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Phytosociological Analysis in Semi-Arid Region of India: A Case Study from Yadgir District, Karnataka

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KEYWORDS Dry Land Ecosystem. Plant Diversity. Species Richness. Species Utilization. Vegetation Analysis

ABSTRACT The present study covers structure, composition and distribution of vegetation in semi-arid ecosystem in respect of trees and shrubs and inventory of herbs. In the primary vegetation layer the highest density (individuals/hectare) was recorded for *Prosopisjuli flora* (133 individuals/ha) lowest for the species namely *Dalbergia sissoo* and *Terminalia catappa* (0.21 individuals/ha). The vegetation composition consists of 26.7 percent of tree species, 17.2 percent of shrubs, 42.5 percent herbs and 13.3 percent climbers forms the structure of natural ecosystems. The people of study region are using the plant diversity for various purposes for example medicine (78 species), fuel wood (26), fodder (23), edible (17), oral hygiene (11), timber (9), and other uses (3). Diversity indices for studied in semi-arid ecosystem found less than that of other ecosystems in India.The area available under forest cover is very less, that is, 3.64 percent of the studied landscape. Hence, strong conservation methods are required to protect the biodiversity for sustainable socio-ecological development.

INTRODUCTION

Arid and semi-arid regions come under dry landwhich are characterized by light inconsistent rainfall of up to 700 mm per annum, periodic droughts and different associations of vegetative cover and soils. The low amount of rainfall along with uncertainty in its pattern adversely affects the development of dry land ecosystems. The arid and semi-arid regions constitute about 65 percent of area of total dryland in the world (Nautiyal et al 2015). However, in India about 53 percent land comes under arid and semi-arid regions which are highly vulnerable to climate change. In India, the semi-arid land spreads over 9, 70,530 km^2, of 99 districts of 11 states, this is 37 percent of the total geographical area of the country. In Karnataka, semi-arid land spreads over 1, 39,000 sq km, which is about 6 percent of the total geographical area of the country (Kalsi 2007). Therefore, Karnataka is second highest state in terms of aridity after the Rajasthan (Murthy and Indumati 2011) where two-thirds of the total geographical area falling in the semi-arid zone receives less than 750 millimetres of annual rainfall with frequent drought conditions.

The varieties of factors were found to be responsible for change in the vegetation dynamics in semi-arid regions. Food and agriculture organizations reported that the population growth of semi-arid region and poverty are the underlying factors determining land degradation and biodiversity loss in the semi-arid regions. The existing plant diversity plays an important role in securing livelihood of the people and support the requirement of fodder, fuel wood, timber, non-timber forest products (NTFPs) and medicinal plants for the people inhabited in the dryland (Omuto et al. 2010). These dryland (arid and semi-arid regions) cover more than more than 40 percent area of the earth surface and have the climatic uncertainties (Sharma 2003) and the major distinguishing feature is the less rain fall and high temperature. The climatic uncertainties and associated variations make the differences between structures and functioning of the natural ecosystem therefore, socio-ecological sustainability of the people living in semi-arid landscapes face lots of challenges.To study the ecosystems, the phytosociological studies are helpful in providing the information on vegetation composition, diversity of species,

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distribution and comparison among the habitat types/ecosystems (Enright et al. 2005; Reddy et al. 2008; Kong et al. 2009). Various biotic and abiotic factors influence the diversity and distribution of the species in the natural ecosystems (Bargali et al. 2013). According to Nowak et al. (2017), one of the major factors for determining the species composition in an ecosystem is soil salinity and humidity, elevation, slope and aspect and ecological studies revels that specific plant communities like ferns and rare species adaptations and also soil contaminated with elevated levels of Co, Cu, Pb, Ni and Zn (Medianista and Labay 2017). Therefore, study on phytosociological attributes is important aspect to be taken into consideration in ecosystem research (Enright et al. 2005; Kong et al. 2009). In forest ecosystems studies the phytosociological studies are foremost requirement for understanding structure and up to certain extent the functional attributes in relation with human and plant interactions. The detailed database on phytosociological studies is available for rich and diverse landscapes of India viz., the Himalaya and the Western Ghats (Ralhan et al. 1982; Saxena and Singh 1982). However, semi-arid regions remained isolated and only few studies are available on the phytosociological attributes of ecosystems (Sharma and Pandey 2010; Prabakaran and Greeshma 2012).Therefore, in this endeavour, the present study was undertaken in the semi-arid region located in Karnataka of India to explore the species diversity, distribution and their richness in the natural ecosystems along with landscape dynamics.

The objectives of the study were (i) To study the species in their compositions, density, abundance, frequency, basal area and important value index (IVI), and (ii) To prepare the diversity indices for the species of the semi-arid ecosystems.

Study Area and Climate

The study region is located in Yadgir district of Karnataka, India (16°72’58"N latitude and 76°74’19"E longitude), bound on the west by Bijapur district, on the north by Gulbarga district, on the east by Maheboobnagar district of Telangana and on the south by Raichur district of Karnataka (Nautiyal et al. 2015). The average elevation of the study area is 426 m from sea level. The landscape which was taken for study is given in Figure 1. The temperature ranges be-

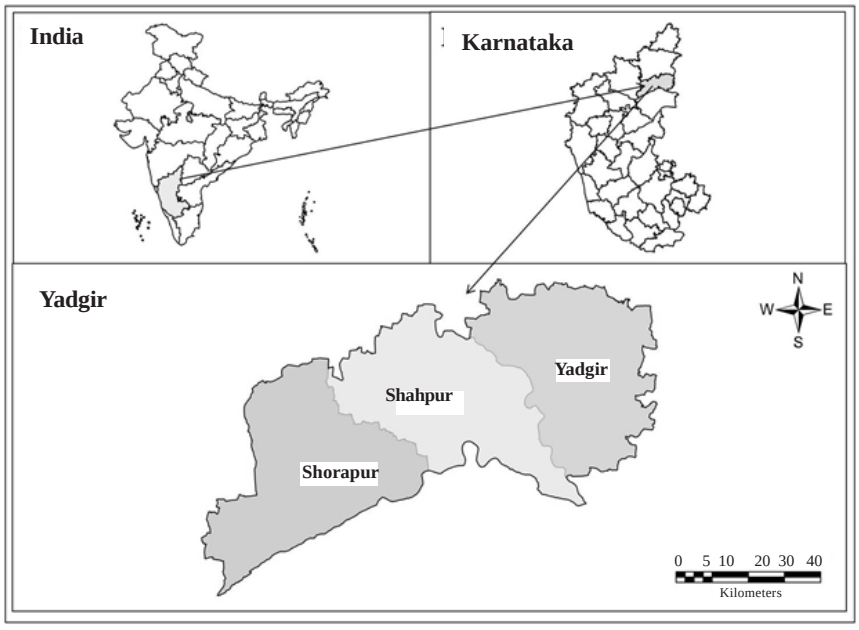

Fig. 1. Geographical location of the study area

tween 44°C in summer to 24°C in winter and relative humidity varies from 20 percent during summer to 60 percent during winter. The average rainfall is 650 mm and the normal rainy days range between 42-50 days in a year.

METHODOLOGY

The study was carried dry deciduous forest of Yadgir district in all the habitats. To analyse the vegetation ecology in the study region, standard methodswere followed (Cottam and Curtis 1956; Ralhanet al. 1982; Saxena and Singh 1982; Nayak et al. 2000; Nautiyal and Kaechele 2008; Hailu 2017). Transects were laid down starting from a base of the study area to end of the vegetation zone in each selected site for various habitat types. In each habitat, 30 quadrates in triplicates (trees (10m x10m) shrubs (5m x5m) and herbs (1mx1m)) were plotted for primary data collection (Nautiyal et al. 2015). The circumference at breast height (CBH) was for tree species at 1.37 m from ground level (Nautiyal et al. 2015). However, in the case of shrubs, circumference was measured at 10 cm above ground level. Individuals with diameter up to 3cm considered as seedlings and young tree with diameter of 3cm to 13cm and measureable about four feet above the ground considered as saplings. Herbarium specimens were prepared for all the species following standard guidelines given by Botanical Survey of India (BSI) (Nautiyal et al. 2015). The primary data collected were analysed for frequency, density, abundance, and density/hectare. Basal area, relative dominance, relative frequency and relative dominance were calculated following the method given by Phillips (1959). The sum of the relative dominance, frequency and dominance gives the importance value indices (IVI) for various species (Curtis 1959). Species richness, concentration of dominance (cd), evenness and similarity index were analysed (MacArthur 1965; Whittaker 1975).

Sample plots have laid down randomly in all the habitats in the region density was calculated using the following the methods given in Nautiyal and Kaechele (2008). The density was calculated as

$$d = \frac{xn}{n}$$

d= Density, xn = Total number of individual of a species in all quadrates

N=total number of quadrates studied

The basal cover has calculated using the following formula. Basal cover of a single tree

$BC=\pi^{*}r2$

$r=radius$, $\pi=3.14$

Species diversity (H´) has computed by the Shannon and Weiner (1963) information index as follows (eqn. 1):

$$H = \sum \frac{ni}{N} \log_n \frac{ni}{N}$$

Where, *N*i is the total density value for species *i* and *N* is the sum of the density values of all the species in that site.

Beta diversity (b) among all the studied forests was calculated following the method given by Whittaker (1975).

$$\beta = \sum \frac{Sc}{S}$$

Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

$$D = \frac{\sum n(n-1)}{N}$$

N = Total number of species, n= number of species in one community

Evenness: Evenness is a measure of the relative abundance of the different species making up the richness of an area.

RESULTS AND DISCUSSION

The quantitative analysis on plant diversity of semi-arid region is essential to understand natural distribution and associated anthropogenic pressure in such human dominating landscapes. With the help of detailed phytosociological study, a total of 232 plant species belonging to 69 families consisting of 56 species of trees, 36 shrubs, 112 herbs and 28 climbers were recorded from the study region.Most of them provide fodder, fuel wood, timber, medicine to the people of the study region. Phytosociological attributes of trees and shrubs are given in the Tables 1 and 2. Dry lands are home for many plants, animals and variety of agricultural crops as well 35 percent of world's human population (Safriel and Adeel 2000). In keeping the population pressure in view, in arid and semi-arid lands, due to high pressure and highly extracting natural resources from the ecosystem such as mainly fuel, timber, edible and medicine, the structure and composition in biodiversity

Table 1: Density, basal area, important value indices, abundance, frequency, nature and utilization pattern of different tree species occurred in semi-arid region (P= planted species, N = naturally regenerating species)

S. No.	*Species name*	*Density ha-1*	*Basal cover (cm2)*	*Abund-ance*	*Freq-uency*	*IVI*	*Nature*	*Uses*
1	*Acacia auriculiformis* A. Cunh. exBenth.	1.15	1.1	0.37	1.15	2.0	P	Fu
2	*Acacia farnesiana* (L.)	0.7	0.03	0.1	0.7	0.5	N	Fu
3	*Acacia leucophloea* (Roxb.) Willd.	1.6	1.2	0.3	1.6	2.6	N	Fu, Ti
4	*Acacia nilotica* sub sp. *indica* (L.) Willd	12.7	7.3	1.1	10.5	17.1	N	Ti, Fu, M, Fo
5	*Aegle marmelos* (L.) Corr.	0.8	0.4	0.2	0.7	1.2	N	Fu, M
6	*Albizial ebbeck* (L.) Benth.	1.1	0.4	0.3	0.8	1.1	N & P	Fu, fo
7	*Annonas quamosa* L.	53.7	1.3	2.7	20.1	28.4	N	Ed,
8	*Azadirachta indica* A. JUSS.	16.4	10.8	1.2	12.0	22.1	N & P	Me, Fu, Fo, Ti, Worship
9	*Bauhinia racemosa* Lam.	2.5	2.1	0.5	2.4	4.2	P	Fu
10	*Borassusf labellifer* L.	0.4	0.5	0.2	0.4	0.9	N	Edible, Mis
11	*Cordia wallichii* G.DON	0.3	0.1	0.1	0.3	0.4	N	Fu
12	*Carica papaya* L.	0.5	0.05	0.2	0.3	0.4	P	Edible
13	*Cassia fistula* L.	4.2	0.5	0.4	2.6	3.1	N & P	Me, Fu
14	*Cassia javanica* L.	0.4	0.2	0.1	0.4	0.5	P	Fu, Fo
15	*Casuarina equisetifolia* Forst.	1.4	0.5	0.2	0.6	1.5	P	Ti, Fu
16	*Chloroxylons wietenia* DC.	6.4	1.8	0.4	2.8	4.9	N & P	Fu
17	*Cocos nucifera* L.	0.7	0.8	0.2	0.3	1.2	P	Ed, Mis
18	*Dalbergia sissoo* Roxb.	0.2	0.2	0.1	0.2	0.4	N	Fu
19	*Delonix elata* (L.) Gamble.	2.7	1.1	0.4	2.5	3.2	N	Fu, Fo
20	*Dichrostachys cinerea* (L.) Wt. & Arn.	0.3	0.04	0.1	0.3	0.2	N	Fu
21	*Dolichandrone atrovirens* (Heyne) Sprague	0.9	0.07	0.3	0.3	0.5	N	Fu, M
22	*Eucalyptus globulus* Labill.	0.8	1.8	0.1	0.6	2.3	P	Ti, Fu, Fo, M
	Ficusar nottiana (Miq.) Miq.	0.6	0.04	0.1	0.5	0.5	N	
24	*Ficus benghalensis* L.	0.8	1.1	0.2	0.7	1.7	N	Fu
25	*Ficus racemosa* L.	0.3	0.3	0.1	0.2	0.5	N	Ed, Fu
26	*Ficus religiosa* L.	5.5	2.1	1.2	4.4	6.3	N & P	Fu, M
27	*Leucaena leucocephala* (Lam.)	26.4	7.7	3.6	7.6	19.9	N	Fu, Fo de Wit, Small timber
28	*Limonia acidissima* L.	0.6	1.4	0.2	0.5	1.9	N	Ed, Fu
29	*Mangifera indica* L.	1.3	3.3	0.4	1.2	4.3	P & N	Ed,Fu
30	*Millingtonia hortensis* L.	0.4	0.2	0.1	0.4	0.6	N	Fu, Fo, Orname-natal
31	*Mimosa intisia* L.	0.3	0.02	0.1	0.2	0.2	N	Fu
32	*Morinda pubescens* J. E. Smith	3.7	2.7	0.4	2.0	4.9	N	Fu
33	*Moringa oleifera* Lam.	0.9	0.3	0.1	0.7	1.0	P	Ed, M
34	*Murraya koenigii* (L.) Spreng.	0.7	0.2	0.1	0.5	0.7	P	Ed, M
35	*Parkinsonia aculeata* L.	0.9	0.1	0.3	0.6	0.8	N	Fu
36	*Phoenix sylvestris* (L.) Roxb.	8.8	1.7	1.6	3.7	6.3	N	Ed, Mis
37	*Phyllanthus emblica* L.	0.3	0.02	0.1	0.3	0.3	N	Ed, M
38	*Phyllanthus polyphyllus* Willd.	0.5	0.02	0.2	0.3	0.3	N	Fu
39	*Pithecellobium dulce* (Roxb.) Benth.	2.2	1.2	0.7	1.9	3.0	N	Ed, Fu
40	*Pongamia pinnata* (L.) Pierre.	5.7	1.1	0.7	4.7	5.1	N & P	Fu, Fo, M
41	*Prosopis cineraria* (L.) Druce.	1.3	0.8	0.2	1.2	1.8	N	Fu, Ti, Worship

Table 1: Contd...

S. No.	*Species name*	*Density ha-1*	*Basal cover (cm2)*	*Abund-ance*	*Freq-uency*	*IVI*	*Nature*	*Uses*
42	*Prosopisjuli flora* (Sw.) DC.	133.5	24.5	2.4	54.2	92.5	N	Fu, Fo, Small timber
43	*Psidium guajava* L.	2.1	0.2	0.56	1.4	1.5	P	Ed, M
44	*Punica granatum* L.	0.3	0.01	0.12	0.3	0.2	P	Ed, M
45	*Samanea saman* (Jacq.) Merr.	1.1	1.3	0.2	1.0	2.1	N	Fu, Fo
46	*Santalum album* L.	15.8	1.4	1.7	9.0	11.2	N	M, Ti
47	*Sapindus aurifolia* Vahl.	0.3	0.4	0.1	0.3	0.6	N	M, Fu
48	*Spathodea campanulata* Beauv.	0.3	0.7	0.1	0.3	1.03	N	Fu
49	*Syzygium cumini* (L.) Skeels.	3.7	3.7	0.9	3.4	6.8	N	Ed, Fu, Ti
50	*Tamarindus indica* L.	4.6	5.0	1.0	3.7	8.5	N	Ed, Fu, Fo, Ti
51	*Tectona grandis* L. f.	3.5	0.6	0.8	1.6	2.5	P	Ti, Fu
52	*Terminalia catappa* L.	0.2	0.05	0.1	0.2	0.2	P	Fu, M
53	*Thespesia populnea* (L.) Sol. Ex Corr.	0.8	0.5	0.2	0.7	1.2	N & P	Fu
54	*Thevetia neriifolia* Juss. Ex. Steud.	1.4	0.08	0.3	0.5	0.8	N	Fu
55	*Wrightia tinctoria* R. Br. Mem. Wern.	0.6	0.1	0.1	0.4	0.5	N	M, Fu
56	*Ziziphus mauritiana* Lam.	8.6	2.3	1.1	7.5	9.1	N	Ed, Fu

Note: F- Fuel, Fd- Fodder, M- Medicinal value, T-Timber, Ed-Edible, Mis- Miscellaneous

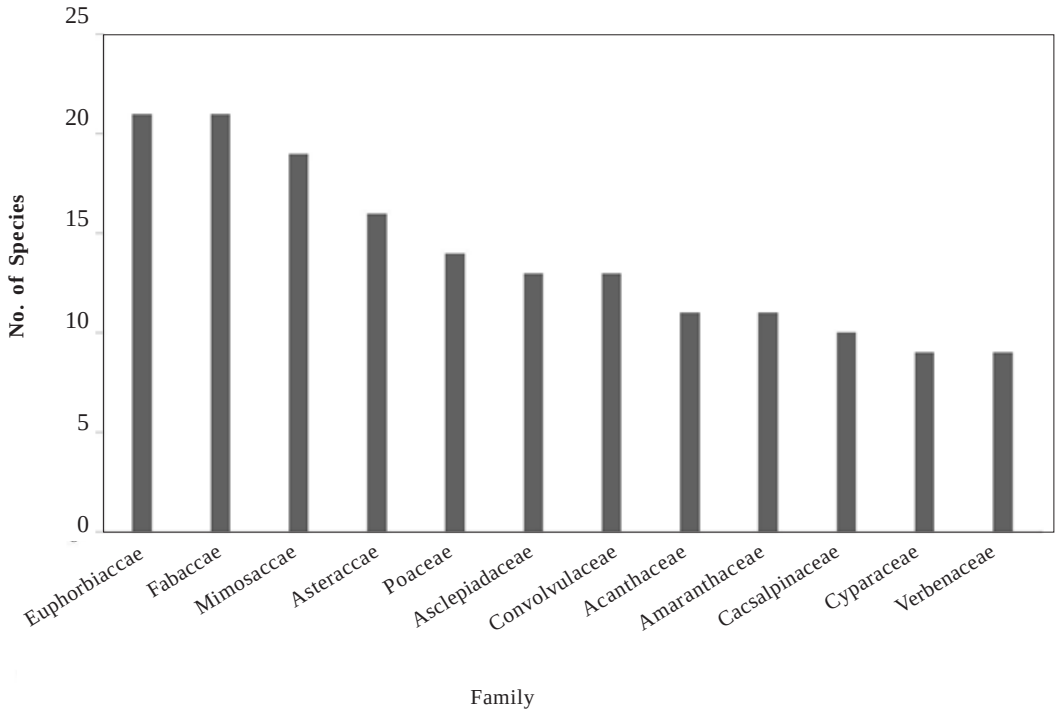

Fig. 2. Dominant families in the study region

Table 2: Density, basal area, important value indices, abundance, frequency, nature and utilization pattern of different shrubs species occurred in semi-arid region (P = planted species, N = naturally regenerating species)

S. . No.	*Species name*	*Density ha-1*	*Basal cover (cm2)*	*Abund-ance*	*Freq-uency*	*IVI*	*Nature*	*Uses*
1	*Abutilon indicum* (L.) Sweet	78.1	10.0	3.9	20.2	28.8	N	Fu
2	*Agave americana* L.	0.9	0.3	0.3	0.7	0.7	N	Fencing, Mis
3	*Anisomeles malabarica* (L.) R. Br. ex Sims	5.6	0.08	1.2	1.7	1.5	N	M
4	*Balanites aegyptiaca* (L.) Delile	23.0	19.0	1.9	11.2	26.7	N	Fu, M
5	*Cadaba fruticosa* (L.) Druce	0.8	0.9	0.1	0.6	1.3	N	
6	*Calotropis gigantea* (L.) R. Br.	7.6	2.5	1.2	6.1	6.1	N	M
7	*Calotropis procera* R. Br.	1.3	0.3	0.4	1.1	0.9	N	M
8	*Canthium coramandelicum* (Burm.f.) Alston.	14.2	3.1	1.4	9.1	8.8	N	Ed, Fu
9	*Carissa spinarum* L.	1.7	0.4	0.2	1.6	1.3	N	Ed, Fu
10	*Dodonaea viscosa* (L.) Jacq.	16.8	2.9	1.8	7.0	8.1	N	Fu
11	*Euphorbia tirucalli* L.	11.9	14.8	1.5	7.2	19.4	N	Fu
12	*Grewia tenax* (Forsk.)	0.9	0.4	0.2	0.8	0.9	N	Fu
13	*Grewia villosa* Willd.	0.6	0.1	0.1	0.4	0.4	N	Fu
14	*Guiland inabonduc* L.	3.0	0.5	0.5	2.6	1.9	N	Fu
15	*Gyrocarpus americanus* Jacq.	0.9	0.1	0.1	0.6	0.5	N	
16	*Hibiscus rosa-sinensis* L.	0.3	0.1	0.1	0.2	0.2	P	Orna-mental
17	*Indigofera tinctoria* L.	0.3	0.07	0.1	0.3	0.2	N	
18	*Ipomoea carnea* Jacq.	81.5	7.3	8.7	9.2	22.0	N	Fu, Mis
19	*Jatropha glandulifera* Roxb.	0.5	0.07	0.1	0.4	0.3	N	M
20	*Lantana camara* L.	82.6	18.3	2.8	28.9	41.5	N	Fu
21	*Leonotis nepetaefolia* (L.) R.Br.	3.0	0.03	0.3	1.0	0.9	N	
22	*Maytenus emarginata* (Willd.) Ding	0.21	0.01	0.1	0.2	0.1	N	Fu
23	*Opuntia dillenii* (Ker - Gawl.) Haw.	6.8	1.8	1.5	2.7	3.8	N	Fencing, Ed
24	*Orthosiphon glabratus Benth.*	0.8	0.3	0.1	0.6	0.6	N	
25	*Pavonia zeylanica Cav.*	21.6	0.2	2.0	9.0	6.8	N	
26	*Phyllanthusr eticulatus Poir.*	4.6	1.2	1.0	4.3	3.6	N	
27	*Ricinus communis L.*	12.6	1.4	1.9	4.1	4.8	N	M, Mis
28	*Securinega leucopyrus* (Willd.) Muell. - Arg.	2.5	0.5	0.6	2.5	1.9	N	Fu
29	*Senna auriculata* L.	29.5	2.6	1.3	21.0	15.2	N	Fu, Fo, M
30	*Senna occidentalis* L.	185.5	1.8	6.3	28.7	37.6	N	M
31	*Stachytarphetaindica* (L.) Vahl	19.7	0.1	2.4	5.8	5.1	N	
32	*Streblus asper* Lour.	0.5	0.1	0.15	0.4	0.3	N	
33	*Tephrosia purpurea* (L.) Pers.	102.6	0.62	4.2	23.4	23.7	N	M
34	*Triumfettar homboidea* Jacq.	7.9	0.04	1.0	3.9	2.6	N	
35	*Vitex negundo* L.	5.4	5.2	0.9	4.1	7.7	N	Fu, M
36	*Xanthium indicum* DC.	31.5	1.4	1.9	15.6	12.1	N	

Note: F- Fuel, Fd- Fodder, M- Medicinal value, T-Timber, Ed-Edible, Mis- Miscellaneous

takes place quickly. Vegetation analysis shows that the species distribution in the study region is sparse and scanty and the pattern reported to be random and contagious (species wise distribution is not presented here). Kong et al. (2009) obtained the similar findings from arid and semi-arid ecosystems.

The plant specimens for all the species were collected withbasic characteristics of plants such as flower, fruit, bark and root. The specimens were preserved and documented following with standard methods and identified with professional taxonomists. In the study area total 63 plant families were recorded and the dominant families based on number of species under each family are Euphorbiaceae (21), Fabaceae (21), Mimosaceae (19), Asteraceae (16), Poaceae (14), Asclepiadaceae (13), Convolvulaceae (13), Acan-

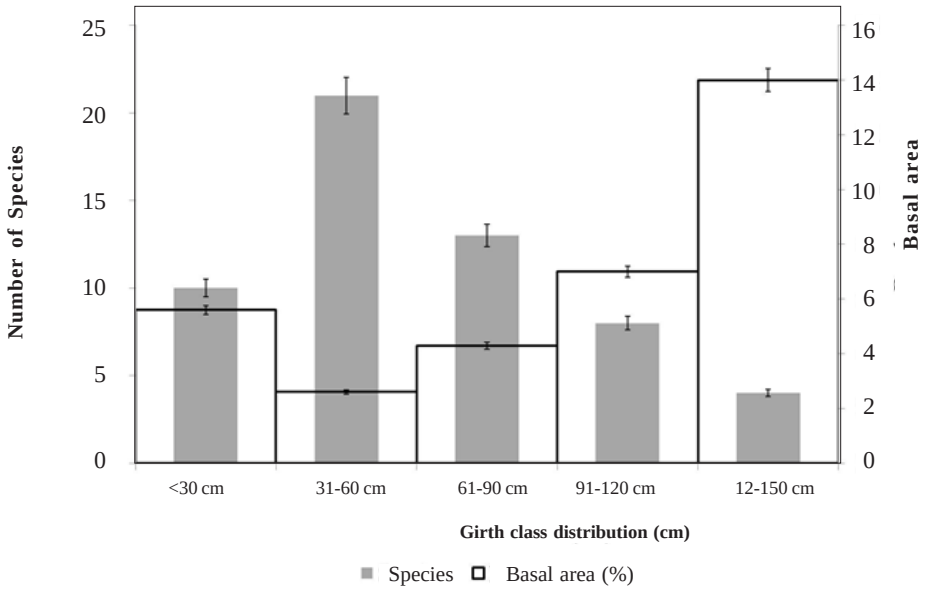

Fig. 3. Population structure of woody species on the basis of girth class distribution (number of species and basal area)

thaceae (11), Amaranthaceae (11), Caesalpinaceae (10), Cyparaceae (9), Verbenaceae (9). On the other hand, similar studies were observed in some other semi-arid ecosystems; the dominant families were recorded as Fabaceae, Euphorbiaceae, Cactaceae and Apocynaceae (Silva et al. 2014). However, among the herbs the dominate family is Poaceae (14) followed by Asteraceae (12).

Species richness and diversity in a forest depends on climatic, edaphic and biotic factors (Tripathi and Singh 2009). In the study region among the tree species the density (individuals per hectare) of *Prosopis juliflora*, 133 trees ha^{-1} is the highest followed by *L. Leucocephala* (26.4 trees ha^{-1}), *A. indica* (16.4 trees ha^{-1}), *Santalum album* (15.8 trees ha^{-1}), *A. nillotica* (12.7 trees ha^{-1}). The least density was calculated for *S. campanulata* (0.3 trees ha^{-1}) and *Dalbergia sissoo* (0.2 trees ha^{-1}). Among the shrubs, highest density was recorded for *Senna occidentalis* (185 species ha^{-1}) followed by *Tephrosia purpurea* (102 species ha^{-1}), *Lantana camara* (82.6 ha^{-1}), *Ipomoea carnea* (81.5 ha^{-1}), *Abutilon indicum* (78.1 ha^{-1}) and *Senna auriculata* (29.5 ha^{-1}). The studied semi-arid landscape located in tropical region however, the density, species diversity and richness in the study area was found less as compared to the other semi-arid and tropical ecosystems in the country (Ahmed 2012; Rawat et al. 2009; Rawat et al. 2010). Based on Important Value Index (IVI) the dominant species in the semi-arid ecosystem was *Prosopis juliflora* (92.5) followed by *Annona squamosal* (28.4), *Azadirachta indica* (22.1), *Leucaena leucocephala* (19.9), *Acacia nillotica* (17.1), *Santalum album* (11.2) and *Zizupus mauritiana* (9.1), *Tamarindus indica* (8.5), *Syzygium cumini* (6.8) and *Ficus religiosa* (6.3) (Table 1). For second-

Table 3: Diversity indices

Diversity indices	*Trees*	*Shrubs*	*Herbs*	*Climbers*
Shannon-wiener index (H')	0.2	0.4	0.8	0.1
Beta diversity	1.2	1.6	1.8	1.7
Evenness Index	0.04	0.09	0.1	0.01
Simpson's Index	0.1	0.10	0.1	0.09
Simpson's Reciprocal Index	5.9	9.6	7.6	11.1
Simpson's Index of Diversity	0.8	0.9	0.8	0.9

ary layer *Lantana camara* with IVI41.5 is dominant species followed by *Senna occidentalis* (37.6), *Abutilon indicum* (28.8), *Balanites aegyptiaca* (26.7), *Tephrosia purpurea* (23.7), *Ipomoea carnea* (22.0), *Euphorbia tirucalli* (19.4), *Senna auriculata* (15.2), *Xanthium indicum* (12.1) and *Canthium coramandelicum* (8.8) (Table 2). *Lantana camara* is exotic weed and invaded almost all habitats of the studied semi-arid ecosystem. Sharma and Pandey (2010) have found *Salvadora oleoides* (IVI 24.6) as dominant shrub species of arid landscape of Rajastan however, in semi-arid regions highest IVI were reported *Lantana camara* (243.6) by Rawat et al. (2009) in semi-arid areas in Punjab and *Wrightia tinctoria* (213.52) by Prabakaran and Greeshma (2012) in the semi-arid regions of Tamil Nadu. The dominant species (IVI 75.29) in range land of Ethiopia was recorded *Eragorostis aspera* by Hailu (2017) and highest IVI (*Ampelocissus latifolia*, 54.4) shrub species recorded by Pramanik and Das (2015) in Gorumara National Park. The IVI of the species from the study region was found quite comparable with the IVI of the species in identical ecosystems (Kanade et al. 2008; Reddy et al. 2008). However, less than that reported for other ecosystems of the country (Bargali et al. 2013; Khali and Bhat 2014; Kunwar and Sharma 2004; Rawat et al. 2010; Reddy and Ugle 2008; Reddy et al. 2011).

The diversity index in the present study ranged from 0.2 to 0.8 which is less compared to other tropical ecosystems 0.8 to 5.4 (Tripathi and Singh 2009; Parejiya et al. 2013). However, the species diversity index in Indian forests ranged between 0.8 to 4.1(Parthasarathy et al. 1992).The low species diversity index suggest for conservation of biodiversity, because the region highly vulnerable to desertification (Pausas and Austin 2001; Parejiya et al. 2013). At primary and secondary vegetation layer both, the basal cover and IVI were recorded highest for *Prosopis juliflora* and *Lantana camera* respectively. Among the trees species 5.6 percent species were less than < 30 cm CBH, 2.6 percent species between 31-60 cm CBH, 4.3 percent species 61-90 cm CBH, 7 percent species between 91-120 cm GBH and 14 percent species were found to have CBH between 121 and 150 cm (Fig. 3). The girth class interval analysis gives the scenario of the vegetation stand structure in an ecosystem (Reddy et al. 2008).

Diversity is a combination of two factors, the number of species present, referred to as species richness and the distribution of individuals among the species, referred to as evenness or equitability. In the ecosystem high degree of species interaction reveals the high species diversity. Low or changing diversity among the species indicate stress on ecosystems. The theory of species diversity takes into account in three different ecological phenomena, that is, species richness, relative abundance and community evenness. These parameters can provide a structure and composition of ecosystem. The diversity parameters are depicted in Table 3.

Shannon –Wiener Index of diversity (H) indicates that species richness (number of species) in the study region and evenness index indicates that species distribution in a particular ecosystem Hussein et al. (2014). In the study region the highest Shannon-Wiener index was obtained for herbs (0.87) followed by shrubs (0.49), trees (0.22) and climbers (0.1) were found to have least distribution (Table 3). Beta (β) diversity represent the amount of compositional variation in a sample (a collection of sample units) (Whittaker 1975). In the study region the highest beta diversity had recorded for herbs (1.8) followed by climbers (1.7), shrub (1.6) and trees (1.2). Evenness index has recorded highest for herbs (0.1) then followed by shrubs (0.09), trees (0.042) and climbers (0.01) were reported with least diversity (Table 3). However the highest evenness index has been recorded in other ecosystems 0.7 for agro-forestry and 0.6 in natural forest system Rawatet al.(2010).There are few studies reported that *Prosopis juliflora*is significantly effecting on reduction of species richness, density and evenness of the associated plant species beneath them (Keblawya and Abdelfatah 2014). The data on herbaceous vegetation is not presented in detail except for some parameters. However, in other ecosystems the value of tree and shrub layers were reported 2.72 and 3.1 (Nautiyal and Kaechele 2008) and for the overall species diversity including trees, shrubs, herbs and climbers the Shannon-Wiener index had reported in temperate forests 3.4 (Saxena and Singh 1982), community forest 3.02 (Kunwar and Sharma 2004) and for wood land (4.27). However in the present study climbers are represents least occurrence (0.1) where in other ecosystem had recorded 0.99 (Tripathi and Singh 2009).

Simpson index and Simpson reciprocal index has been used to evaluate the diversity of the region. The Simpson's index ranges between 0 and 1; 0 represents infinite diversity and 1 is no diversity[1]. In the study region the Simpson index values wererecorded for trees 0.8 followed by shrubs 0.9, herbs 0.8 and climbers 0.9. However in other ecosystems the Simpson index diversity has been reported 0.8 for entire ecosystems including trees, shrubs, herbs and climbers (Kunwar and Sharma 2004).

Plant Species and Their Uses

The flora of the study area contains many species that have been used in the variety of ways apart from the medicinal uses (78 species), for example timber (9 species), edible fruits (17 species), fuel wood (26 species), fodder (23 species), oral hygiene (11) and miscellaneous 3 species (Nautiyal et al. 2015). The utilization of various species has been studied in this region and it is by using questioners and interviewing the local people.Traditional Ecological Knowledge (TEK) plays an important role in sustainable use and conservation of biodiversity and has been proved a time-efficient and cost-effective approach (Srivastav et al. 2011). Herbal drugs constitute a major part in all traditional systems of medicines and 25 percent of allopathic drugs are reported from plant origin (Kala et al. 2006). India is the seventh largest country in the globe having rich plant diversity with around 47,000 species, of which more than 7500 species are being used as medicinal plants (Balakumbahan et al. 2010). Therefore, the traditional ecological knowledge gathered through centuries of experience of human and ecosystems and descended from generation to generation need proper documentation along with biodiversity studies (Pfoze et al. 2010).

In this region, among the shrub species *Lantana camara* and *Abutilon indicum* found relatively higher density and widely distributed. *Lantana camara* is invasive species and encroached the habitats of many species in the ecosystems. *Lantana camara* is being used as fuel wood and fencing by the people of study region.*Catunaregam spinosa* used as a fuel wood and fruits are edible, *Calotropis gigantea* leaves used as medicine reduce the fever, cough, and stomach pain and *Cassia auriculata* bark used as medicine control of diarrhea. *Azadirachta indica* and *Acacia nillotica* were major timber species in the present study region, which provide a major share of timber requirement for domestic use. Farmers have planted *Eucalyptus sp.* in their field for commercial selling and used as a timber and fuel wood requirement as well as domestic use. *Prosopis juliflora* is the major source for meeting the requirement of domestic fuel wood.

CONCLUSION

Plant sociology study is important to understand the structure and composition of vegetation diversity inthe ecosystems. The results obtained from conducting the study on diversity of plant species along with temporal landscape analysis would serve the purpose of providing baseline information on existing structure and functioning of ecosystems. In future this would enable the researchers for future studies on the ecosystems and drivers of change so that proper strategies could be framed for human dominating semi-arid ecosystems. With the help this study it was found that the density of the species in the semi-arid ecosystems is low and the area under vegetation cover is quite low which is declining at faster rate due to variety of factors. Hence the conservation methods are required to protect the biodiversity in semi-arid region so that objectives of sustainable socio-ecological development could be met. A systematic, scientific research is required for providing proper strategies for resource conservation, livelihood development and ecosystem development.

RECOMMENDATIONS

1. Important ex-situ and in-situ plant conservation methods has been recommended in the study to ensure conservation of species diversity in the selected study area (Nautiyal et al. 2015).
2. Afforestation is one of the most suitable methods for biodiversity conservation in semiarid landscape as it prevents soil erosion and helps in sustainable landscape development.
3. Semiarid regions shelter many important medicinal plants, critically important species (key tone species) and for endangered taxa. It is hence imperative to ensure significant

species diversity is maintained as the area is highly vulnerable (Nautiyal et al. 2015).

4. For better conservation of species diversity in these dry land ecosystems, continuous monitoring and documentation is necessary (Nautiyal et al. 2015).
5. Dry land regions are more vulnerable when compared to other ecosystem; there is hence a need to create adequate awareness programmes for the local people enlightening them of the various aspects and significance of semiarid ecosystem (Nautiyal et al. 2015).

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