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Trees Diversity, Distribution, and Conservation in urban centers: A study of Bilaspur city of Chhattisgarh state, India

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Abstract: **The present study was conducted to investigate the tree species diversity and distribution in Bilaspur city of Chhattisgarh, India to ascertain their importance and conservation. The data was collected by using a standard inventory of tree species of Bilaspur city, Chhattisgarh. To assess the tree species diversity and distribution a complete enumeration of tree species in avenue/roadside trees, private gardens/home gardens, school grounds, public parks/garden, public and private institutions and places with conglomerates of tree species. In this study all trees with diameter at breast height (dbh) ≥ 10cm were identified and data on mean height, DBH, basal area were collected. Data were analyzed using Graph Pad Prism 8 software. The results showed a good diversity in Bilaspur city of Chhattisgarh. Total of 60 tree species belonging to 22 families were identified at different location. In total 1404 individual trees were enumerated at all the sample plots. The Shannon-Weiner index value of 3.32, suggests a good and diverse tree species ecosystem in this urban center. In, contrast the lower values of the species evenness recorded in the present investigation indicates that the tree species are not uniformly distributed. This study provides baseline information for ecosystem management of urban tree species.**

Index Terms: **Urban tree species diversity, Distribution pattern, Diversity index, Shannon-weiner index, Simpsons diversity index, Species conservation.**

I. INTRODUCTION

The rapid growth in the urban centre of the developing nations due to rural-urban migration is alarming. The population density of these urban centers is increasing day by day which supports in the increase of infrastructural development of the cities. The increase in the urban population in the urban centers has now created a high pressure on the land, scarce natural resources, infrastructure and environmental quality and stability. In this growing urbanized environments, one of the key challenges for sustainable urban planning is the maintenance and development of urban vegetated areas. The urban centers or cities of India constitute a habitat for an increasingly large proportion of the world's population, thus playing a critical role in maintaining the balance ecologically, economically and socially for well being. The highly populated cities of any country need organization, arrangement, management and planning to enhance environmental sustainability. Unlike protected and reserve forests of any country the urban vegetation managed largely for recreational purposes, have a significant impact on the urban environment (Oleyar et al. 2008). Thus the monitoring of this vegetation form of the urban centers or cities is important from the ecological point of view.

Bilaspur city is known as the mini capital of Chhattisgarh and comes under tier 3 cities of the country. The city under smart city project of Government of India has a good vegetation cover. The different vegetation forms of this city are avenue/roadside trees, private gardens/home gardens, school

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grounds, public parks/garden, public and private institutions and place with conglomerates of tree species. The benefits derived from this urban forest cover of Bilaspur Smart city are enormous ranging from healthy environment which translates to healthy citizens, social, aesthetical and ecological benefits. The Urban vegetation cover, especially trees, provides numerous benefits that can improve air and water quality, building energy conservation, cooler air temperatures, reductions in ultraviolet radiation, and many other social and environmental benefits (Dwyer et al. 2000; Kuo and Sullivan 2001; Westphal 2003; Wolf 2003; Nowak and Dwyer 2007; Agbelade et al., 2016)

Despite the importance of the urban vegetation cover, these green spaces remain little researched in most parts of the world (Cornelis and Hermy 2004; Weifeng et al. 2006; Davies et al. 2008; Clarke et al. 2008), in contrast to the attention is paid on the forested areas (Nagendra 2008). The lack of understanding of biodiversity distributions and dynamics in urban centers or cities of the world makes it very much difficult to planning urban conservation strategies (Weifeng et al. 2006; Alvey 2006; Jim and Chen 2009). Systematic research on the urban forestry has largely been conducted in America and Europe (Fernandez-Juricic and Jokimaki 2001; Cornelis and Hermy 2004),with comparatively few studies have been conducted in the Asia/Pacific from which largely focused on Australia, South East Asia and Russia (Jim and Liu 2001; Weifeng et al. 2006; McKinney 2008). A very little information is available about the biodiversity and its dynamics of urban forests in South Asia (Nagendra and Gopal 2010; Singh et al. 2010).

This paper assesses the tree species diversity and composition in the central Indian city of Bilaspur, Chhattisgarh. The city was once considered famous for its greenery, but due to high rural-urban migration population and urbanization its vegetation cover has been drastically affected. Moreover, in recent times, many green spaces being encroached on for developmental activities, but due to the protests by the local people a number of parks, roadside plantations have been laid at number of locations. As with other South Asian cities (Nagendra and Gopal 2010; Singh et al. 2010), there is a few knowledge about the tree species diversity in the Bilaspur city. Such information is essential in order to properly evaluate the contribution of urban forests to the ecological integrity and health (Sudha and Ravindranath 2000). Based on the ecological,economic and social importance of the vegetative cover of the Bilaspur city, the present study was designed to provide baseline surveys of tree species diversity in the city of Bilaspur. The results of the present investigation will provide a database which will be useful for researchers, city planners, educators, urban activists, students and the interested public .

II. MATERIAL AND METHODS

2.1. Study area

Bilaspur city of Chhattisgarh was purposefully selected for this research. The Bilaspur City is located in the southern part of District Bilaspur. Bilaspur city is situated at the bank of river Arpa. The river provides a good moisture catchment, which is reason for its good vegetation cover. Geographically, the extension of this city is $22^{\circ} 20'$ North to $20^{\circ} 10'$ North and $82^{\circ}0'$ East to $82^{\circ} 15'$ East. Total Geographical area of this city is 46.12sq km and it extends 8km from North-West to South-East on the both side bank of Arpa river. The climate of Bilaspur city is tropical, semi arid, and monsoon type. Thus, it has hot summers, moderate winters and rainy monsoon seasons.

2.2. Data Collection

Data for urban tree diversity was conducted by using forest tree inventory method. Sample plots of 25m by 25m were used to record the information of tree diversity in Bilaspur city, taking care to ensure that a minimum distance between the sample plots should be 200m maintained. The sample plots for tree diversity assessment were laid down in the avenues, roadside trees, public parks or gardens, school grounds, public and private institutions and any space with conglomerates of trees. Within a sample plot, all trees were identified to the species level, and their diameter at breast height (DBH) and height were recorded. The representative taxa in the sample plots were identified with the help of floras (Pullaiah & Ramamurthy, 2002; Pullaiah, Ramamurthy, & Karuppusamy, 2007; Pullaiah & Rao, 2002).

2.3. Data Analysis

Based on the individuals recorded in the sampling plot samples of Bilaspur city, vegetation data were quantitatively analyzed for basal area, relative density, relative frequency and relative dominance. The relative diversity of family was evaluated as the number of species with the family expressed as percentage of total number of species within all the families represented in the community (Pandey&Barik, 2006). The data were used to compute the diversity indices of the tree species existing in the study area.

2.3.1. Importance Value Index (IVI) and Family Importance Value (FIV)

The Importance Value Index (IVI) and Family Importance Value (FIV)of tree species were determined by the equation given by (Panda et al., 2013).

2.3.2. Shannon-Wiener Index (H)

The Shannon-Wiener Index (H) was calculated by the equation give by Shannon and Wiener (1949) as;

$$H = -\sum (ni/N) \, log \, 2(ni/N)$$

Where,H =Shannon-Wiener Index ,Ni =Importance value of each species, N = Total importance value

2.3.3. Shannon's maximum diversity index(H_{max})

Shannon's maximum diversity index was calculated by the formula given by Guo et al., (2003)

$$H = -\sum[(pi) * log(pi)]$$

where:H - Shannon diversity index, p_i - Proportion of individuals of i-th species in a whole community, $p_i = n / N$, where n - individuals of a given type/species; and N - total number of individuals in a community,

2.3.4. Species richness

Species richness or Margalefs diversity index (d) is one of the major components of species diversity. This index is expressed by the following equation (Margalef, 1958)

$$d = S - 1/logN$$

2.3.5. Simpsons diversity index

This index of dominance also known as Simpsons diversity index is the sum of total of square of the proportion of the species in the that specific community and is calculated by the following equation (Simpson, 1949);

$$c = \sum (ni/N)2$$

Where,c = Index of dominance,Ni = Importance value of each species,N = Total importance value

2.3.6. Species Evenness (e)

Another major component of diversity is evenness of equitability in the apportionment of individuals among the species. It is expressed as given by (Pielou, 1966) as ;

$$e = H/ logS$$

Where, H =Shannon-Wiener Index,S =Number of species

2.3.7.Basal area

$$A = \pi r^2$$

Where, A=area, π = constant (3.14), r=radius

2.3.8.Total biomass

TB is the sum of the AGB and BGB (Sheikh et al , 2011)

TB= AGB+BGB

Where, TB= Total Biomass, AGB= Above Ground Biomass, BGB= Below Ground Biomass

2.3.9.Carbon Stock

Generally 50% of biomass of any plant species is considerd as carbon(Pearson et al 2005). Therefore, the weigt of carbon in the tree was estimated by multiplying the biomass of the tree by 50% (Birdsey 1992).

Carbon Stock (kg/tree)= Biomass×50%

III. RESULTS

A good diversity in the tree species were found in Bilaspur city of Chhattisgarh.The tree species diversity of Bilaspur city is 60 species belonging to 22 families identified at different avenues, roadside trees, public parks or gardens, school grounds, public and private institutions . In total 1404 individual trees were enumerated at all sample plots. The maximum observed tree species shown in Table-1 were *Pongamia pinnata* and *Ficus pengalensis* (n=50), *Terminalia arjuna* (n=47), *Mangifera indica* (n=46), *Delonix regia, and Peltophorum ferrugineum* (n=42). The least observed species were *Holarrhenaha ntidysenerica* (n=1), *Albizia saman* (n=2), *Ficusc arica* (n=2), *Prosopis cineraria* (n=2) , *Grewia tiliaefolia* (n=2), *Hardwikia binata* (n=2) and *Pterocarpus marsupium* (n=2) (Table-1). Across all the tree species 28 tree species were common in Bilaspur city whereas 32 tree occur rarely. A total of twenty two (22) families were encountered in Bilaspur city Table-2). Family with high number of species includes Fabaceae, Anacardiaceae, Moraceae, Moraceae, Myrtaceae and Combretaceae in Bilaspur city (Table-2).

S.No	Name Tree Species	Family	Local Name	Number of trees	Occurance
01	*Acacia catechu*	Fabaceae	Khair	30	Common
02	*Acacia nilotica*	Fabaceae	Babul	28	Common
03	*Acacia leucophloea*	Fabaceae	Reunja	08	Rare

04	*Adina cordifolia*	Rubiaceae	Haldu	07	Rare
05	*Aegle marmelos*	Rutaceae	Bel	12	Rare
06	*Albizzia lebbek*	Fabaceae	Kala Siris	31	Common
07	*Albzia procera*	Fabaceae	SafadSiris	30	Common
08	*Albizia saman*	Fabaceae	Rain tree	02	Rare
09	*Ailanthus excelsa*	Simarubaceae	Maharukh	40	Common
10	*Alstonia scolaris*	Apocynaceae	Chhatrak	09	Rare
11	*Anogeissus latifolia*	Combretaceae	Dhawada	11	Rare
12	*Annona squamosa*	Annonaceae	Sheetaphal	09	Rare
13	*Anthocephalus cadamba*	Rubiaceae	Kadamb	31	Common
14	*Azadirachta indica*	Meliaceae	Neem	40	Common
15	*Bauhinia variegata*	Fabaceae	Kachnar	06	Rare
16	*Bauhinia purpurea*	Fabaceae	Keolar	05	Rare
17	*Bombax ceiba*	Bombaceae	Samel	12	Rare
18	*Boswellia serrata*	Burseraceae	Salai	10	Rare
19	*Buchania lanzan*	Anacardiaceae	Chironjee	15	Rare
20	*Butea monosperma*	Fabaceae	Chhoela	30	Common
21	*Cassia siama*	Fabaceae	Kassod	40	Common
22	*Cassia fistula*	Fabaceae	Amaltas	31	Common
23	*Citrus medica*	Rutaceae	Nimbu	33	Common
24	*Dalbergia paniculata*	Fabaceae	Dhobin	11	Rare
25	*Dalbergia sisso*	Fabaceae	Sisham	39	Common
26	*Delonix regia*	Fabaceae	Gulmohar	42	Common
27	*Embilica officinalis*	Euphorbiaceae	Amla	12	Rare
28	*Erythrinia indica*	Fabaceae	Munga	15	Rare
29	*Eucalyptus spps*	Myrtaceae	Neilgiri	39	Common
30	*Eugenia jombolana*	Myrtaceae	Jamun	07	Rare
31	*Ficus bengalensis*	Moraceae	Bargad	50	Common
32	*Ficus religiosa*	Moraceae	Pipal	47	Common
33	*Ficus carica*	Moraceae	Anjeer	02	Rare
34	*Ficus glomerata*	Moraceae	Gular	06	Rare
35	*Gmelina arborea*	Lamiaceae	Khamer	05	Rare
36	*Grewia tiliaefolia*	Tiliaceae	Dhaman	02	Rare
37	*Holarrhena hantidysenterica*	Apocynaceae	Koriya	01	Rare
38	*Hardwikia binate*	Fabaceae	Anjan	02	Rare
39	*Lagerstroemia parviflora*	Lythraceae	Seja	37	Common
40	*Laucaenea leucocephala*	Fabaceae	Subabul	30	Common
41	*Maduca indica*	Sapotaceae	Mahua	07	Rare
42	*Mangifera indica*	Anacardiaceae	Aam	46	Common
43	*Moringa oleifera*	Mongiaceae	Senjhra	25	Common
44	*Murraya koenigii*	Rutaceae	Mithineem	06	Rare
45	*Ougenia dalbergia*	Leguminosae	Tilsa	05	Rare
46	*Peltophorum ferrugineum*	Fabaceae	PeelaGulmohur	42	Common
47	*Pongamia pinnata*	Fabaceae	Karanj	50	Common
48	*Psidium guyava*	Myrtaceae	Guava	35	Common
49	*Pterocarpus marsupium*	Euphorbiaceae	Bija	02	Rare
50	*Prosopis cineraria*	Leguminosae	Chenkur	02	Rare
51	*Saraca indica*	Fabaceae	Ashoka	33	Common
52	*Semecarpus anacardium*	Anacardiaceae	Bhelwa	10	Rare
53	*Shorea robusta*	Dipterocarpaceae	Sarai	11	Rare
54	*Tamarindus indica*	Fabaceae	Imali	29	Common
55	*Terminalia arjuna*	Combretaceae	Kahua	47	Common
56	*Terminalia bellerica*	Combretaceae	Baihra	05	Rare
57	*Terminalia chebula*	Combretaceae	Harra	03	Rare
58	*Terminalia tomentosa*	Combretaceae	Saj	09	Rare
59	*Tectona grandis*	Lamiaceae	Sagwan	35	Common
60	*Zizyphus mauritiana*	Rhamnaceae	Ber	41	Common

Table 1. List and attributes of tree species occurring in the Bilaspur city of Chhattisgarh, India

The results reveal that the top ten families with an abundance of 1391 individuals (84.11%) of the total tree abundance in the Bilaspur city(Table-2). Eleven families were represented by single tree species with an abundance of 223 individuals which account for 15.89% of total abundance. The Family importance value was used to show the composition of a family with respect to the tree species and total individuals it accounts. The FIV values ranged from 72.20 to 1.8 across all the tree families(Table-2). The maximum FIV was encountered by Fabaceae (530.33) and the minimum values were recorded by Meliaceae (1.8) respectively. The tatal basal area for each family was also recorded in this study. It was found that the highest basal area was recorded by the Fabaceae family (530.30), it was followed by Moraceae (286.5), Anacardiaceae (164.05), Myrtaceae (142.35), Combrataceae (146.54) respectively and the lowest basal area was noted in Tiliaceae (0.94) family (Table-2). It was observed that the higher the basal area, abundance, number of species in a family higher was its FIV.

S.No	Family	Species richness	Density (kg/m^3)	FIV	Basal Area (m^2)
01	Anacardiaceae	03	70	12.782	164.05
02	Annonaceae	01	09	3.221	1.89
03	Apocynaceae	02	10	5.407	22.607
04	Bombaceae	01	12	2.63	30.66
05	Burseraceae	01	10	3.3	8.46
06	Combrataceae	05	75	9.6	136.54
07	Dipterocarpaceae	01	11	5.12	32.7
08	Euphorbiaceae	02	14	7.21	9.44
09	Fabaceae	21	519	72.70	530.33
10	Lamiaceae	02	40	6.56	10.50
11	Leguminosae	02	07	2.4	1.7
12	Lythraceae	01	37	3.5	2.1
13	Meliaceae	01	30	1.8	11.9
14	Mongiaceae	01	25	3.53	30.2
15	Moraceae	04	105	28.12	286.5
16	Myrtaceae	03	82	10.44	142.35
17	Rhamnaceae	01	41	3.21	1.15
18	Rubiaceae	02	38	6.15	5.6
19	Rutaceae	03	51	10.06	18.94
20	Sapotaceae	01	07	3.51	17.24
21	Simarubaceae	01	39	2.94	1.22
22	Tiliaceae	01	02	1.9	0.94

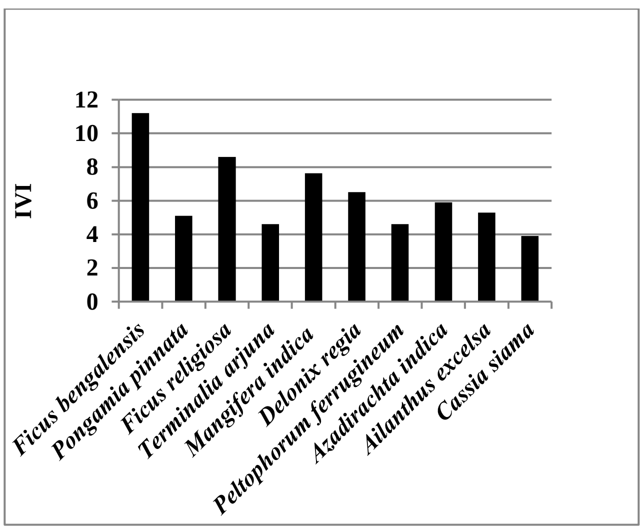
Table 2. The contribution of tree families to species richness, density, family importance value (FIV) and basal area in Bilaspur city of Chhattisgarh.

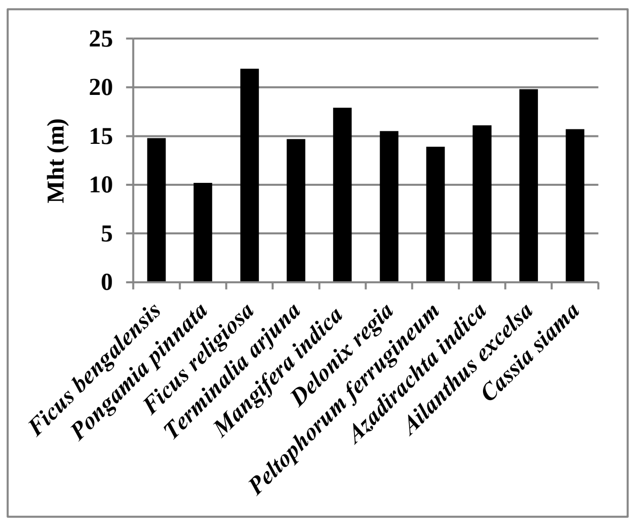
In the present study we also recorded the mean height, mean diameter at breast height, importance value index and basal area of top ten dominant tree species of Bilaspur city. The results elucidate that the mean height was maximum in *Ficus religiosa*(21.9m), it was followed by *Ailanthus excelsa* (19.8m),*Mangifera indica* (17.9m), *Azadirachta indica*(16.1m), *Cassia siam*(15.7m), *Delonix regia* (1.5m), *Terminalia arjuna*(14.7), *Peltophorum ferrugineum*(13.9m), and *Pongamia pinnata* (10.2m) respectively (Table-3). The mean diameter at breast height ranged between 2.05m to

0.46m, with maximum DBH in *Ficus bengalensis* and minimum DBH in *Pongamia pinnata*. The IVI values across the ten dominant tree species reveal that the highest IVI values were recorded for *Ficus bengalensis* (11.2) and lowest IVI values were represented by *Cassia siama* (3.9). Highest basal area was recorded for *Ficus bengalenis* (3.229) and lowest for *cassia siama* (0.119)

S.No	*Name Tree Species*	FQ	Mht (m)	MDbh (cm)	IVI	B.A (m^2)	AGB (kg/tree)	BGB (kg/tree)	TB (kg/tree)	Carbon Stock (kg/tree)
1	*Ficus bengalensis*	50	14.8	205	11.2	3.299	450.225	117.058	567.283	283.6415
2	*Pongamia pinnata*	50	10.2	10.7	5.1	0.255	22.493	5.848	28.341	14.1705
3	*Ficus religiosa*	47	21.9	157	8.6	1.935	344.558	8.958	353.516	176.758
4	*Terminalia arjuna*	47	14.7	50	4.6	0.196	109.008	28.342	137.35	68.675
5	*Mangifera indica*	46	17.9	72	7.63	0.407	157.43	40.934	198.364	99.182
6	*Delonix regia*	42	15.5	46	6.5	0.166	100.202	26.052	126.254	63.127
7	*Peltophorum ferrugineum*	42	13.9	69	4.6	0.374	150.835	39.217	190.052	95.026
8	*Azadirachta indica*	40	16.1	48	5.9	0.181	104.605	27.194	131.799	65.8995
9	*Ailanthus excelsa*	40	19.8	51	5.3	0.204	111.209	28.914	140.123	70.0615
10	*Cassia siama*	40	15.7	39	3.9	0.199	84.793	22.046	106.839	53.4195

Table 3. Summary of growth characteristics and diversity indices for ten most common tree species in Bilaspur City of Chhattishgarh,India. FQ = number of tree stems in the city, BA = Basal area of trees in the city, MHt = Mean height, MDbh = Mean diameter at breast height, IVI= Importance Value Index





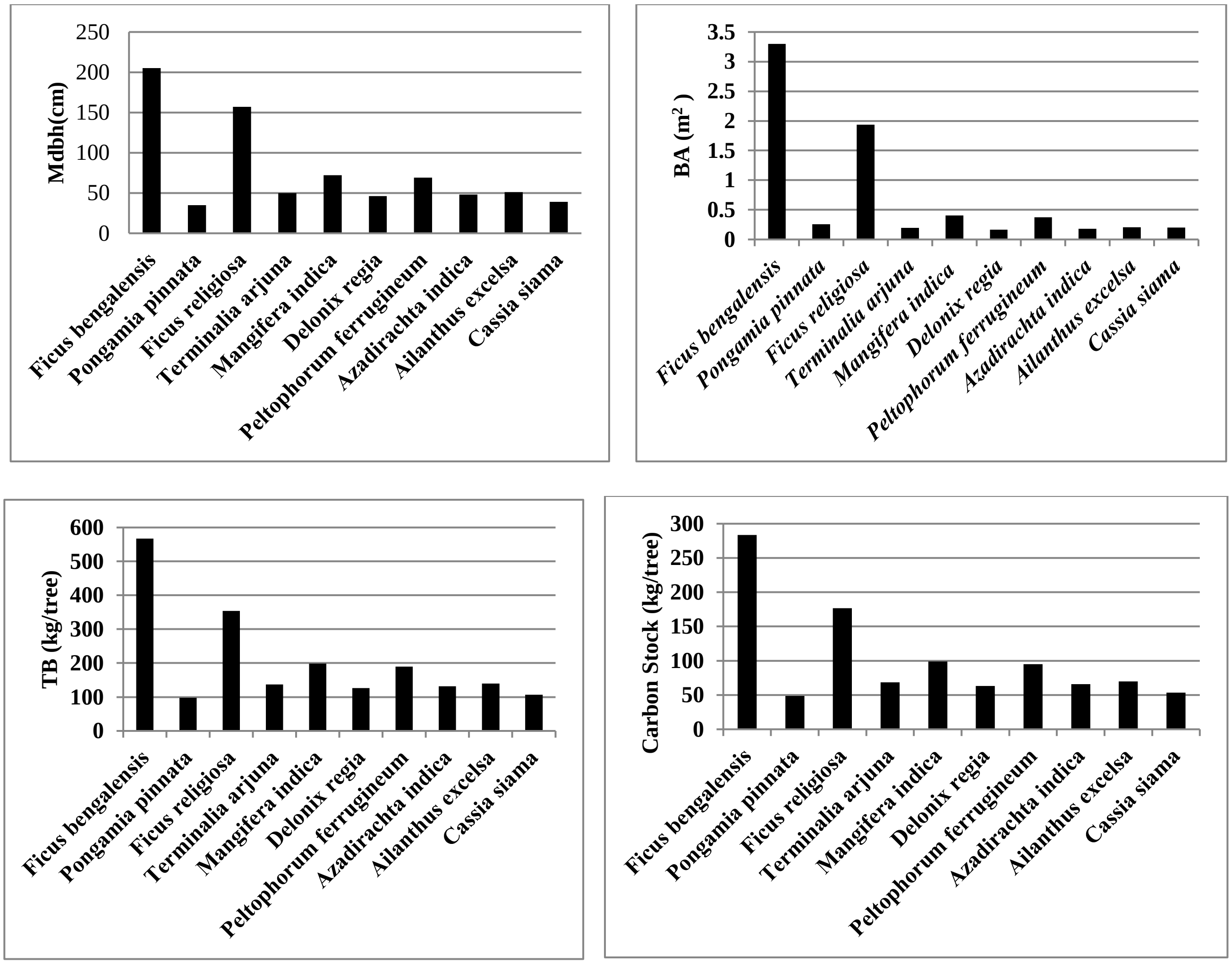


Fig. 1. Average growth parameters of mean height, mean diameter , Importance value index (IVI), Basal area, Total biomass and Carbon Stock of ten most common tree species in Bilaspur.

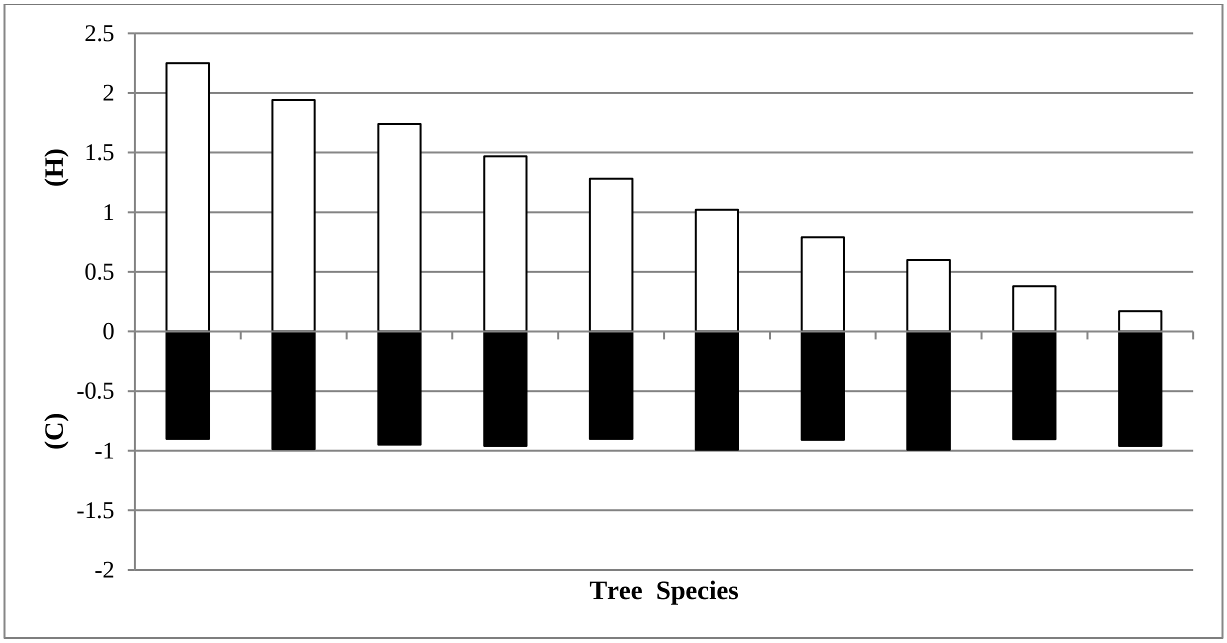


Fig.2. Comparison between Shannon index of general diversity(H) and index of dominance(C) for the tree species recorded in Bilaspur,Chhattisgarh ☐ - Shannon Index of general diversity(H), ■ - Index of dominance (C)

IV. DISCUSSION

Understanding tree species diversity and dynamics is very important in assessing sustainability of vegetation, conservation of tree species and ecosystems management (Kacholi, 2014). Currently, the present study describes the tree species diversity and dynamics of Bilaspur city of central India. The density, composition, abundance and distribution of individual tree species are the best indicators of plant diversity (Wattenberg and Breckle, 1995). Misra, (1968) reported that the strongest plant species numerically depends on their abundance. In the present study we found *Pongamia pinnata*, *Ficusbenga lensis*, *Terminalia arjuna*, *Mangifera indica*, *Delonix regia* and *Peltophorum ferrugineum* recorded the highest density values. However the distribution of tree species in Bilaspur city is dominated by only few species, with the top ten species accounting for almost half of all tree species. The higher density of only few species in Bilaspur city might be due to human interference through selective utilization and conservation of such species (Ahn, 1970) and ecological adaptability of these dominant tree species. Nagendra and Gopal (2010) recorded a same type of trend in tree species distribution in Banglore city of Karnnataka. The trees found in the Bilaspur city include both exotic and native tree species. Thus forms strata of both exotics and native flora. Urban forests are known to consist of a mix of introduced and native species (McKinney 2008; Garcillán et al. 2009). It was suggested by many authors that a mix of introduced and native tree species may be beneficial for some aspects of biodiversity (McIntyre and Hobbs 1999; Hunter 2007), but it is clearly reported that the presence of a large number of native species alters the ecosystem structure and function in a systematic way (McKinney 2006). Thus in some cities of the world plantation of native vegetation is preferred (Martin et al. 2004).

Biodiversity indices of Bilaspur city were calculated to assess the status of biodiversity conservation in this urban center and compare them with the biodiversity of other urban centers. The species diversity of any urban center depends upon adaptation of species and increases with stability of community. The Shannon-Weiner index for Bilaspur was measured to be 3.32, which suggest a good and diverse tree species ecosystem in this urban center. In, contrast the lower values of the species evenness recorded in the present investigation indicates that the tree species aren't uniformly distributed. (Agbelade et al., 2016) investigated the biodiversity indices of two cities of Nigeria and reported same type of trend as obtained in the present study. The Shannon-Wiener index of Bilaspur city is higher than those obtained in many urban centers (Cornelis, 2004; Hunter, 2007; Jim and

Chen, 2009). The converse index is obtained between the Shannon's maximum diversity index (Hmax) and Simpsons diversity index (C) which is indicates the index of dominance and index of diversity of the trees species and they are forms the mirror image (Tiwari, 1993). The Importance Value Index (IVI) or Family Importance Value (FIV) is used for species conservation measures, whereby the tree species with lower IVI value need high conservation than those tree species with higher IVI values(Kacholi, 2014). The presence of many tree species with lower IVI in the present study indicates that these species should be given more conservation priorities, also the families with lower FIV needs kind attention of the urban forest policy making bodies in future .The rarity of IVI and FIV could be attributed to various, such as poor distribution of species, anthropogenic disturbances, competition between species, etc. (Comita et al., 2007; Hubbell et al., 2001; Schwarz et al., 2003). The present study reveals that city unfortunately lacks a consistent and elite tree policy that specifies which tree species to plant, and towards what purposes. Greater attention should be given for the selection of trees planted in the urban centers, not just with a view for easy maintenance, but with some efforts to select an appropriate mix of trees that supports other biodiversity and provide better environmental and ecosystem services. Further studies are required which will facilitate the monitoring of basic ecology, enable the identification, conservation and protection of large heritage of tree species in the Bilaspur city and which will also facilitate monitoring of changes over time.

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