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Floristic Diversity and Species Composition in Urban Areas at Sub-Himalayan Region of West Bengal, India

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***Abstract*:** Urban green landscapes are crucial in the period of drastic population increase, climate change concerns and pollution. Urban forestry conserves biodiversity and provides ecosystem services, thereby increasing the aesthetic value of cities. However, studies on the urban vegetation cover and their quantification are rare in India. Hence, the present analysis focused on the vegetation composition, quantitative characters and diversity indices in urban areas. The study was carried out through stratified random quadrat sampling and line transect method in urban green areas (three parks and one institutional area) of Cooch Behar city, West Bengal, India. Around 76 plant species, which belong to 67 genera and 39 families, were documented in the studied areas. The highest species richness was reported in Nripendra Narayan Park, followed by Royal Eco Heritage Park. Royal Eco Heritage Park is highly diverse according to the species diversity index. The species *Codiaeum variegatum, Polyalthia longifolia* and *Neolamarckia cadamba* are reported from all the urban forestry landscapes. The study serves as a managerial planning tool for the proper maintenance and management of urban green spaces.

***Keywords*:** Vegetation diversity, Urban green sites, Species composition, Himalayas

Dramatic urbanization is happening unevenly worldwide (Sun et al 2020). According to the UN (2018) report, the urban population will increase up to 68% of the world population (6.6 billion) by 2050. This population trend develops concern in developing countries where urban environmental problems and lack of food security hinder sustainability (Sun et al 2020, Kuddus et al 2020). Moreover, the city transport sector, industrialization and reduction in green space are leading more to climate change. Urban areas that presently contribute less than three per cent of the global terrestrial surface; account for 78 % of carbon emissions, 60 % of residential water use and 76 % of wood used for industrial purposes (Pandey and Chaudhry 2010). If the current urban growth rate continues, the global urban land cover will increase by 1.2 million km^2 by 2030, with considerable loss of habitats in critical biodiversity hotspots (Seto et al 2013). Therefore, urban forestry practices are significant and are of immediate need of the hour. Urban forestry practices mitigate sound and air pollution, provides ecosystem services (Wirtz et al 2021) and conserve biodiversity (Giuliano et al 2004, Khera et al 2009). Tree components in urban forestry practices sequester carbon which mitigates climate change.

In India, urban forestry-related works are scanty (Nagendra and Gopal 2010a, Chaudhry and Tewari 2011) compared to the forest vegetation studies. Even though few studies mention the environmental implications of urbanization, analysis and documentation of urban park-oriented biodiversity are less. Urban forestry vegetation, distribution and utilization need more scientific explorations to reveal the conservation roles of such urban landscapes. Hence, the present study documented vegetation quantitatively and the composition of urban green space in sub-humid climatic conditions of West Bengal, India. This study and its information are helpful to plan the strategies for urban landscape vegetation management and conservation.

MATERIAL AND METHODS

Site description: Cooch Behar is a historical town established by the erstwhile Koch dynasty and comes under the Terai zone of West Bengal (sub-Himalayan foothill region). The Cooch Behar district is located in West Bengal, India with 26^0 23' 45.8" N latitude and 89^0 23' 16.7" E Longitude and at 43 m above mean sea level. The present study was carried out at three parks with a total area of 5, 10 & 15 ha (Nripendra Narayan Park (N. N. Park), Royal Eco Heritage Park, Rajbari Heritage Site) and one institutional area (Border Security Force-BSF-50 ha) in the town of Cooch Behar, West Bengal, India. There is a considerable variation in seasonal and diurnal temperature of the study sites, mostly moist tropical in nature. The total annual rainfall received was about 2305.91 mm of which about 80 % was recorded from April to September and relative humidity ranged from about

49 to 94 %. The summer and winter temperatures are mild with the highest of 33°C during August and the lowest of 9°C during January.

Field survey, sampling and inventory: All the areas of parks and institutions were physically visited for documentation purposes. The identification was done mostly at the location except for a few species that were not identified easily were mounted on the herbarium sheets following the standard method of herbarium for further identification. The mounted specimens were cross-checked with the available herbarium in the Department of forestry UBKV, Pundibari, West Bengal, India. Trees or shrubs along the boundary or paths of the sites were sampled through line transects of size 2 m × 10 m long and for others through stratified random nested quadrat (20 x 20) sampling method. Standard procedures were adapted to calculate density, relative frequency, relative abundance, relative density and importance value index (Raunkiaer 1934, Cintron and Novelli 1984). Some of the frequently used diversity indices like species richness, species diversity index (Menhinick 1964), concentration of dominance (Simpson 1949), Shannon-Wiener diversity index (Shannon and Weiner 1963) and species evenness index (Pielou 1975) were used to analyze the vegetation diversity of the urban green areas.

RESULTS AND DISCUSSION

Diversity indices and species composition: Overall, 76 plant species were documented from the parks and institutional area, which belong to 67 genera and 39 families (Table 1, 2; Fig. 1). Among the parks and institutional areas, N. N. Park was dominated by other sites with 42 species (25 families and 40 genera), followed by Royal Eco Heritage Park with 41 (24 families and 39 genera). The species diversity index or Menhinick's index was 4.58 for Royal Eco Heritage Park followed by N. N. Park, Rajbari Heritage and the lowest 1.09 for the BSF campus of the Cooch Behar Town. The Shannon and Weiner index of species was 6.00 for N. N. Park, followed by Royal Eco Heritage Park, BSF area and Rajbari. The evenness index was 0.05 for Royal Eco Heritage Park and N. N. Park. The highest index value estimated for Royal Eco Heritage Park indicates the diversity and highest species richness. However, the diversity of the sites was neither too high nor too less as the presence of species was more or less frequent. The concentration of dominance value of overall species was 5.75 for Royal Eco Heritage Park and 5.65 for N. N. Park. This reflects the number of chances the species encountered during sampling was low and a lower value means the chances of encountering being high, indicates an abundance of occurrence.

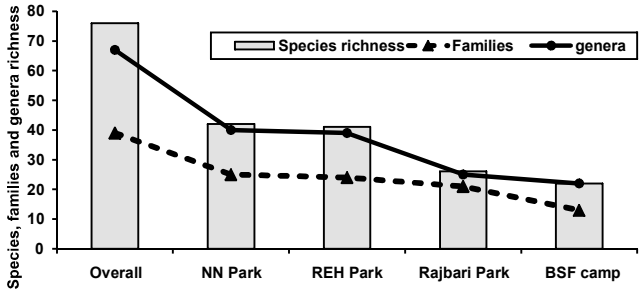

Fig. 1. Species, family and genera richness in the green sites

Vegetation analysis of urban parks: The degree of dispersion of the species in the N. N. Park ranged from 16.7 to 83.3 %. The chance of occurrence of *Callistemon lanceolatus, Elaeocarpus ganitrus* and *Mimusops elengi* each was lowest while *Jatropha curcas* was the most frequent species. The chance of occurrence of trees and shrubs ranged from 16.7 to 66.7 % and 16.7 to 83.3 % respectively, while for herbs it was 33.3 %. The relative frequency ranged from 1.2 to 5.9. The highest relative frequency was estimated for *Jatropha curcas* and the lowest for *Mimusops elengi, Neolamarckia cadamba* and *Syzygium cumini* each. Similarly, the value of relative frequency showed that the chance of occurrence of *J. curcas* was highest concerning all other species while the chance of occurrence was least for species like *M. elengi, N. cadamba and S. cumini*. Herb species with a relative frequency of 2.4 had the lowest chance of occurrence with other life forms *i.e.*, shrubs (2.4-5.9) and trees (1.2-4.7). The density of species was in the range of 0.2-10.0 % indicating the highest numerical strength for *Dalbergia sissoo* and lowest for *M. elengi, N. cadamba* and *S. cumini*. The numerical strength of the herbs was 0.7 %, while it ranged from 0.8-8.2 % for shrubs and 0.2-10.0 % for trees. Numerical strength values indicate that the trees were the dominating species in N. N. Park. Similarly, the relative density was in the range of 0.2 (*M. elengi, N. cadamba* and *S. cumini*)- 16.5 (*D. Sissoo*). Relative density estimated for herbs (1.1), shrubs (1.1-13.5), and trees (0.3-16.5) indicate that herbs were low in numerical strength population density relative to shrubs and trees. The abundance of documented species was in the range of 1.0-16.3 %. In N. N. Park *Hibiscus rosa-sinensis* was the most abundant species, while the least abundant species were *M. elengi, N. cadamba and S. cumini*. Similarly, relative abundance estimated was in the range of 0.7-10.9 i.e., *H. rosa-sinensis* was the most abundant species relative to all other documented species and *M. elengi, N. cadamba* and *S. cumini* were the least abundant species relative to all other species. A similar trend was observed for herbs, shrubs, and trees as was estimated for relative density. IVI reflect the

Table 1. Vegetation diversity in parks

Scientific name	D	RD	RF	RA	IVI	D	RD	RF	RA	IVI	D	RD	RF	RA	IVI
	N. N. Park					R. E. H. Park					R. H. Site Park				
Araucaria araucana K. Koch	0.3	0.6	2.4	0.7	3.6										
Areca catechu (L. f.)	0.7	1.1	2.4	1.3	4.8						0.3	0.7	2.0	1.5	4.2
Artocarpus Heterophyllus Lam.	0.7	1.1	1.2	2.7	5.0	0.5	0.8	2.8	0.7	4.3	1.0	2.0	5.9	1.5	9.4
Azadirachta indica A. Juss						0.5	0.8	1.4	1.4	3.6					
A. integrifolia						1.8	2.7	2.8	2.5	8.0					
Albizia lebbeck Benth.	0.5	0.8	3.5	0.7	5.0	1.0	1.6	4.2	1.0	6.7					
Anacardium occidentale L						0.3	0.4	1.4	0.7	2.5					
Albizia procera (Roxb.) Benth.						1.0	1.6	4.2	1.0	6.7					
Alstonia scholaris (L) R. Br	0.3	0.6	1.2	1.3	3.1										
Bombax ceiba L.	0.5	0.8	1.2	2.0	4.0						0.5	1.0	2.0	2.2	5.2
Borassus flabellifer L.	0.3	0.6	2.4	0.7	3.6										
Bischofia javanica Blume						1.0	1.6	1.4	2.9	5.8					
Butea monosperma	0.3	0.6	1.2	1.3	3.1										
Bambusa ventricosa McClure	0.2	0.3	1.2	0.7	2.1	0.3	0.4	1.4	0.7	2.5					
B.vulgaris Schrad. Ex J. C. Wendl						0.3	0.4	1.4	0.7	2.5	0.3	0.3	2.0	0.7	3.0
Cassia fistula L.	0.2	0.3	1.2	0.7	2.1	1.5	2.3	2.8	2.2	7.3					
Calophyllum inophyllum L.											0.5	1.0	5.9	0.7	7.6
Callistemon lanceolatus (Sm.)	1.7	2.8	1.2	6.7	10.6	0.5	0.8	1.4	1.44	3.6					
Cocos nucifera L.	1.8	3.0	3.5	2.5	9.01	0.5	0.8	2.8	0.7	4.3	0.7	1.3	3.9	1.5	6.7
*Cinnamomum tamala*T. Nees& C.H. Eberm						0.5	0.8	1.4	1.4	3.6					
Caryota urens L.						1.0	1.6	1.4	2.9	5.8					
Delonix regia (Hook) Raf	0.2	0.3	1.2	0.7	2.1	2.0	3.1	1.4	5.8	10.3	0.5	1.0	3.9	1.1	6.0
Dalbergia sissoo Roxb. ex DC	10.0	16.5	4.7	10.1	31.2	0.3	0.4	1.4	0.7	2.5					
Elaeocarpus ganitrus Roxb./Sphaericus	0.3	0.6	1.2	1.3	3.1										
Ehretia acuminata (D. C) R. Br.						2.8	4.3	4.2	2.6	11.1					
Eucalyptus globulus Labill	0.3	0.6	2.4	0.7	3.6										
Ficus benghalensis Linn	0.5	0.8	3.5	0.7	5.0										
F. elastica Roxb. ex Hornem											0.7	1.3	3.9	1.5	6.7
F. glomerata Roxb.						0.5	0.8	2.8	0.7	4.3					
F. religiosa L.						1.0	1.6	4.2	1.0	6.7					
F. roxburghii Lour.											0.2	0.3	2.0	0.7	3.0
Gmelina arborea Roxb.											0.2	0.3	2.0	0.7	3.0
Grevillea robusta Cunn. ex R. Br.	1.8	3.0	3.5	2.5	9.0										
Litsea monopetella (Roxb.)						2.0	3.1	4.2	1.9	9.2					
Lagerstroemia parviflora (L) Pers	1.3	2.2	3.5	1.8	7.5										
L. speciosa (L) Pers	1.0	1.7	4.7	1.0	7.4	5.5	8.5	2.8	7.9	19.2					
Michelia champaca L.	0.3	0.6	1.2	1.3	3.1	0.3	0.4	1.4	0.7	2.5					
Mimusops elengi L.	0.2	0.3	1.2	0.7	2.1	6.5	10.1	2.8	9.4	22.2	1.0	2.0	0.7	3.0	3.0
Mangifera indica L.	2.3	3.9	3.5	3.1	10.5	1.3	1.9	2.8	1.8	6.5	0.3	0.7	2.0	1.5	4.2

Cont...

Table 1. Vegetation diversity in parks

Scientific name	D	RD	RF	RA	IVI	D	RD	RF	RA	IVI	D	RD	RF	RA	IVI
	N. N. Park					R. E. H. Park					R. H. Site Park				
Mallotus tetracoccus (Roxb.) Kurz.					25	3.0	1.4	2.2	4.7						
Neolamarckia cadamba (Roxb.)	0.2	0.3	1.2	0.7	2.0	5.5	8.5	5.6	4.0	18.1	7.3	14.4	7.8	8.2	30.4
Oncoba spinosa Forssk											0.2	0.3	2.0	0.7	3.0
Psidium guajava L.						0.8	1.2	1.4	2.2	4.7	0.8	1.2	1.4	2.2	4.7
Polyalthia longifolia (Soon)	0.7	1.1	1.2	2.7	5.0	8.5	13.2	2.5	12.3	28.2	8.5	13.2	2.8	12.3	28.2
Pongamia pinnata (L.) Pierre	2.7	4.4	3.5	3.6	11.5	0.3	0.4	1.4	0.7	2.5					
Plumaria rubra Linn	0.3	0.6	2.4	0.7	3.6	1.3	1.9	4.2	1.2	7.3					
Pinus wallichiana A.B. Jacks	0.7	1.1	2.4	1.3	4.8										
Roystonea regia O. F. Cook	0.7	1.1	2.4	1.3	4.8	4.5	7.0	2.8	6.5	16.2					
Saraca asoca (Roxb.) Willd.											1.0	1.6	4.2	1.0	6.7
Syzygium cumini (L) Skeeks	0.2	0.3	1.2	0.7	2.1						0.2	0.4	1.8	0.7	2.9
Swietenia mahagoni	0.2	0.3	1.2	0.7	2.1	1.8	2.7	2.8	2.5	8.0					
Shorea robusta Roth						0.3	0.4	1.4	0.7	2.5					
Samanea saman F. Muell	0.5	0.8	2.4	1.0	4.2										
Terminalia arjuna (Roxb.) Weight & Arn	0.3	0.6	2.4	0.7	3.6						0.7	1.3	3.9	1.5	6.7
Toona ciliate M. Roem						1.0	1.6	2.8	1.4	5.8					
Terminalia elliptica Wild	1.5	2.5	2.4	3.0	7.8	2.0	3.1	1.4	5.8	10.3					
Tectona grandis L. f						0.3	0.4	1.4	0.7	2.5					
Tabernaemontana divaricata R. Br. Ex Roem. & Schult											1.3	2.7	5.9	2.0	10.6
Thuja orientalis L.						1.0	1.6	2.8	1.4	5.8					
Citrus limetta L.	0.7	1.1	1.2	2.7	5.0	1.0	1.6	2.8	1.4	5.8	0.2	0.3	2.0	0.7	3.0
Codiaeum variegatum (L) A. Juss.											1.3	2.6	7.8	1.5	11.9
Duranta plumieri	5.2	8.5	2.4	10.4	21.3	0.3	0.4	1.4	0.7	2.5					
Hibiscus rosa sinensis L.	8.2	13.5	3.5	10.9	27.9	0.3	0.4	1.4	0.7	2.5	7.8	15.4	3.9	17.5	36.7
Jatropha curcas L.	6.7	11.0	5.9	5.4	22.2										
Murraya exotica (L.) Jack	4.2	6.9	4.7	4.2	15.8										
Rosa rubiginosa L.											14.7	28.9	3.9	32.7	65.5
Celosia argentea											2.5	4.9	5.9	3.7	14.5
Canna indica L.	0.7	1.1	2.4	1.3	4.8										
Musa paradisica											0.2	0.3	2.0	0.7	3.0

RF-Relative frequency; D-Density (individuals/ha); RD-Relative density; RA-Relative abundance; IVI-Importance value index

importance of a particular species in its habitat IVI estimated for the documented species in N. N. Park was in the range of 2.1- 31.2. The most important species in the park were *D. sissoo* and the least *M. elengi, N. cadamba* and *S. cumini*. In herbs, IVI was 4.8 for *Canna indica* and in shrubs, it was *H. rosa-sinensis* with an IVI of 27.9. The next valuable trees after *D. sissoo* were *Pongamia pinnata* (11.5), degree of dispersion of the plant species in Royal Eco Heritage Park was in the range of 25-100 % i.e., the most frequent species in the park was *Neolamarckia cadamba*, while the least frequent species were *Syzygium jambos, Mallotus tetracoccus* and *Bischofia javanica*. The degree of dispersion of shrubs was 25-50 % and trees 25-100 %. Relative frequency estimated for the documented species was 1.4-5.6, i.e., *N. cadamba* was the most frequent species relative to all other documented species, while the least frequent species in relative terms were *Tectona grandis and Bambusa vulgaris*.

The density was in the range of 0.3- 8.5%. *Polyalthia longifolia* was the most numerically dominant species in the park due to its conical canopy which enhanced the aesthetic beauty of the park. The numerical strength of shrubs was 0.3-1.0 % and trees 0.3- 6.5 %. The relative density of all the documented species was in the range of 0.4-13.2. Relative density for the shrubs was in the range of 0.4-1.6 and for trees 0.4-10.1. The abundance of the entire documented species was in the range of 1.0-17.0 %. The most abundant species documented in the park was *Polyalthia longifolia* and the least abundant species were *Syzygium jambos, Tectona grandis* and *Bambusa vulgaris*. The relative abundance ranged between 0.7 and 12.3. The most abundant was *P. longifolia* relative to all other documented species in the park. IVI values estimated for the documented species of the park were 2.5-28.2. Thus, the most important species in this park was *P. longifolia* for its avenue and aesthetic values due to its dark green foliage, drooping branches and conical canopy. The other important species in this park were *Mimusops elengi* (22.2) and *Lagerstroemia Speciosa* (19.24). These species are also preferred avenue and aesthetic plants. The least important plant in the park was *S. jambos, T. grandis*

Table 2. Vegetation analysis of B. S. F. campus, Cooch Behar town

SN	F	D'	A'	RD	RF	RA	IVI
Areca catechu	66.7	8.3	12.5	13.0	5.2	12.9	31.0
Artocarpus hetrophyllus	66.7	3.3	5.0	5.2	5.2	5.2	15.5
Azadirachta indica	50.0	1.2	2.3	1.8	3.9	2.4	8.1
Albizia procera	100.0	6.2	6.2	9.6	7.8	6.4	23.7
Bombax ceiba	33.3	0.8	2.5	1.3	2.6	2.6	6.5
Butea monosperma	83.3	2.0	2.4	3.1	6.5	2.5	12.1
Cassia fistula	33.3	0.8	2.5	1.3	2.6	2.6	6.5
Delonix regia	50.0	1.0	2.0	1.6	3.9	2.1	7.5
Dalbergia sissoo	50.0	1.2	2.3	1.8	3.9	2.4	8.1
Eucalyptus globulus	33.3	0.3	1.0	0.5	2.6	1.0	4.2
Ficus religiosa	33.3	0.8	2.5	1.3	2.6	2.6	6.5
Gmelina arborea	50.0	2.2	4.3	3.4	3.9	4.5	11.7
Lagerstroemia speciosa	83.3	6.8	8.2	10.6	6.5	8.5	25.6
Melia azedarach	50.0	2.0	4.0	3.1	3.9	4.1	11.1
Michelia champaca	33.3	0.7	2.0	1.0	2.6	2.1	5.7
Mangifera indica	100.0	4.5	4.5	7.0	7.8	4.6	19.4
Psidium guajava	33.3	2.0	6.0	3.1	2.6	6.2	11.9
Polyalthia longifolia	83.3	13.7	16.4	21.2	6.5	16.9	44.7
Syzygium cuminii	66.7	2.7	4.0	4.2	5.2	4.1	13.5
Shorea robusta	50.0	1.0	2.0	1.6	3.9	2.1	7.5
Tectona grandis	83.3	1.7	2.0	2.6	6.5	2.1	11.2
Duranta plunnmieri	50.0	1.2	2.3	1.8	3.9	2.4	8.1

SN- scientific name; F-frequency, D'- density; A': abundance; RD-relative density; RF-relative frequency; RA- relative abundance; IVI-important value index

and B. Vulgaris with an IVI value of 2.5 each. They were just scattered and casually planted trees in the interior of the park.

The frequency of the documented species was estimated in the range of 25-100 % i.e., *Codiaeum variegatum*, *Polyalthia longifolia* and *Neolamarckia cadamba* were documented from all the sampled plots of the site, while *Mimusops elengi, Oncoba spinosa and Syzygium cumini* were observed from the quarter of the sampled plots. Trees and shrubs occurred on all sampled plots and herbs on a quarter of the sampled plots. Similarly, the relative frequency was in the range of 1.4-5.6. The density of documented species in the site ranged between 0.2 and 14.7 %. *Rosa rubiginosa* was observed with the highest density in the site, while *M. elengi, O. spinosa and S. Cumini* were observed with the lowest density. The relative density ranged between 0.3 (*Mimusops elengi, Oncoba spinosa* and *Syzygium cumini*) and 28.9 (*Rosa rubiginosa*). Species abundance estimated in the Rajbari Heritage site was 1.0-44.0 % and the most abundant species found in the site was *R. rubiginosa* and the least abundant species were *M. elengi, O. spinosa*, *and S. cumini* and six other species. Similarly, relative abundance estimated was in the range of 0.7-32.7 and *R. rubiginosa* was most abundant relative to all documented species from the site, while *M. elengi, O. spinosa and S. cumini* were least abundant relative to all other documented species. The IVI was in the range of 3.0-65.5 and the most important species at the site was *R. rubiginosa* followed by *H. rosa-sinensis* (36.8), *and Polyalthia longifolia* (30.4) and the least was *M. elengi, Neolamarckia cadamba* and *S. cumini* with IVI value of 3.03 each. Rajbari Heritage site, Cooch Behar town is a heritage archaeologically protected site and popular among visitors. The species selected in its garden and along the path add to the aesthetic beauty of the heritage building.

Institutional area (BSF campus): BSF campus was abundant with open space with fewer scattered trees kept aside for their security operations, drilling and parking, thus the site was observed with the least species richness of all study sites (Table 2). Most of the species found on the campus were either planted along the paths and roads or surrounding the building infrastructures meant for providing shade and seasonal fruits with avenue purpose. The frequency or the degree of dispersion of the documented plant species on the BSF campus ranged between 33.3 and 100 %. The most frequent species were *Albizia procera* and *Mangifera indica* and the least frequent species were *Eucalyptus globulus, Michelia champaca and Ficus religiosa*. *Duranta plumieri* was the only shrub species found on the BSF campus. The relative frequency ranged between 2.6 and 7.8. *Albizia procera* and *Mangifera indica* were the most abundant species relative to all other documented species.

The density of the documented species was estimated in the range of 0.3-13.7 %. The species with maximum numerical strength on the campus was *Polyalthia longifolia* while *Eucalyptus globulus* was with minimum numerical strength. The other numerically stronger species on the campus were *Acacia catechu* (8.3) and *Lagerstroemia speciosa* (6.8). Similarly, the relative density estimated was in the range of 0.5 (*E. globulus*)-21.2 (*Polyalthia longifolia*). The abundance of the documented species on the campus ranged between 1.0 to 16.4 %. The abundance of the species in the campus in descending order was *P. longifolia* (16.4 %), *A. catechu* (12.5 %), *L. speciosa* (8.2 %), *Michelia champaca, Shorea robusta* (2.0 % each) and *E. globules* (1.0 %). A similar order of the species was also observed for relatives and the range estimated was 1.0-16.9. The estimated IVI for the documented species on the campus was in the range of 4.1-44.6. In this site also the most important species was *P. longifolia* followed by *A. catechu* (31.0), *L. speciosa* (25.6) and the lesser important species were *E. globulus* (4.1), *M. champaca* (5.7), *Shorea robusta* (7.5) and *Dalbergia sissoo* (7.5). The species with high IVI were planted all along the paths and roads as avenue plantations, while the lower IVI species were scattered trees providing shade. *Duranta plumieri* the only shrub species on the campus with an IVI of 8.1 was a hedgerow planted all along the paths and in front of the buildings. The land for the campus was acquired by the BSF from the residents and the scattered trees were the actual plantation of the homegardens of the residents which were retained by the BSF.

The other species which were estimated with higher IVI were planted in a planned manner for campus beautification as avenues and aesthetics. It was observed that in the studied urban sites especially the parks, preference for species with large canopies that bears an enormous amount of flowers and fruits was more as compared to small and narrow canopy trees. Contrast species preferences were also reported from urban sites in Bengaluru (Nagendra and Gopal 2010a, b) and Guangzhou, China (Jim and Liu 2001). Large trees were reported as a better habitat for avian and small mammal species, accumulate more biomass, stock more carbon; remove more air particulate pollutants, greater shade and more effective cooling (Mcpherson and Simpson 2003, Pauleit 2003). This is a welcome trend at a time when initial impacts of climate change are being experienced globally (Nagendra and Gopal 2010a, Nowak 2010). A similar study estimating biodiversity indices of different urban green sites of Bangaluru, India (Nagendra and Gopal 2010a) and Nairobi, Kenya (Nyambane et al 2016) concluded that the

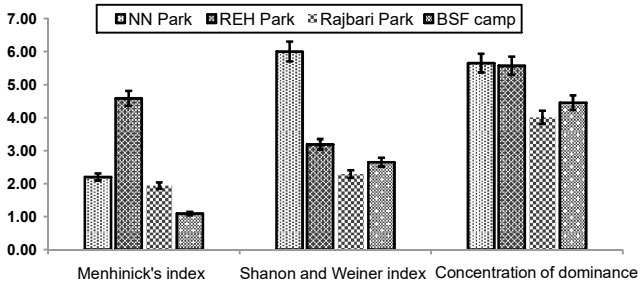

Fig. 2. Diversity indices of the study area

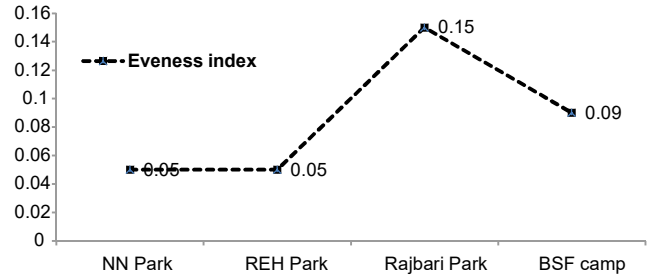

Fig. 3. Evenness index of the study area

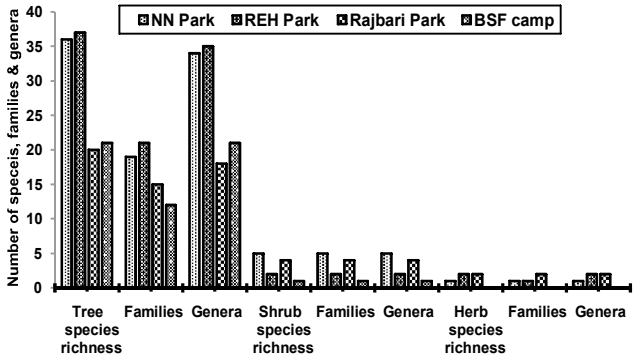

Fig. 4. Life form diversity in study areas

sites were quite phyto-diverse with the dominance of few tree species with significant variation of diversity among the studied sites. It was reported that the common biodiversity indices like those estimated in this study vary among and within the cities or urban landscape through time (Barbour et al 1980, Iverson and Prasad 2001, Nowak et al 2008).

Urban green spaces or the extent of vegetation cover in urban landscapes is influenced by several species and the number of individuals planted which in turn is influenced by the combination of natural and anthropogenic factors (Nowak 2010). Natural factors include native vegetation and its abundance, natural biotic interactions (seed dispersers, pollinators, and plant consumers), and climatic factors. The dominance of native species in the present study sites is clearly because the region is classified under Indo Malayan Biodiversity Hotspot (Myers et al 2000) and park managers had the choice of species from the wide range available best suited for the park. Conditioned on these natural influences is the anthropogenic system which includes people, urban infrastructure, land use and management decisions (Rathore and Jasrai 2013, Widyatmoko et al 2013, Edmondson et al 2014, Mitra and Zaman 2014, Churkina et al 2015, Livesley et al 2016, Mandari and Gunawan 2016).

BSF campus with more than 50 ha was documented with the lowest of 22 species richness, while N. N. Park with about 10 ha area with 42 species, Rajbari Heritage site with about 15 ha area with 26 species and Royal Eco Heritage Park with about 5 ha area harboured 41 species. This is contrary to the ecological concept of the species-area relationship and supported by studies reporting larger park areas with higher species richness due to greater habitat diversity and microhabitat heterogeneity than smaller ones (Cornelis and Henry 2004, Khera et al 2009, Carbó-Ramírez and Zuria 2011) the present study documented lesser species richness in larger areas. This is a clear instance of natural systems superimposed by an anthropogenic system. The species documented in the studied sites was the result of the creator's or developer's choice. The BSF campus has more open areas left for Border Security Force's operational purpose and trees are planted only along the roads and paths, residences and other buildings and rarely with scattered trees. Rajbari Heritage site conserves the Royal palace of the erstwhile Royal family of Cooch Behar in the heart of the town so dominated by lawns with occasional scattered trees and trees planted along the boundaries. The site was in dilapidated conditions and neglected till the Archaeological Survey of India took over in 2000 AD. The other two sites were the historical parks established by the Royal Family of Cooch Behar within the town area, thus with smaller area coverage but with more species. The studied parks were located within the Cooch Behar town and were comparatively species-rich as compared to the BSF campus which is located at the periphery of the town. It was reported that the species richness and diversity of plants located inside the cities were more as compared to their surrounding locations (Nowak 2010). Some non-native plant species were also documented from the study sites which might have invaded through transportation corridors or escaped from cultivation.

CONCLUSION

The present study was an initiation to understand the urban vegetation in the sub-humid climatic conditions of

West Bengal, India in terms of its species richness, composition and conservation. These urban green sites of Cooch Behar City are a fairly diverse community in which the species are moderately even distributed with higher chances of encountering a species and dominance distributed among the species. Thus, urban green sites can also be managed for *ex-situ* conservation of species and also as a repository of plant species. Further research in parks is required to understand the Cooch Behar or regional specific characteristics and consequently, the implications for planning policies in the urban context. This study has policy implications for planners and urban designers, as well as for environmental organizations.

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