology

The sites to carry out the studies were finalized after carrying out a thorough survey of the sanctuary and procurement of the relevant maps, information, etc. of the study sites. For the assessment of floristic diversity and phytosociology, the area of the different sites was further subdivided into three altitudes. While carrying out the phytosociological study stratified random sampling was carried out and quadrates of size 10mx10m and 3mx3m were laid out randomly for enumerating trees and shrubs + tree saplings, respectively. Plants will be identified with the help of standard Floras [20-22]. Quantitative analyses of vegetation, such as density, frequency, dominance, and basal area of trees and shrubs were investigated [23,24]. The Importance Value Index (IVI) was computed for various species by adding the relative values of frequency, density, and basal area [25]. Based on IVI values, dominant, co-dominant, and main associated species were identified.

The abundance-to-frequency ratio (A/F) of different species was determined to elicit the distribution pattern of the floral elements. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution [26]. The plant species diversity was calculated by following formulas:

➤ Shannon-Wiener Diversity Index (H):

The plant species diversity will be calculated following Shannon-Wiener diversity Index (H) [27].

$$H = - \sum_{i=1}^S (N_i/N) \ln (N_i/N)$$

Where N_i = Number of individuals of species i and N = Total number of individuals of all the species.

➤ **Simpson's Index:**

Dominance Index (C) will be measured by Simpson's Index [28].

$$C = \sum_{i=1}^S (N_i/N)^2$$

Where N_i = total number of individuals of particular species and N = total number of individuals of all species.

➤ **Richness Index:**

Richness Index will be estimated as per [29] i. e. $R = S - 1/\ln N$

➤ **Evenness Index:**

Evenness Index will be calculated as per [30] i. e. $E = H/\ln S$

Where S = Total number of species, N = Total number of individuals of all the species, H = Index of Diversity.

Endangered species were recorded from the latest conservation status and management prioritization (CAMP) report and previously published reports [31]. The status of their population in the wild was studied with the quantitative analysis of floristic diversity. The causes of depletion, habitat management, conservation strategies, and cultivation suggestions were studied [32,18].

3. RESULTS AND DISCUSSION

Phytosociological studies for shrubs and trees were conducted in the Chandi beat, Majathal wildlife sanctuary. The range of altitude varied from 625m to 1960m. The total number of plant species recorded in the study area was 155, belonging to 46 families and 97 genera (Plate-1). The dominant families included Fabaceae, Moraceae, Asteraceae, Malvaceae, Lamiaceae, Urticaceae, and Rosaceae (Fig. 2). At an elevation of 625-1000 m, the total number of tree

species was 48 (Table 1). *Pinus roxburghii* was the dominant species having a maximum value for density ha^{-1} (90) followed by *Lanea coromandelica* (64), *Bauhinia variegata* (64), and the lowest value (4) for *Litsea glutinosa*. Maximum frequency % was observed for *Bauhinia variegata* (28.00) followed by *Lanea coromandelica* (26.00), and minimum value (4.00) was observed for *Litsea glutinosa*, *Albizia lebbeck*, *Bridelia verrucosa*, *Dalbergia sissoo*, *Leuceana leucocephala*, *Machillus odoratissima* and *Terminalia bellirica*. Abundance was found to be highest for *Cassia fistula* and *Pinus roxburghii* (4.50) followed by (3.50) *Senegalia catechu* and minimum value (1.00) was observed for *Litsea glutinosa*, *Grewia tiliifolia*, *Kydia calycina*, *Melia azedarach*, *Albizia procera*, *Erythrina suberosa* and *Falconeria insignis*. *Pinus roxburghii* (37.19) recorded the highest value of IVI followed by *Lanea coromandelica* (22.12), and the least dominant was *Litsea glutinosa* (1.82). A contiguous distribution pattern was observed in tree species. The concentration of dominance (C), diversity index (H), richness index (R), and evenness index (E) for trees was 0.04, 3.58, 7.62, and 0.93, respectively (Table 7). A similar type of flora species has been recorded in the Pine forests of Himachal Pradesh at lower altitudes [33-35,18].

The total number of 63 shrub species was recorded at an elevation of 625-1000 m (Table 2). *Woodfordia fruticosa* was dominant species having highest value for density ha^{-1} (2592.59) followed by *Rubus ellipticus* (1092.59) *Bergera koenigii* (1037.04) and lowest value (37.04) was observed for *Trema politoria*, *Pistacia chinensis*, *Mallotus philippensis*, *Ficus auriculata*, and *Falconeria insignis*. Maximum frequency % was observed for *Woodfordia fruticosa* (38.33) followed by *Rubus ellipticus* (35.00), *Bergera koenigii* (30.00) and minimum value (3.33) was observed *Ziziphus oxyphylla*, *Ziziphus jujube*, *Vitex negundo*, *Toona ciliata*, *Sterculia villosa*, *Solanum viarum*, *Solanum indicum*, *Rhamnus virgate*, *Opuntia tuna* and *Pistacia chinensis*. In terms of abundance, *Woodfordia fruticosa* was the dominant species having a maximum value (6.09) followed by *Isodon rugosus* (5.60), *Leptodermis lanceolata* (5.33), and a minimum value (1.00) was observed for *Falconeria insignis*, *Ficus auriculata*, *Mallotus philippensis*, *Pistacia chinensis*, *Toona ciliata*. On the basis of IVI, *Woodfordia fruticosa* recorded the highest value (30.54) followed *Rubus ellipticus* (17.12), *Bergera koenigii* (16.10) and the least dominant was *Solanum virginianum* (1.00). Contiguous

distribution pattern was observed for shrubs at Chandi beat. The concentration of dominance, diversity index, richness index, and evenness index for shrub was 0.04, 3.71, 8.99 and 0.90 respectively (Table 7). Other supporting pieces of evidence also show similar type of results for biodiversity and phytosocial studies [36-41]

At an elevation varying from 1000m-1500m, the total number of tree species recorded was 37 (Table 3). *Pinus roxburghii* was dominant species having the maximum highest value for density ha^{-1} (110) followed by *Punica granatum* (56) and *Bauhinia variegata* (50), and the lowest value (4) was observed for *Albizia lebbeck*, *Albizia julibrissin*, *Syzygium cumini* and *Grewia tiliifolia*. Maximum frequency % was recorded for *Punica granatum* (40.00) followed by *Pinus roxburghii* and *Pyrus pashia* (36.00) and minimum value (2.00) was recorded for *Albizia lebbeck*, *Albizia procera*, and *Syzygium cumini*. *Bauhinia variegata* (3.57) recorded the highest value of abundance followed by *Pinus roxburghii* (3.06) and a minimum value (1.00) was observed for *Grewia tiliifolia*. Based on IVI *Pinus roxburghii* (48.40) showed the highest value followed by *Punica granatum* (27.38) and the least dominant was *Grewia tiliifolia* (2.21). A contiguous distribution pattern was observed for trees. The concentration of dominance, diversity index, richness index, and evenness index for trees was 0.06, 3.18, 6.25, and 0.89 respectively (Table 7) Other studies done by different authors also showed the results on similar lines whereas at an elevation of 1000-1500 dominant species was *Pinus roxburghii* [38-41] (Uniyal et al., 2010, Thakur et al., 2016 and Devi et al., 2019, Jhamta et al., 2019).

In between elevations of 1000m-1500m, 50 species of shrubs including saplings (Table 4) were recorded. *Rubus ellipticus* was the dominant species having a maximum value for density ha^{-1} (1592.59) followed by *Myrsine africana* (1277.78), *Woodfordia fruticosa* (1055.55), and the lowest value (37.04) was observed for *Ficus auriculata*. The highest value for frequency % was recorded for *Rubus ellipticus* (51.67) followed by *Woodfordia fruticosa* (35.00), *Myrsine africana* (26.67), and minimum value (3.33) was recorded for *Cyathula tomentosa*, *Falconeria insignis*, *Ficus auriculata*, *Salvia strobilifera*, *Toona ciliate*, *Ziziphus oxyphylla*. In term of abundance, maximum abundance was recorded for *Chromolaena odorata* (6.25) followed by *Leptodermis lanceolata* (6.00), *Senna occidentalis* (6.00), and

minimum value (1.00) was recorded for *Ficus auriculata*, *Opuntia tuna*, *Pinus roxburghii* and *Pistacia chinensis*. On the basis of IVI, *Rubus ellipticus* (23.83) recorded the highest value followed by *Myrsine africana* (18.54), *Berberis lycium* (16.23), and the least dominant was *Ziziphus oxyphylla* (1.20). Contiguous distribution pattern was observed for shrubs. The concentration of dominance, diversity index, richness index, and evenness index for shrub was 0.04, 3.59, 7.17, and 0.92 respectively (Table 7).

At an elevation of 1500m-1960m the total number of tree species recorded was 21 (Table 5). *Pinus roxburghii* was the dominant species recorded having a maximum value for density ha^{-1} (112) followed by *Quercus leucotrichophora* (94) and *Cedrus deodara* (82), and the lowest value (4) was recorded for *Butea monosperma* and *Rhododendron arboreum*. Maximum frequency % was recorded for *Pinus roxburghii* (40.00) followed by *Quercus leucotrichophora* (32.00) and minimum value (4.00) was observed *Ficus auriculata*, and *Rhododendron arboreum*. Abundance was found to be highest for *Quercus leucotrichophora* (2.94) followed by *Pinus roxburghii* (2.80), and the lowest value (1.00) was observed for *Salix tetrasperma* and *Butea monosperma*. *Pinus roxburghii* (54.36) recorded the highest value for IVI followed by *Quercus leucotrichophora* (48.58), *Cedrus deodara* (35.41), and lowest was *Ficus auriculata* (1.85). Contiguous distribution pattern was observed for trees. The concentration of dominance, diversity index, richness index, and evenness index for shrub was 0.10, 2.59, 3.50 and 0.85 respectively (Table 7). Many studies have also given similar results of species association, structure, composition, and phytosocial analysis [42,5,35,43-46].

Amongst 41 shrubs recorded at an elevation of 1500-1960, *Myrsine Africana* was the dominant species having maximum value for density ha^{-1} (1388.89) followed by *Rubus ellipticus* (740.74), *Rosa moschata* (611.11) and minimum value (37.04) was observed for *Bauhinia variegata*, *Solanum viarum*, *Pistacia chinensis* (Table 6). The highest frequency % was recorded for *Myrsine africana* (51.67) followed by *Rubus ellipticus* (35.00), *Berberis lycium* (23.33), and lowest value (3.33) was observed *Bauhinia variegata*, *Himalrandia tetrasperma*, *Pinus roxburghii*, *Pistacia chinensis*, *Pyrus pashia*, *Salvia strobilifera*, *Solanum viarum*, and *Toona ciliata*. In terms of abundance, *Isodon rugosus*

was the dominant species having maximum value (5.60) followed by *Rosa moschata* (4.71) *Sarcococca saligna* (4.67), and minimum value (1.00) was recorded for *Bauhinia variegata*, *Pistacia chinensis*, *Prunus cerasoides*, *Solanum viarum* On the basis of IVI, *Myrsine africana* (45.62) recorded the highest value followed by *Rubus ellipticus* (17.14), *Woodfordia fruticosa* (14.38) and least dominant was *Solanum viarum*

(1.25). Contiguous distribution pattern was observed for shrubs. The concentration of dominance, diversity index, richness index, and evenness index for shrub was 0.04, 3.37, 6.22, and 0.91 respectively (Table 7). Many studies show similar type of results and associations of plant species in different locations of Chir Pine and Ban forest types [47-51,44,52,46,18].

Table 1. Phytosociological attributes of tree species in Chandi beat at 625-1000 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Ailanthus excelsa</i> Roxb.	14.00	8.00	1.75	0.22	4.72
2	<i>Albizia chinensis</i> (Osbeck) Merr.	12.00	6.00	2.00	0.33	5.00
3	<i>Albizia lebbek</i> (L.) Benth.	8.00	4.00	2.00	0.50	3.23
4	<i>Albizia procera</i> (Roxb.) Benth.	8.00	8.00	1.00	0.13	3.73
5	<i>Bauhinia variegata</i> L.	64.00	28.00	2.29	0.08	19.85
6	<i>Bombax ceiba</i> L.	16.00	8.00	2.00	0.25	6.44
7	<i>Bridelia montana</i> (Roxb.) Willd.	6.00	4.00	1.50	0.38	2.20
8	<i>Broussonetia papyrifera</i> (L.) L'Hér. ex Vent	12.00	10.00	1.20	0.12	4.97
9	<i>Butea monosperma</i> (Lam.) Kuntze	12.00	6.00	2.00	0.33	3.98
10	<i>Cassia fistula</i> L.	36.00	8.00	4.50	0.56	8.73
11	<i>Celtis australis</i> L.	14.00	8.00	1.75	0.22	5.25
12	<i>Cordia dichotoma</i> G.Forst.	14.00	6.00	2.33	0.39	4.74
13	<i>Dalbergia sissoo</i> Roxb. ex DC.	32.00	14.00	2.29	0.16	10.93
14	<i>Engelhardia colebrookeana</i> Lindl.	16.00	6.00	2.67	0.44	5.23
15	<i>Erythrina suberosa</i> Roxb.	8.00	8.00	1.00	0.13	4.09
16	<i>Falconeria insignis</i> Royle	8.00	8.00	1.00	0.13	3.97
17	<i>Ficus auriculata</i> Lour.	18.00	12.00	1.50	0.13	7.48
18	<i>Ficus palmata</i> Forssk.	8.00	6.00	1.33	0.22	3.58
19	<i>Ficus racemosa</i> L.	8.00	6.00	1.33	0.22	3.33
20	<i>Flacourtia indica</i> (Burm.f.) Merr.	12.00	8.00	1.50	0.19	3.96
21	<i>Grewia optiva</i> J.R.Drumm. ex Burret	10.00	8.00	1.25	0.16	4.38
22	<i>Grewia tiliifolia</i> Vahl	6.00	6.00	1.00	0.17	2.85
23	<i>Hymenodictyon orixense</i> (Roxb.) Mabb	12.00	12.00	1.00	0.08	4.86
24	<i>Kydia calycina</i> Roxb.	6.00	6.00	1.00	0.17	3.04
25	<i>Lannea coromandelica</i> (Houtt.) Merr.	64.00	26.00	2.46	0.09	22.09
26	<i>Leucaena leucocephala</i> (Lam.) de Wit	12.00	4.00	3.00	0.75	3.92
27	<i>Litsea glutinosa</i> (Lour.) C.B.Rob.	4.00	4.00	1.00	0.25	1.82
28	<i>Machilus odoratissima</i> Nees	8.00	4.00	2.00	0.50	2.71
29	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	12.00	6.00	2.00	0.33	3.80
30	<i>Melia azedarach</i> L.	6.00	6.00	1.00	0.17	2.69
31	<i>Moringa oleifera</i> Lam.	12.00	6.00	2.00	0.33	4.51
32	<i>Oroxylum indicum</i> (L.) Kurz	8.00	6.00	1.33	0.22	3.14
33	<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	20.00	12.00	1.67	0.14	6.85
34	<i>Phoenix sylvestris</i> (L.) Roxb.	20.00	8.00	2.50	0.31	6.60
35	<i>Phyllanthus emblica</i> L.	12.00	6.00	2.00	0.33	3.68
36	<i>Pinus roxburghii</i> Sarg.	90.00	20.00	4.50	0.23	37.12
37	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J.L.Stewart) Rech.f.	18.00	8.00	2.25	0.28	7.67
38	<i>Punica granatum</i> L.	30.00	10.00	3.00	0.30	8.11
39	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don	26.00	10.00	2.60	0.26	9.00
40	<i>Salix tetrasperma</i> Roxb.	12.00	10.00	1.20	0.12	4.72
41	<i>Senegalia catechu</i> (L.f.) P.J.H.Hurter & Mabb	28.00	8.00	3.50	0.44	7.58

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
42	<i>Sterculia villosa</i> Roxb. ex Sm.	16.00	8.00	2.00	0.25	5.31
43	<i>Syzygium cumini</i> (L.) Skeels	8.00	6.00	1.33	0.22	3.78
44	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	6.00	4.00	1.50	0.38	2.53
45	<i>Toona ciliata</i> M.Roem.	20.00	8.00	2.50	0.31	7.94
46	<i>Trema politoria</i> (Planch.) Blume	18.00	8.00	2.25	0.28	5.06
47	<i>Ziziphus jujuba</i> Mill.	12.00	6.00	2.00	0.33	4.04
48	<i>Ziziphus oxyphylla</i> Edgew.	16.00	6.00	2.67	0.44	4.34

Table 2. Phytosociological attributes of shrub species in Chandī beat at 625-1000 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Abutilon indicum</i> (L.) Sweet	222.22	5.00	4.00	0.80	2.92
2	<i>Asparagus adscendens</i> Roxb.	407.41	10.00	3.67	0.37	5.12
3	<i>Barleria cristata</i> L.	444.44	13.33	3.00	0.23	6.81
4	<i>Bauhinia variegata</i> L.*	74.07	3.33	2.00	0.60	2.05
5	<i>Berberis asiatica</i> Roxb. ex DC.	407.41	8.33	4.40	0.53	5.44
6	<i>Berberis lycium</i> Royle	537.04	16.67	2.90	0.17	8.38
7	<i>Bergera koenigii</i> L.	1037.04	30.00	3.11	0.10	16.10
8	<i>Boehmeria virgata</i> var. <i>macrostachya</i> (Wight) Friis & Wilmot-Dear	185.19	3.33	5.00	1.50	2.85
9	<i>Bridelia stipularis</i> (L.) Blume	222.22	6.67	3.00	0.45	3.45
10	<i>Broussonetia papyrifera</i> (L.) L'Hér. ex Vent.*	92.59	6.67	1.25	0.19	4.29
11	<i>Buddleja asiatica</i> Lour.	370.37	8.33	4.00	0.48	5.33
12	<i>Callicarpa macrophylla</i> Vahl	370.37	11.67	2.86	0.24	6.03
13	<i>Capparis spinosa</i> L.	185.19	6.67	2.50	0.38	3.61
14	<i>Carissa spinarum</i> L.	370.37	6.67	5.00	0.75	5.18
15	<i>Cassia fistula</i> L.*	74.07	3.33	2.00	0.60	2.56
16	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	481.48	8.33	5.20	0.62	6.41
17	<i>Colebrookea oppositifolia</i> Sm.	370.37	6.67	5.00	0.75	5.34
18	<i>Cotinus coggygria</i> Scop.	444.44	20.00	2.00	0.10	7.73
19	<i>Debregeasia longifolia</i> (Burm.f.) Wedd.	240.74	5.00	4.33	0.87	3.89
20	<i>Dodonaea viscosa</i> Jacq.	518.52	16.67	2.80	0.17	8.10
21	<i>Euphorbia royleana</i> Boiss.	203.70	5.00	3.67	0.73	6.21
22	<i>Falconeria insignis</i> Royle*	37.04	3.33	1.00	0.30	1.70
23	<i>Ficus auriculata</i> Lour.*	37.04	3.33	1.00	0.30	1.05
24	<i>Flacourtia indica</i> (Burm.f.) Merr.*	111.11	3.33	3.00	0.90	2.20
25	<i>Flemingia macrophylla</i> (Willd.) Kuntze ex Merr.	148.15	6.67	2.00	0.30	2.75
26	<i>Hypericum oblongifolium</i> Choisy	388.89	15.00	2.33	0.16	6.34
27	<i>Indigofera cassioides</i> Rottler ex DC.	148.15	5.00	2.67	0.53	2.41
28	<i>Indigofera tinctoria</i> L.	185.19	5.00	3.33	0.67	2.51
29	<i>Isodon rugosus</i> (Wall. ex Benth.) Codd	518.52	8.33	5.60	0.67	6.66
30	<i>Jasminum mesnyi</i> Hance	111.11	5.00	2.00	0.40	2.09
31	<i>Justicia adhatoda</i> L.	481.48	20.00	2.17	0.11	8.16
32	<i>Leptodermis lanceolata</i> Wall.	296.30	5.00	5.33	1.07	3.85
33	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.*	37.04	3.33	1.00	0.30	2.01
34	<i>Mimosa rubicaulis</i> subsp. <i>himalayana</i> (Gamble) H.Ohashi	185.19	8.33	2.00	0.24	3.25
35	<i>Myrsine africana</i> L.	370.37	8.33	4.00	0.48	4.61
36	<i>Opuntia tuna</i> (L.) Mill.	92.59	3.33	2.50	0.75	2.69
37	<i>Ototropis multiflora</i> (DC.) H.Ohashi & K.Ohashi	259.26	10.00	2.33	0.23	4.14

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
38	<i>Phanera vahlii</i> (Wight & Arn.) Benth.	185.19	6.67	2.50	0.38	5.29
39	<i>Phoenix loureiroi</i> Kunth	166.67	5.00	3.00	0.60	4.88
40	<i>Phoenix sylvestris</i> (L.) Roxb.*	148.15	5.00	2.67	0.53	3.21
41	<i>Pinus roxburghii</i> Sarg.*	92.59	5.00	1.67	0.33	3.47
42	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J.L.Stewart) Rech.f.*	37.04	3.33	1.00	0.30	1.36
43	<i>Pleurolobus gangeticus</i> (L.) J.St.-Hil. ex H.Ohashi & K.Ohashi	111.11	5.00	2.00	0.40	1.63
44	<i>Pouzolzia rugulosa</i> (Wedd.) Acharya & Kravtsova	277.78	8.33	3.00	0.36	4.40
45	<i>Punica granatum</i> L.*	222.22	6.67	3.00	0.45	4.45
46	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don*	166.67	5.00	3.00	0.60	2.53
47	<i>Rhamnus virgata</i> Roxb.	111.11	3.33	3.00	0.90	3.42
48	<i>Rosa moschata</i> Herrm.	222.22	5.00	4.00	0.80	3.00
49	<i>Rubus ellipticus</i> Sm.	1092.59	35.00	2.81	0.08	17.12
50	<i>Senna occidentalis</i> (L.) Link	444.44	10.00	4.00	0.40	6.66
51	<i>Sohmaea laxiflora</i> (DC.) H.Ohashi & K.Ohashi	185.19	5.00	3.33	0.67	2.54
52	<i>Solanum indicum</i> L.	166.67	3.33	4.50	1.35	2.24
53	<i>Solanum viarum</i> Dunal	111.11	3.33	3.00	0.90	1.66
54	<i>Solanum virginianum</i> L.	74.07	1.67	4.00	2.40	1.00
55	<i>Sterculia villosa</i> Roxb. ex Sm.*	55.56	3.33	1.50	0.45	1.46
56	<i>Toona ciliata</i> M.Roem.*	37.04	3.33	1.00	0.30	1.60
57	<i>Trema politoria</i> (Planch.) Blume*	185.19	5.00	3.33	0.67	2.66
58	<i>Vitex negundo</i> L.	148.15	3.33	4.00	1.20	2.11
59	<i>Woodfordia fruticosa</i> (L.) Kurz	2592.59	38.33	6.09	0.16	30.54
60	<i>Xanthium strumarium</i> L.	111.11	3.33	3.00	0.90	1.75
61	<i>Zanthoxylum armatum</i> DC.	333.07	20.00	2.58	0.13	11.76
62	<i>Ziziphus jujuba</i> Mill.*	74.07	3.33	2.00	0.60	3.35
63	<i>Ziziphus oxyphylla</i> Edgew.*	111.11	3.33	3.00	0.90	1.69

* Saplings of trees

Table 3. Phytosociological attributes of tree species in Chandi beat at 1000-1500 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Ailanthus excelsa</i> Roxb.	12.00	4.00	3.00	0.75	4.85
2	<i>Albizia chinensis</i> (Osbeck) Merr.	10.00	8.00	1.25	0.16	5.36
3	<i>Albizia julibrissin</i> Durazz.	6.00	4.00	1.50	0.38	2.83
4	<i>Albizia lebbeck</i> (L.) Benth.	4.00	2.00	2.00	1.00	2.19
5	<i>Albizia procera</i> (Roxb.) Benth.	6.00	2.00	3.00	1.50	2.38
6	<i>Bauhinia variegata</i> L.	50.00	14.00	3.57	0.26	17.58
7	<i>Bombax ceiba</i> L.	16.00	12.00	1.33	0.11	8.35
8	<i>Broussonetia papyrifera</i> (L.) L'Hér. ex Vent	14.00	12.00	1.17	0.10	8.89
9	<i>Butea monosperma</i> (Lam.) Kuntze	10.00	4.00	2.50	0.63	4.18
10	<i>Celtis australis</i> L.	6.00	4.00	1.50	0.38	2.96
11	<i>Engelhardia colebrookeana</i> Lindl.	12.00	8.00	1.50	0.19	7.37
12	<i>Erythrina suberosa</i> Roxb.	8.00	4.00	2.00	0.50	3.50
13	<i>Falconeria insignis</i> Royle	14.00	8.00	1.75	0.22	5.59
14	<i>Ficus auriculata</i> Lour.	8.00	4.00	2.00	0.50	3.45
15	<i>Ficus palmata</i> Forssk.	14.00	12.00	1.17	0.10	6.98
16	<i>Ficus racemosa</i> L.	12.00	8.00	1.50	0.19	4.97
17	<i>Flacourtia indica</i> (Burm.f.) Merr.	12.00	4.00	3.00	0.75	3.81
18	<i>Grewia optiva</i> J.R.Drumm. ex Burret	10.00	4.00	2.50	0.63	4.56

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
19	<i>Grewia tiliifolia</i> Vahl	4.00	4.00	1.00	0.25	2.05
20	<i>Hymenodictyon orixense</i> (Roxb.) Mabb	6.00	4.00	1.50	0.38	2.44
21	<i>Kydia calycina</i> Roxb.	8.00	4.00	2.00	0.50	3.76
22	<i>Lannea coromandelica</i> (Houtt.) Merr.	28.00	16.00	1.75	0.11	12.32
23	<i>Leucaena leucocephala</i> (Lam.) de Wit	12.00	4.00	3.00	0.75	3.46
24	<i>Machilus odoratissima</i> Nees	8.00	4.00	2.00	0.50	3.51
25	<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	16.00	8.00	2.00	0.25	6.69
26	<i>Phyllanthus emblica</i> L.	12.00	8.00	1.50	0.19	5.64
27	<i>Pinus roxburghii</i> Sarg.	158.00	56.00	2.82	0.05	64.62
28	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J.L.Stewart) Rech.f.	10.00	6.00	1.67	0.28	4.23
29	<i>Prunus cerasoides</i> Buch.-Ham. ex D.Don	16.00	6.00	2.67	0.44	6.11
30	<i>Punica granatum</i> L.	56.00	40.00	1.40	0.04	25.27
31	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don	42.00	16.00	2.63	0.16	14.93
32	<i>Quercus leucotrichophora</i> A.Camus	38.00	16.00	2.38	0.15	22.43
33	<i>Syzygium cumini</i> (L.) Skeels	4.00	2.00	2.00	1.00	2.12
34	<i>Toona ciliata</i> M.Roem.	12.00	8.00	1.50	0.19	7.78
35	<i>Trema politoria</i> (Planch.) Blume	8.00	4.00	2.00	0.50	2.72
36	<i>Ziziphus jujuba</i> Mill.	6.00	4.00	1.50	0.38	3.24
37	<i>Ziziphus oxyphylla</i> Edgew.	20.00	10.00	2.00	0.20	6.91

Table 4. Phytosociological attributes of shrub species in Chandi beat at 1000-1500 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Asparagus adscendens</i> Roxb.	407.41	15.00	2.44	0.16	5.95
2	<i>Barleria cristata</i> L.	222.22	6.67	3.00	0.45	3.27
3	<i>Berberis asiatica</i> Roxb. ex DC.	388.89	10.00	3.50	0.35	7.67
4	<i>Berberis lycium</i> Royle	907.41	25.00	3.27	0.13	16.23
5	<i>Bergera koenigii</i> L.	703.70	16.67	3.80	0.23	9.56
6	<i>Boehmeria nivea</i> (L.) Gaudich.	148.15	6.67	2.00	0.30	2.38
7	<i>Buddleja asiatica</i> Lour.	370.37	13.33	2.50	0.19	7.30
8	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	462.96	6.67	6.25	0.94	7.09
9	<i>Colebrookea oppositifolia</i> Sm.	444.44	10.00	4.00	0.40	6.25
10	<i>Cotinus coggygria</i> Scop.	370.37	18.33	1.82	0.10	6.93
11	<i>Cyathula capitata</i> Moq.	148.15	5.00	2.67	0.53	2.38
12	<i>Cyathula tomentosa</i> (Schult.) Moq.	129.63	3.33	3.50	1.05	2.10
13	<i>Daphne papyracea</i> Wall. ex G.Don	537.04	18.33	2.64	0.14	12.18
14	<i>Debregeasia longifolia</i> (Burm.f.) Wedd.	111.11	5.00	2.00	0.40	2.02
15	<i>Deutzia staminea</i> R.Br. ex Wall.	370.37	10.00	3.33	0.33	5.19
16	<i>Duhaldea cappa</i> (Buch.-Ham. ex D.Don) Pruski & Anderb.	296.30	6.67	4.00	0.60	5.58
17	<i>Falconeria insignis</i> Royle*	74.07	3.33	2.00	0.60	2.90
18	<i>Ficus auriculata</i> Lour.*	37.04	3.33	1.00	0.30	1.82
19	<i>Flacourtia indica</i> (Burm.f.) Merr.*	74.07	5.00	1.33	0.27	5.32
20	<i>Himalrandia tetrasperma</i> (Wall. ex Roxb.) T.Yamaz.	166.67	10.00	1.50	0.15	3.16
21	<i>Hypericum oblongifolium</i> Choisy	351.85	8.33	3.80	0.46	4.83
22	<i>Indigofera tinctoria</i> L.	296.30	8.33	3.20	0.38	3.68
23	<i>Isodon rugosus</i> (Wall. ex Benth.) Codd	574.07	16.67	3.10	0.19	7.39
24	<i>Justicia adhatoda</i> L.	481.48	13.33	3.25	0.24	7.29
25	<i>Lantana camara</i> L.	314.81	13.33	2.13	0.16	4.76
26	<i>Leptodermis lanceolata</i> Wall.	555.56	8.33	6.00	0.72	6.67

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
27	<i>Mimosa rubicaulis</i> subsp. himalayana (Gamble) H.Ohashi	277.78	10.00	2.50	0.25	5.99
28	<i>Myrsine africana</i> L.	1277.78	26.67	4.31	0.16	18.54
29	<i>Opuntia tuna</i> (L.) Mill.	111.11	10.00	1.00	0.10	11.22
30	<i>Pinus roxburghii</i> Sarg.*	55.56	5.00	1.00	0.20	2.73
31	<i>Pistacia chinensis</i> subsp. integerrima (J.L.Stewart) Rech.f.*	55.56	5.00	1.00	0.20	1.31
32	<i>Pleurolobus gangeticus</i> (L.) J.St.-Hil. ex H.Ohashi & K.Ohashi	159.26	6.67	3.50	0.53	5.01
33	<i>Pouzolzia rugulosa</i> (Wedd.) Acharya & Kravtsova	129.63	8.33	1.40	0.17	2.80
34	<i>Prunus cerasoides</i> Buch.-Ham. ex D.Don*	148.15	10.00	1.33	0.13	3.52
35	<i>Punica granatum</i> L.*	222.22	10.00	2.00	0.20	3.78
36	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don*	259.26	16.67	1.40	0.08	7.60
37	<i>Rhamnus virgata</i> Roxb.	111.11	5.00	2.00	0.40	1.72
38	<i>Ricinus communis</i> L.	148.15	8.33	1.60	0.19	3.90
39	<i>Rosa moschata</i> Herrm.	351.85	13.33	2.38	0.18	5.69
40	<i>Rubus ellipticus</i> Sm.	1592.59	51.67	2.77	0.05	23.83
41	<i>Rubus niveus</i> Thunb.	222.22	8.33	2.40	0.29	3.27
42	<i>Salvia strobilifera</i> (Benth.) J.G.González	92.59	3.33	2.50	0.75	1.46
43	<i>Sarcococca saligna</i> (D.Don) Müll.Arg.	574.07	10.00	5.17	0.52	7.15
44	<i>Senna occidentalis</i> (L.) Link	333.33	5.00	6.00	1.20	5.80
45	<i>Solanum viarum</i> Dunal	185.19	6.67	2.50	0.38	2.71
46	<i>Toona ciliata</i> M.Roem.*	55.56	3.33	1.50	0.45	2.64
47	<i>Vitex negundo</i> L.	259.26	10.00	2.33	0.23	6.17
48	<i>Woodfordia fruticosa</i> (L.) Kurz	1055.55	35.00	2.71	0.08	14.72
49	<i>Zanthoxylum armatum</i> DC.	444.44	13.33	3.00	0.23	7.30
50	<i>Ziziphus oxyphylla</i> Edgew.*	74.07	3.33	2.00	0.60	1.20

* Saplings of trees

3.1 Threatened Plants

There were three woody plant species found as threatened category plant according to CAMP, 2013 report [31] i.e., *Pleurolobus gangeticus*, *Oroxylum indicum* and *Zanthoxylum armatum* (Table 8). The density of *Pleurolobus gangeticus* at 620-1000m was 111 individuals per ha, 159 individuals per ha at 1000-1500 m and 90 individuals per ha at 1500-1960 m altitude. *Zanthoxylum armatum* has recorded 533 individuals per ha at 620-1000 m, 444 individuals per ha at 1000-1500 m, and 574 individuals per ha at 1500-1960 m altitude (Tables 2, 4 and 6). This shows that the species was not endangered in this locality. *Oroxylum indicum* recorded 8 individuals per ha at 620-1000m, and no individuals were found at 1000-1500 m and 1500-1960m altitude and showed 2% frequency (Table 1). The tree is only confined to the lower altitude in the study area and few plants outside were also recorded during field surveys. The population of this tree in the wild was at an alarming stage because of exploitation from the

field for decoration in traditional Himachali caps. Due to the collection of pods seeds can not disperse naturally and regeneration in the natural habitat was not observed.

3.2 Threatened Plants Conservation Strategies

As the results has shown in the study area, three threatened plants species has been found but the population status of *Zanthoxylum armatum* was quite good due to the best suitable habitat conditions in the locality but the population size of other species was not very satisfactory as it requires conservation measures to improve its populations in the natural vicinity. *Desmodium giganticum* has shown less population in the wild which requires nursery raising and protection against forest fire as it has been observed very common incidence in the study area. *Oroxylum indicum* plant's pods are collected for cap decoration in traditional outfits, and root collection for medicinal uses which can be a reason for less population in the wild. Its nursery-

raising and plantation programs, cultivation around the agricultural farms, awareness about the endangered plants in local people, encouragement for forest department, more research from educational and research organizations, *in-vitro* propagation, and vegetative propagation techniques should be encouraged by the local forest department and research organizations. Supporting studies which also give strategies for the conservation of different plants [51,53,48,54,55,44,52,40,56, 45,46,18].

Table 5. Phytosociological attributes of tree species in Chandi beat at 1500-1960 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Ailanthus excelsa</i> Roxb.	36.00	14.00	2.57	0.18	19.74
2	<i>Albizia chinensis</i> (Osbeck) Merr.	12.00	8.00	1.50	0.19	7.28
3	<i>Bauhinia variegata</i> L.	52.00	18.00	2.89	0.16	21.24
4	<i>Butea monosperma</i> (Lam.) Kuntze	4.00	4.00	1.00	0.25	3.11
5	<i>Cedrus deodara</i> (Roxb. ex D.Don) G.Don	82.00	14.00	5.86	0.42	35.41
6	<i>Celtis australis</i> L.	12.00	8.00	1.50	0.19	8.35
7	<i>Cornus capitata</i> Wall.	14.00	8.00	1.75	0.22	7.25
8	<i>Ficus auriculata</i> Lour.	4.00	2.00	2.00	1.00	1.85
9	<i>Ficus palmata</i> Forssk.	12.00	8.00	1.50	0.19	6.64
10	<i>Grewia optiva</i> J.R.Drumm. ex Burret	16.00	10.00	1.60	0.16	8.25
11	<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	6.00	4.00	1.50	0.38	3.24
12	<i>Pinus roxburghii</i> Sarg.	112.00	40.00	2.80	0.07	54.36
13	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J.L.Stewart) Rech.f.	10.00	4.00	2.50	0.63	4.83
14	<i>Prunus cerasoides</i> Buch.-Ham. ex D.Don	16.00	10.00	1.60	0.16	9.33
15	<i>Punica granatum</i> L.	32.00	14.00	2.29	0.16	14.42
16	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don	30.00	12.00	2.50	0.21	13.38
17	<i>Quercus leucotrichophora</i> A.Camus	94.00	32.00	2.94	0.09	48.58
18	<i>Rhododendron arboreum</i> Sm.	4.00	2.00	2.00	1.00	3.03
19	<i>Robinia pseudoacacia</i> L.	32.00	16.00	2.00	0.13	13.07
20	<i>Salix tetrasperma</i> Roxb.	10.00	10.00	1.00	0.10	7.59
21	<i>Toona ciliata</i> M.Roem.	12.00	8.00	1.50	0.19	9.07

Table 6. Phytosociological attributes of shrub species in Chandi beat at 1500-1960 m elevation

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
1	<i>Asparagus adscendens</i> Roxb.	407.41	10.00	3.67	0.37	8.03
2	<i>Bauhinia variegata</i> L.*	37.04	3.33	1.00	0.30	1.26
3	<i>Berberis asiatica</i> Roxb. ex DC.	92.59	5.00	1.67	0.33	2.40
4	<i>Berberis lycium</i> Royle	592.59	23.33	2.29	0.10	12.84
5	<i>Bergera koenigii</i> L.	296.30	6.67	4.00	0.60	5.18
6	<i>Boehmeria nivea</i> (L.) Gaudich.	92.59	5.00	1.67	0.33	2.49
7	<i>Boehmeria virgata</i> var. <i>macrostachya</i> (Wight) Friis & Wilmot-Dear	185.19	8.33	2.00	0.24	4.74
8	<i>Cedrus deodara</i> (Roxb. ex D.Don) G.Don*	111.11	8.33	1.20	0.14	7.58
9	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	203.70	5.00	3.67	0.73	3.49
10	<i>Colebrookea oppositifolia</i> Sm.	277.78	8.33	3.00	0.36	5.70
11	<i>Cotinus coggygria</i> Scop.	222.22	8.33	2.40	0.29	4.64
12	<i>Daphne papyracea</i> Wall. ex G.Don	537.04	13.33	3.63	0.27	15.96
13	<i>Debregeasia longifolia</i> (Burm.f.) Wedd.	185.19	5.00	3.33	0.67	10.57
14	<i>Deutzia staminea</i> R.Br. ex Wall.	296.30	8.33	3.20	0.38	5.73
15	<i>Ficus auriculata</i> Lour.*	74.07	5.00	1.33	0.27	4.98

Sr. No.	Name of Species	Density ha ⁻¹	Frequency (%)	Abundance	A/F	IVI
16	<i>Ficus palmata</i> Forssk.*	111.11	8.33	1.20	0.14	8.19
17	<i>Himalrandia tetrasperma</i> (Wall. ex Roxb.) T.Yamaz.	111.11	3.33	3.00	0.90	2.49
18	<i>Hypericum oblongifolium</i> Choisy	462.96	18.33	2.27	0.12	11.32
19	<i>Indigofera cassioides</i> Rottler ex DC.	296.30	10.00	2.67	0.27	5.80
20	<i>Isodon rugosus</i> (Wall. ex Benth.) Codd	518.52	8.33	5.60	0.67	7.81
21	<i>Justicia adhatoda</i> L.	185.19	10.00	1.67	0.17	4.60
22	<i>Leptodermis lanceolata</i> Wall.	351.85	11.67	2.71	0.23	6.88
23	<i>Myrsine africana</i> L.	1388.89	51.67	2.42	0.05	45.62
24	<i>Pinus roxburghii</i> Sarg.*	74.07	3.33	2.00	0.60	5.81
25	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J.L.Stewart) Rech.f.	37.04	3.33	1.00	0.30	2.57
26	<i>Pleurolobus gangeticus</i> (L.) J.St.-Hil. ex H.Ohashi & K.Ohashi	90.11	5.00	2.00	0.40	2.76
27	<i>Pouzolzia rugulosa</i> (Wedd.) Acharya & Kravtsova	166.67	6.67	2.25	0.34	3.60
28	<i>Prunus cerasoides</i> Buch.-Ham. ex D.Don	74.07	6.67	1.00	0.15	5.09
29	<i>Punica granatum</i> L.	185.19	5.00	3.33	0.67	6.80
30	<i>Pyrus pashia</i> Buch.-Ham. ex D.Don	166.67	6.67	2.25	0.34	7.72
31	<i>Quercus leucotrichophora</i> A.Camus	55.56	3.33	1.50	0.45	3.78
32	<i>Rosa moschata</i> Herrm.	611.11	11.67	4.71	0.40	9.74
33	<i>Rubus ellipticus</i> Sm.	740.74	35.00	1.90	0.05	17.14
34	<i>Rubus niveus</i> Thunb.	314.81	6.67	4.25	0.64	5.29
35	<i>Salvia strobilifera</i> (Benth.) J.G.González	74.07	3.33	2.00	0.60	1.84
36	<i>Sarcococca saligna</i> (D.Don) Müll.Arg.	518.52	10.00	4.67	0.47	8.36
37	<i>Solanum viarum</i> Dunal	37.04	3.33	1.00	0.30	1.25
38	<i>Toona ciliata</i> M.Roem.*	55.56	3.33	1.50	0.45	4.26
39	<i>Vitex negundo</i> L.	259.26	6.67	3.50	0.53	4.60
40	<i>Woodfordia fruticosa</i> (L.) Kurz	388.89	8.33	4.20	0.50	6.72
41	<i>Zanthoxylum armatum</i> DC.	574.07	23.33	2.21	0.09	14.38

* Saplings of trees

Table 7. Concentration of dominance (C), Index of Diversity (H), Richness index (R) and Richness index (R) for trees and shrubs at different elevation in Chandi beat

Altitude	Plant Category	Concentration of dominance (C)	Index of Diversity (H)	Richness Index (R)	Evenness Index (E)
625-1000 m	Tree	0.04	3.58	7.78	0.93
	Shrub	0.03	3.86	9.12	0.93
1000-1500 m	Tree	0.06	3.20	6.25	0.89
	Shrub	0.03	3.62	7.19	0.93
1500-1960 m	Tree	0.11	2.55	3.47	0.84
	Shrub	0.04	3.37	6.22	0.91

Table 8. List of threatened plants found in Chandi beat

S. No.	Name of species	Habit	Threat status (As per Shimla CAMP, 2003)	Threat status (As per Kullu CAMP, 2010)	Threat status (As per IUCN, 2023)
1	<i>Pleurolobus gangeticus</i> (L.) J.St.-Hil. ex H.Ohashi & K.Ohashi	Shrub	-	NE	LC
2	<i>Oroxylum indicum</i> (L.) Kurz	Tree	-	NE	EN
3	<i>Zanthoxylum armatum</i> DC.	Shrub	EN	EN	LC

NE- Near Endangered, LC- Least concern, EN- Endangered

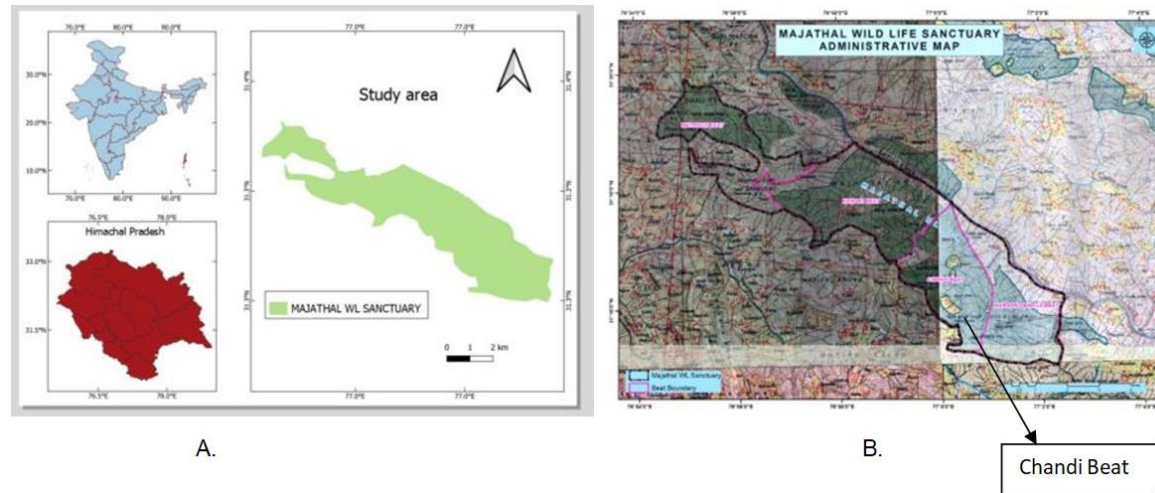


Fig. 1. A and B Map of Majathal Wildlife Sanctuary, Himachal Pradesh (Data source-Himachal Pradesh Forest Department)

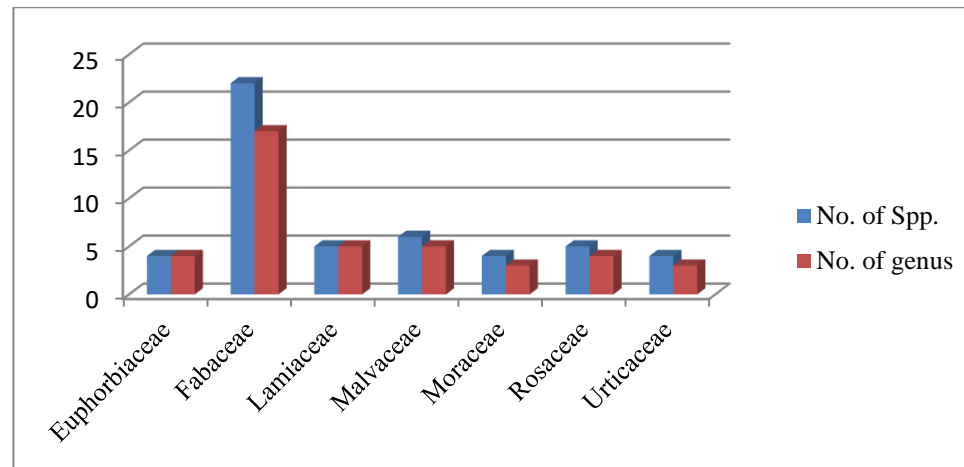


Fig. 2. Dominant families and number of genera and species found in Majathal Wildlife Sanctuary



Woodfordia fruticosa (L.) Kurz



Ficus auriculata Lour.



Senna occidentalis (L.) Link



Indigofera cassioides Rottler
ex DC.



Moringa oleifera Lam.



Ougeinia oojeinensis (Roxb.)
Hochr.



Bauhinia variegata L.



Euphorbia royleana Boiss.



Zanthoxylum armatum DC.



Bergera koenigii L.



Punica granatum L.



Berberis lycium Royle

Plate 1. Arboreal flora found in Majathal Wildlife Sanctuary, Solan



Oroxyllum indicum (L.) Kurz



Himachali Cap



Himachali (Kinnauri) local girl wearing the cap with *Oroxyllum indicum* seeds

Plate 2. *Oroxyllum indicum* tree and its seeds used as cap decorative

4. CONCLUSIONS

India is one of the largest countries in the world which holds a great wealth of nature in terms of diverse flora and fauna. In the present study, we tried to generate baseline data for the woody flora wealth of Majathal Wildlife Sanctuary. The study will help in the conservation aspects and knowing the real wealth of nature for better utilization and conservation for mankind and a glorious future of biodiversity conservation, which is a need of the hour as the climate is changing and deteriorating bio-resources. Nursery-raising and plantation programs should be encouraged by the local forest department. The study also gave a focused view of the population of endangered plant species and their present scenario. In many areas, the sanctuary was not accessible with steep slopes which is the main reason for the spread of fire in the summer season which causes the main damage to floristic diversity over time. The State Forest Department and research organizations in the state can make people aware of the importance of biodiversity and conservation methods. The present study will provide scientific ways to manage the Wildlife sanctuary.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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