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Tree species composition, biomass and carbon stocks in Urban Green Spaces of Prayagraj

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ABSTRACT

Urban Green Spaces store higher above ground biomass (AGB) and AGB carbon (AGBC). In the present study the tree composition, diversity, dominance and carbon stocks in the AGB U.G.C. of viz., the Company Garden (C.G.), Minto Park (M.P.), Khusro Bagh (K.B.), PD Tandon Park and the Hathi Park (H.P.) of Prayagraj, India were assessed. A total of 27, 24,21,18 and 14 different tree species belong to 15,14,11,12 and 9 families were found in the C.G, M.P., K.B.,PD and H.P., respectively. In the C.G, M.P., K.B., PD and H.P the Shannon diversity index (1.22) (2.35) (2.91) (2.79) (2.50) and the Simpson index (0.050) (0.046) (0.062) (0.066) (0.094) were significant. The AGB, BGB, TGB and carbon in C.G. were (49.14) (13.27) (62.41) (31.21) respectively. However, compared to other site a higher carbon stock was found in C.G.

Key words: *Urban Green Spaces, Biomass, Carbon stock*

Introduction

Forests are both intensively and extensively influenced by global climate variability (IPCC, 2006). Forests play an important role in the climate system (Shahid and Joshi, 2018). Globally, Forests act as both source and sink of carbon (Harvey *et al.*, 2010). The forests and soil can be well managed to sequester or safeguard substantial amounts of carbon on the land (Sharma *et al.,* 2011). Forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural 'brake' on climate change (Dey *et al*., 2014). Global warming has emerged as the major environmental challenge which was resulted due to anthropogenic activities. Tropical forests span only about 15% of Earth's surface, but serve as hotspots for both biodiversity and carbon. They act as sinks for around 40% of global terrestrial carbon (Brown *et al*., 1999) (Gandhi and Sundarapandian, 2017) and comprise 80% of the total terrestrial plant biomass. Biodiversity and carbon are widely recognized to be highly productive ecosystems (Sohel *et al.,* 2019) and stock more carbon in biomass and soil together than present in the atmosphere (Ogawa *et al.,* 1965) With the intense focus on the increasing levels of atmospheric CO_2 and the potential for global climate change, there is an urgent need to assess the feasibility of managing ecosystem to sequester and store C (IPCC, 2013). CO_2 has been identified as one of the major greenhouse gases (Sierra *et al.,* 2007). Tropical forests contain 247 Gt of carbon in vegetation, with dry forests and rainforests share about 110 and 134 Gt of it respectively (Foley, 1965), (Saatchi *et al*., 2011) and 193 Gt of it is stored aboveground (Ravindranath *et al.*, 1997). Plant biodiversity and the relationship with

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carbon cycle have become an important aspect, given the international efforts to moderate or minimize the impact of climate change through reducing the conversion of natural ecosystems (Malhi *et al.,* 1999), (Saatchi *et al.*, 2011). In order to assess theimpact of deforestation and re-growth rates on the global Ccycle, it is necessary to know the C stocks as biomass perunit area for different forest types (Ghimire *et al.,* 2018). Carbon stock estimation reflects the potentiality of forestin climate change mitigation (Ghimire *et al.,* 2018). While reliable data on regeneration patterns are required for successful management and conservation of natural forests (Eilu and Obua, 2005). Tropicalforests are known to exchange more carbon dioxide with the atmosphere than any other biome (Foley, 1995), (Giri *et al*., 2019) and increasing biomass of intacttropical forests can absorb carbon at a rate of 1.1±0.3 Pgper year, thereby decelerating the rate of global warming by about 15% (Lu *et al.*, 2010), (Subashree and Sundarapandian, 2017). The United Nations Programme for Reducing Emissions from Deforestation and Forest Degradation (REDD) has potential to provide considerable benefits for biodiversity conservation through protection of various forests species (Haripriya, 2000), (Gardner *et al.,* 2012), (Saatchi *et al*., 2011). The rapid conversion like plantation and agricultural lands of tropical forests was a major source of greenhouse gases (Mohanraj *et al.,* 2011). Plants act as a major carbon sink and capture carbon from the atmosphere and store it in the form of fixed biomass during the growth process (Chavan and Rasal, 2010), (Pearson *et al.,* 2005). Hence, a functional relationship is required between diversity and carbon sequestration that has implications for carbon management projects. Carbon stock estimation reflects the potentiality of forest in climate change mitigation (Ghimire *et al*., 2018). while reliable data on regeneration patterns are required for successful management and conservation of natural forests (Eilu and Obua, 2005). The role of forest in mitigation of global climate change has been already recognized and various studies have suggested forests as a high potential of storing terrestrial C. In a forest, terrestrial C is stored in different pools but tree and soil are the main pools that store more C than the other pools. Thus, the estimation of C storage in tree biomass and soil is important to understand the potential offorest in climate change mitigation. Plant biodiversity and the relationship with carbon cycle have become an important aspect, given the international efforts to moderate or minimize the impact of climate change through reducing the conversion of natural ecosystems (Malhi *et al.,* 1999), (Saatchi *et al.,* 2011).

Materials and Methods

Study area

Study was carried out in the urban green spaces of Prayagrajis a district in Uttar Pradesh's south-eastern region, India (Fig. 1). It is surrounded by the districts of Pratapgarh and Jaunpur in the north,

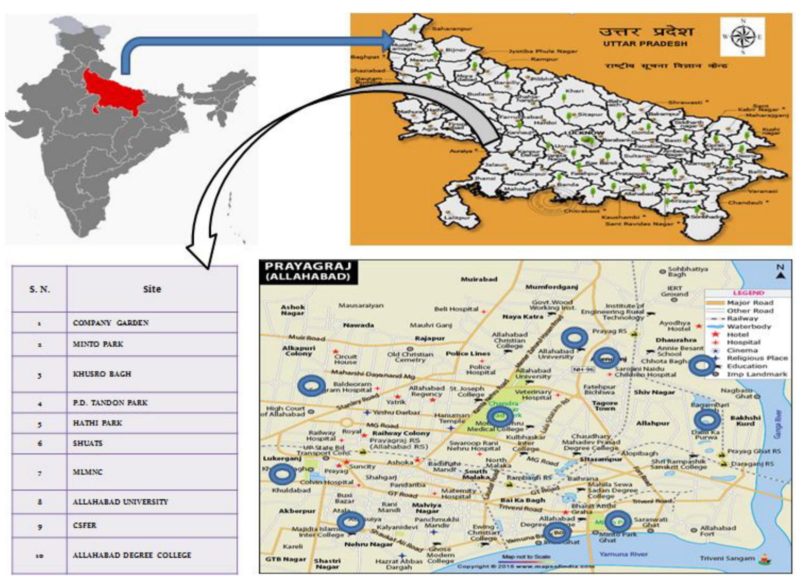

Fig. 1. Location map of study area in the Prayagraj green urban spaces, India.

Varanasi in the east, Kaushambi in the west, Mirzapur and Rewa in Madhya Pradesh on the south, and is between the parallels of North latitudes 24°47' and 25°47' and East longitudes 81°09' and 82°21' (98 masl). There are three distinct physical parts of the city, similar to the district itself: (1) Trans-Ganga or the Ganga par Plain, (2) Ganga-Yamuna doab (confluence), and (3) Trans-Yamuna or the Yamuna par tract, all of which are formed by Ganga and its tributary Yamuna, with the latter joining the former at Prayagraj, and the confluence is known as sangam. The city's general geography is flat with mild undulations. The study covers different green urban spaces in Prayagraj UP. viz. Company garden, Minto park, Khusrobagh, P.D Tandon park, Hathi park, SHUATS, MLMNC, ADC, CSFER, AU.

Sampling and data analysis

The study was conducted Prayagraj in different green urban spaces from 2019. The vegetation analysis was carried out by using the quadrates of random sampling method. Quadrats of 20m×20m (400 m^2) size were randomly laid to examine tree species, Quadrats 5m×5 m (25 m^2) size for shrubs & 1m ×1m for size for herbs was chosen in each quadrat at selective site.

Estimation of biomass and carbon stock

1. Allometric equation given by Chave *et al.* (2005), for tree diameter (5-60 cm) for the Dry life zone with an annual rainfall of less than 1500 mm/year, will be used for estimating aboveground biomass of trees (kg/tree) in each urban green spaces.

$$(AGB)\ est = 0.112(rD^2H)^{0.916}$$

Where, (AGB)est = Estimated aboveground tree biomass (kg/tree)

D = diameter at breast height in cm

H = tree height in m

r = wood density in g/cm^3

2. BGB (Below Ground Biomass) has been calculated by the multiplying the AGB by 0.27, as per factor prescribed by Hangarge et al.

BGB= Aboveground tree biomass x 0.27

3. TGB (Total Ground Biomass)

TB (Total Biomass) has calculated by the sum total of AGB and BGB

Total biomass= AGB+BGB

4. Generally, for any plant species 50% of its biomass is considered as carbon (Pearson *et al.,* 2005).

Carbon Storage = Biomass x 50% or Biomass / 2

5. The elemental carbon removed from the atmosphere (CO_2) was then calculated as per procedure followed by Dury *et al.* (2005).

$$CO_2e = C_b \times 3.67$$

Results and Discussion

An area of UGS of Prayagraj occupies 5 study sites (Table 1). In the site, 0.4 ha area was occupied by Campany Garden, 0.8 by Minto Park, 0.6 ha by Khusro Bagh, 0.36 ha was occupied by PD tandon and while only 0.32 ha was occupied by Hathi Park.

Table 1. Urban green spaces types and area covered by each habitat found in the Prayagraj U.P.

S. No.	Urban green spaces habitat types	Area covered in each forest (ha)
1	Campany Garden (dense)	0.4
2	Minto Park (open)	0.8
3	Khusro Bagh (dense)	0.6
4	PD tandon (open)	0.36
5	Hathi Park (open)	0.32

Descriptions of various plant species which belong to different families, BA and DBH is described in Table 2. In the case of the site-1 , of the 27 recorded tree species, 6 tree species belong to the Fabaceaeand this family was dominant followed by Myrtaceae (4), Moraceae (3) and rest were <2. Similarly, in the site-2, out of 24 recorded tree species, Fabaceae was 5 followed by Miliaceae, Annonaceae and Moraceae (2), while others occupy < 2. In the site-3, out of 21 recorded tree species, Fabaceae was 5 followed by Moraceae, Myrtaceae (4), while others occupy < 2. In the site-4, out of 18 recorded tree species, Fabaceae was 3 followed by Moraceae, Bombacaceae (4), while others occupy < 2. In the site-5, out of 14 recorded tree species, Fabaceae, Moraceae and Myrtaceaewas 2, while others occupy < 2. A summary of number of tree, diversity in the C.G., M.P., K.B., PDT in H.P. of Prayagraj is described in Table 3. The tree density in the present study (5.55-3 trees ha^{-1}) is less than that reported study for several Tropical area (Sundarapandian *et al.,* 2013), (Ayyappan and Parthasarathy, 1999). In-

Table 2. Basal area (BA) and diameter at breast height (DBH) of individual tree species found in Urban Green Spaces (UGS) of Prayagraj, India.

Name of the family	Name of the species	Local name	BA ($m^2 ha^{-1}$)					DBH (cm)				
			Campany Garden	Minto Park	Khusro Bagh	PD tandon	Hathi Park	Campany Garden	Minto Park	Khusro Bagh	PD tandon	Hathi Park
Fabaceae	*Tamrindusindica*	Imli	0.071		0.159		0.255	60.2		56.3		46.3
Miliaceae	*Azadirechtaindica*	Neem	0.031	0.08	0.708	0.54	0.246	21.1	22.4	32.3	32.6	48.3
Moraceae	*Ficusracemosa*	Gular	0.126			0.553	0.594	48			54.3	61.2
Fabaceae	*Cassia fistula*	Amaltas	0.031	0.091		0.152		41.1	42.1	26.6	41.3	
Fabaceae	*Albezialebbeck*	Siris	0.071	0.132				41.6	32.2			
Fabaceae	*Peltophorumpterocarpum*	Peltaphorum	0.071		0.166			13.1				
Fabaceae	*Dalbergiasissoo*	Sesham	0.126					44.2				
Fabaceae	*Delonixregia*	Gulmohar	0.031	0.264	0.212			31.1	32.7	51.2		
Ulmaceae	*Holopteleaintegrifolia*	Chilbil	0.071	0.107	0.188	0.246		18.1	26.3		46.1	
Annonaceae	*Polyalthialongifolia*	Ashok	0.031	0.119	0.322	0.352	0.113	19.3	17.4	44.1		37.2
Miliaceae	*Meliaazedarach*	Bakain	1.130	0.302	0.145	0.159		21.2	21.2	21.3	24.1	
Moraceae	*Ficusbenghalensis*	Bargad	0.071		1.188			85.1		81.5		
Myrtaceae	*Syzygiumcumini*	Jamun	0.071		0.004			63.1		57.1		
Moraceae	*Ficusreligiosa*	Pipal	0.126	0.636	2.543	0.753	0.594	45.7	46.2	95.3	67.3	56.2
Combretaceae	*Terminaliaarjuna*	Arjun	0.126	0.102				31.1	26.3			
Myrtaceae	*Psidiumguajava*	Amrud	0.071	0.042	0.042			18.4	22.6	27.3		
Phyllanthaceae	*Embilicaofficinalis*	Amla	0.031	0.038	0.042			38.1	37.2	31.1		
Myrtaceae	*Eucaltptus globules*	Safeda	0.138		0.567		0.075	21.1		29.4		19.3
Myrtaceae	*Callistemon viminalis*	Bottle tree	0.071	0.08	0.096	0.132	0.119	25.1	19.5	23.2	43.2	25.1
Bombacaceae	*Bombaxceiba*	Semal, Semar	0.071	0.043		0.331		32.2	29.2		37.1	
Anacardiaceae	*Mangiferaindica*	Aam	0.145	1.13	0.567		0.478	46.1	32.1	63.7		53.4
Malvaceae	*Pterospermumacerifolium*		0.045					32.6				
Lamiaceae	*Tectonagrandis*	Teak	0.071	0.052		0.075		21.1	19.4		25.2	
Aracaceae	*Wodyetia bifurcate*	Pakad	0.031	0.102	0.229	0.102	0.080	29.4	26.1	24.3	47.5	28.2
Apocynaceae	*Alstoniascholaris*	Saptaparni	0.126	0.145	0.204	0.18	0.090	24.3	47.4		39.3	38.1
Rutaceae	*Aeglemarmelos*	Bel	0.071	0.302		0.145		45.1	32.2	34.2	34.1	
Sapotaceae	*Mimusopselengi*	Malshri	0.071	0.057		0.119	0.091	27.1	31.3		23.1	34.2
Sapotaceae	*Madhucaindica*	Mahua		0.664			0.352		37.5			48.3
Fabaceae	*Bauhinia variegata*	Kachnar		0.212	0.035	0.237	0.173		34.1	49.3	23.3	39.1
Fabaceae	*Leucaenalucocephala*	Subabool		0.049					26.3			
Moraceae	*Artocarpusheterophyllus*	Kathal		0.045	0.264				24.2	48.1		
Annonaceae	*Annona squamosal*	Anona		0.071					31.2			
Moraceae	*Artucarpuslacucha*	Lachohra			0.113					42.1		
Combretaceae	*Neolamarckiacadamba*	Kadam				0.113	0.159				32.2	31.1
Bombacaceae	*Ceibapetendra*	Kapok				0.08					46.1	
Fabaceae	*Moringaoleiflera*	Sahjan				0.145					32.2	

Table 3. Summary of tree diversity in the C.G., M.P., K.B., PD Tandon and HathiPark

Study sites	Campany Garden	Minto Park	Khusro Bagh	PD tandon	Hathi Park
Number of families	15	14	11	12	9
Number of tree species	27	24	21	18	14
Density (trees ha^{-1})	5.55	4.9	4.33	4.11	3
Basal area (m2 ha^{-1})	3.12	4.60	8.07	4.42	3.42
Simpson index of diversity	0.050	0.046	0.062	0.066	0.094
Shannon diversity index	3.13	2.35	2.91	2.79	2.50

Table 4. T-test of Total no. of species and Total no. of Families

Site Name	Total no. of species reported	Total no. of Families
Site 1	27	15
Site 2	24	14
Site 3	21	11
Site 4	18	12
Site 5	14	9
Mean	20.8	12.2
SD	5.07	2.39
Variance	1.60	0.75
T- Statistic	6.969	6.74
T. cal (0.05%)	2.77	2.77
T.tab (0.01)	4.6	4.6
Level of significant	**S**	**S**

stead, the presence of 9-15 families, 14-27 numbers of trees were reported earlier for different tropical forest support the present findings (Lu *et al.*, 2010).

Overall, a higher tree density (5.55 tree ha^{-1}) (4.9 tree ha^{-1}) but lower basal area (3.12 m^2 ha^{-1}) (4.60 m^2 ha^{-1}) were recorded in C.G. and M.P and higher basal area (8.07 m^2 ha^{-1}) (4.42 m^2 ha^{-1}) (3.42 m^2 ha^{-1}) but lower tree density (4.33 tree ha^{-1}) (4.11 tree ha^{-1}) (3 tree ha^{-1}) were recorded in K.B., PD.T and H.P.

In H.P. there was appreciably higher Simpson index of concentration of dominance (0.094) and Shannon diversity index 3.13 in the C.G. it was not significant (Table 3). The Shannon diversity index in the present study which is comparable with the findings of (Pan *et al.*, 2013), (Sundarapandian *et al.*, 2013) who reported Shannon diversity indexas 0.83 to 4.1 for different Indian forests.

Above ground biomass and carbon stocks

The forest type, age of the forest, size class of treeetc. influence the potential of forest to sequester carbon.The AGB and AGBC stocks of tree species in the UGS of Prayagraj are described in (Tables 5). The

Table 5. Above ground biomass (AGB) and C stock of tree species in Campany Garden, Minto Park, Khusro Bagh, PD tandon and Hathi Park of Prayagraj.

Site	Aboveground carbon (Mg ha^{-1})	Belowground carbon (Mg ha^{-1})	Total biomass (Mg ha^{-1})	Total Carbon sequestered (t Mg ha^{-1})
CampanyGarden	49.14	13.27	62.41	31.21
Minto Park	14.62	3.95	14.81	7.4
KhusroBagh	32.54	8.79	41.33	20.67
PD tandon	15.47	4.18	19.65	9.82
Hathi Park	22.43	6.06	28.49	14.25

Table 6. Estimates of aboveground biomass (AGB) and C stocks of tropical forests in different Asian countries

Study Area	Forest Type and Location	AGB (Mgha^{-1})	C Stock (Mgha^{-1})
Ogawa *et al.* (1965)	Tropical forest, Thailand	-	60.0-179.0
Brown and Lugo (1982)	Tropical forest, Sri Lanka	154.0	77.0
Ravindranath *et al.* (1997)	India	126.0	-
Haripriya (2000)	India	67.4	
Baishya *et al.* (2009)	Tropical forest, India	324.0	162.0
Chaturvedi *et al.* (2011)	Tropical drydeciduous forest, India	-	87.0
Present study	Tropical forest of Urban spaces in Prayagraj	22 – 49	11.21 - 24

AGB of the present study ranged from 49.14 Mg ha^{-1} to 14.62 Mg ha^{-1}. Which is comparable with findings of (Hall and Uhling, 1991), (Pragasan, 2014) (Haripriya, 2000). Similarly, the values of carbon stocks in this study ranged from 31.21Mg ha^{-1} to 7.4 Mg ha^{-1}, which supports the other previous studies (Baishya *et al.*, 2009), (Ogawa *et al.*, 1965), (Flint and Richards, 1996). Which is comparable to (Cairns *et al.*, 2003), (Chaturvedi, 2011), (Hall and Uhling, 1991), (Sierra *et al.*, 2007). This result may be attributed to the disturbance in these forests.

Studies on diversity and functional relationship have very recently started in forest ecosystems and have yet to produce results. Different authors have different opinion regarding this. According to (Caspersen and Pacala, 2001), there is a positive relationship between diversity and productivity. In present study, significant relationship was found between diversity indices and AGB. Species richness and Shannon diversity index showed positive relationship with AGB, while Simpson index of concentration of dominance showed negative correlation with AGB. Ealier findings of (Kirby and Potvin, 2007) contrasts the present findings (Kirby and Potvin, 2007) were not able to find any evidence for relationship between tree species diversity and aboveground biomass.

A strong and positive relationship was found between basal area and AGB. The relationship between AGB and basal area in forest stand is likely to be associated with tree architectural development because the lower part of the tree trunk must contain the growth process of the tree since initiation. We tried to show top five relative contributing species of AGB and aboveground C stocks. It will help forest management and selective logging of tree species. Thus, the potential effects on overall AGB and C stock from the removal or conservation of these species of different families are considered to be significant.

Conclusion

A total of 5 sites were found in the UGS of Prayagraj, India, respectively. In the C.G., (0.4ha) area was occupied dense forest. In M.P., (0.8 ha) area was covered with dense/closed forest. In K.B., (0.6 ha) area was covered with dense/closed forest. In PDT Park area was covered with (0.36 ha) while in H.P., area was covered with dense/closed forest and (0.8 ha) was covered. A total of 27, 24, 21, 18 and 14 different tree species belong to 15,14, 11, 12 and 9 families was recorded in the, Campany Garden, Minto Park, Khusro Bagh, PD tandon and Hathi Park respectively. a higher tree density (5.55 tree ha^{-1}) but lower basal area (3.12 m^2 ha^{-1}) were recorded in C.G. and higher basal area (8.07 m^2 ha^{-1}) butlower tree density (4.33 tree ha^{-1}) were recorded in K.B. Appreciably higher AGB (49.14 Mg ha^{-1}) and Carbon stock (31.21 Mg ha^{-1}) was recorded in the C.G.

From the above study, we concluded that the AGB and C stock of present tropical forest sites were comparable with the findings of earlier workers. In most of the forests in the present study, younger trees contributed more AGB and C stock than the older trees. We found that basal area had significant positive relationship with AGB.

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