

Carbon storage by trees in urban parks: A case study of Jammu, Jammu and Kashmir, India

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Abstract

With the increasing concern about the climate change and global warming, there is need of sources which can help in mitigating the increasing effect of green house gases. Urban trees can play an important role in this by carbon storage and sequestration. Keeping in view the importance of urban green spaces, the present study was conducted in 35 urban parks of Jammu city, J&K, with the objectives to estimate the above ground biomass and carbon in trees of urban parks of Jammu city. For the purpose of study *i.e.* tree diversity in urban parks, sample plots of 20 m × 20 m size were laid to collect information. The estimation of above ground biomass and carbon was carried out by adopting standard methodology developed by Forest Research Institute, Dehradun, India. The results of the study show that the total area under various parks studied was found to be 35.91 ha. The results of the growing stock of trees growing in the parks studied show that the total volume of the trees growing in the parks was found to be 80360.11m³ and the total above ground biomass was found to be 64020.50 t which comes to 1782.80 t / ha. Total above ground carbon stored in the trees of these park is 39112.50 t (1089.18 t / ha).

Keywords: carbon storage, urban parks, biomass, growing stock

Introduction

Urban parks and open green spaces are of a strategic importance for the quality of life of our increasingly urbanized society. Increasing empirical evidence, in fact, indicates that the presence of natural assets (*i.e.* urban parks and forests green belts) and components (*i.e.* trees, water) in urban contexts contributes to the quality of life in many ways (Chiesura, 2004) ^[1]. Besides important environmental services such as air and water purification, wind and noise filtering, or

Microclimate stabilization, natural areas provide social and psychological services, which are of crucial significance for the livability of modern cities and the well being of urban dwellers. A park experience may reduce stress, enhance contemplativeness, rejuvenate the city dweller, and provide a sense of peacefulness and tranquility (Kaplan, 1989) ^[2]. The presence of trees and grass in outdoors common spaces may promote the development of social ties (Kuo *et al.*, 1998) ^[3]. Trees mitigate the urban heat island effect through cooling from shading and evapo-transpiration (Akbari, 2002) ^[4]. Through their moderation of the climate, trees are a valuable means by which to conserve energy and subsequently reduce costs (McPherson and Simpson 1999) ^[5]. Furthermore, trees reduce air pollution by trapping particulate matter in their canopies, absorbing noxious pollutants through their leaves and producing oxygen through photosynthesis. Trees intercept rainfall in their canopies while their root systems create soil conditions that induce infiltration, thus reducing runoff. Additional benefits resulting from the presence of a healthy urban forest include reduced noise pollution and increased wildlife habitat (Bolund and Hunhammar, 1999) ^[6]. Urban forests can play an important role in mitigating the impacts of climate change by reducing CO₂ in urban areas. In recent years the role of urban trees and parks in reducing levels of carbon dioxide and other greenhouse gases in the atmosphere has been identified as an additional benefit.

Urban trees can reduce the levels of atmospheric CO₂ through sequestration and reducing CO₂ emissions by conserving energy used for heating and cooling (Nowak and Crane, 2002) ^[7]. Urban trees and shrubs can transform CO₂ into above- and below ground biomass through photosynthesis, a process called carbon sequestration, and store carbon in the form of stems, branches, or roots (Nowak, 1994). Urban trees and forests affect climate change, but are often disregarded because their ecosystem services are not well understood or quantified. One ton of carbon storage in the tree therefore represents removal of 44/12 or 3.67 t of Carbon from the atmosphere, and the release of 2.67 t of oxygen back into the atmosphere. (Ugle *et al.*, 2010) ^[8]. Despite the importance of these green spaces, they remain little researched in most parts of the world in contrast to the attention paid on parks in forested areas. This lack of understanding of biodiversity distributions and dynamics in urban parks makes it very difficult to plan strategies for urban conservation (Jim and Chen 2009) ^[9].

Study area

Jammu is summer capital of Jammu and Kashmir, the northern most state of India, the region spreads between 32° 17' to 36° 58' North latitude and 73° 26' to 80°30' East longitude occupying a total area of 2, 22,236 Km². The old Jammu city is confined to the right bank and the later expansions of the city have largely taken place on the left bank of the river. Large scale urbanization and industrialization has given rise to what is called now Greater Jammu, the name given to old, new and the suburbs of Jammu. Growth of Jammu urban agglomeration has been very fast. The total built up area inside the municipal boundary of Jammu city in 1972 was 14.90 sq.km with a decadal increase of 20.38 sq.km in 1980, 33.08 sq.km in 1992 and 65.49 sq.km in 2011. Jammu municipal limits extend from Bantalab chowk in east to Kunjwani chowk in west.

Study area consists of parks situated within the Jammu municipal limits.

Methodology

As per information collected from Department of Garden, Parks and Floriculture, J&K Government, Jammu, there are 78 urban parks located within Municipal limits of Jammu city varying in size from 0.050 ha to 8.345 ha. For this study *i.e.* Carbon storage by trees in urban parks, 50 sample plots of 20 m × 20 m size were laid in 35 urban parks to collect information (Nagendra and Gopal, 2010a) [10]. For above ground biomass and carbon estimation of trees, standard methodology developed by Forest research institute, Dehradun was used. Plotwise field data *i.e* the local name of the tree, girth at breast height and tree height were transferred into database environment. Volume of individual trees was estimated using local species specific volumetric equations (FRI 1996). The published and field based compiled literature

by Forest Survey of India (FSI), Forest Research Institute (FRI 1996) was reviewed to find out the site and species specific volumetric equations and specific gravity for the tree species. Those Species for which special equation was not found general volume equation was used. Both plot-wise and species-wise volume obtained by using volume equation was multiplied with species specific gravity to obtain biomass.

Estimation of carbon in park trees

The carbon content in the trees was calculated by multiplying the total biomass by a conversion factor 0.475 (IPCC 2005). Thus above ground carbon was calculated for each plot and then for each park by multiplying the area of the park with the carbon calculated for plot in that park. In those parks where more than one plots were laid down average carbon was calculated and that was multiplied with area to calculate total above ground carbon of trees in that park.

Results and discussion

Table 1: Name of the Parks Studied With Their Location, Area, Volume, Biomass and Carbon

S. No.	Name	Location	Hectares	Volume	Biomass	Carbon
1	Agarwal park	Trikuta Nagar	0.1485	29.267	17.533	8.328
1	Baag-e-bahu park	Babey	8.3459	14870.1	6799.3	1320.43
3	Badyal park	Gandhi Nagar	0.1644	206.763	119.571	56.79631
4	Bc road park	Near bus stand	0.6774	1007.82	547.897	260.251
5	Ch. Pyaraylal park	Gandhi Nagar	0.1347	15.557	8.994	4.272
6	Ghandi nagar sec a	Gandhi Nagar	0.19	27.499	15.436	7.332
7	Environment and wildlife awareness park	Bhavani nagar	7.1036	571.14	230.994	109.722
8	Gole market park	Gandhi Nagar	0.7368	7341.928	3697.715	1756.414
9	Green belt park(channi)1	channi	2.1394	1148.19	773.497	367.411
10	Green belt no. 1	Gandhi Nagar	0.6415	696.172	380.885	180.920
11	Green belt no.2	Gandhi Nagar	0.7968	2331.58	1557.95	740.024
12	Green belt no.3	Gandhi Nagar	0.7709	1389.44	765.344	363.538
13	Green belt no.4	Gandhi Nagar	0.7026	1192.611	476.989	226.5695
14	Hari singh palace park	Hari singh palace	0.3702	1561.956	772.482	366.93
15	Hospital road 1	Gandhi Nagar	0.5488	100.674	59.293	28.164
16	Hospital road 2	Gandhi Nagar	0.5119	566.482	348.72	165.642
17	Mastana park	Trikuta nagar	0.1294	6.566	4.072	1.934
18	Mubarakh mandi park	Mubarakh mandi	0.6606	1185.28	269.716	381.948
19	Nagrota children park	Ustad maholla	0.292	553.11	30.885	14.67
20	Nanak nagar park	Nanak nagar	0.1718	51.104	30.3	14.3927
21	Rajinder park	canal road	1.6968	41492.98	44690.21	31585.986
22	Rani park	Parade	0.5353	628.707	280.931	133.442
23	Sada park	Gandhi Nagar	0.2553	41.818	24.807	11.783
24	Saheed baghat singh park	Gandhi Nagar	0.1422	65.869	39.615	18.817
25	Shamsan ghat park	Nai basti	0.3189	36.013	32.947	15.65
26	Shivaji park	Roop nagar	0.3153	28.117	17.854	8.481
27	Small plot park	Gandhi Nagar	0.9288	419.098	244.337	116.06
28	Trikuta nagar sec.3	Trikuta nagar	0.0846	10.565	6.229	2.959
29	Vijay park	Nai basti	0.1321	10.789	6.393	3.296
30	Zanana park	Parade	1.108	2170.511	1388.549	659.561
31	Greeb belt park (channi)2	channi	2.443	0	0	0
32	Lohan park	Paloura	0.3564	0	0	0
33	Bua dati park	Paloura	0.2893	0	0	0
34	Floriculture park 1	Gandhi Nagar	1.008	523.66	342.53	162.700
35	Floriculture park 2	Gandhi Nagar	1.059	78.74	38.05	18.08
	Total		35.91	80360.11	64020.03	39112.50

Table 2: Species-Wise Volume, Biomass and Carbon of Tree Species of Selected Parks of Jammu City

S.no.	Species	Volume(m ³)	Biomass (tons)	Carbon (tons)
1	Acacia auiculiformis A.Cunn	28.546	18.184	8.637
2	Acacia modesta Wall.	37.0658	21.869	10.388
3	Acacia nilotica L.	4.688	3.141	1.492
4	Aegle marmelos L.	32.749	24.693	11.729
5	Albizia lebbek L.	49.759	26.571	12.621
6	Alstonia scholaris L.	2289.077	1222.367	580.624
7	Araucaria cook Hook.	43.191	23.755	11.284
8	Azadirachta indica A.Juss	6.583	4.477	2.126
9	Bauhinia variegata L.	80.187	44.103	20.949
10	Bombax ceiba L.	22.762	7.967	3.784
11	Calliandra haematocephala Husk.	63.567	38.140	18.117
12	Callistemon sps	993.365	645.687	306.701
13	Caryota urens L.	14.895		
14	Cassia fistula L.	23.882	17.816	8.463
15	Cassia javanica L.	31.497	19.087	9.066
16	Chamerops humilis L.	1.046	-	-
17	Chorisia speciosa A.St.Hill.	160.869	62.739	29.801
18	Dalbergia sisoo Roxb.	174.729	68.144	32.369
19	Delonix regia Hook.	229.719	137.831	65.470
20	Eriobotrya japonica L.	31.61	8.85	4.20
21	Erthyria indica L.	7.726	6.799	3.229
22	Eucalyptus sp.	5304.132	3585.593	1703.157
23	Ficus bengalensis L.	65412.666	32313.857	15349.08
24	Ficus benamina L.	155.213	100.733	47.848
25	Ficus elastica Roxb.	705.193	275.025	130.637
26	Ficus racemosa L.	4.158	1.617	0.768
27	Ficus religiosa L.	2205.756	858.039	407.569
28	Ficus virens W.T.Aiton	1008.504	342.89136	162.873
29	Grevillea robusta A. Cunn.	6346.600	2157.844	1024.976
30	Hamelia patens Jacq.	15.368	-	-
31	Jacaranda mimosifolia D.Don	126.090	76.915	36.535
32	Kigelia pinnata Jacq.	38.215	21.553	10.238
33	Lagerstroemia speciosa L.	22.079	15.235	7.236
34	Lannea coromandelica Merr.	279.796	139.059	66.053
35	Magnolia grandiflora L.	33.739	16.870	8.013
36	Mangifera indica L.	2052.053	1206.607	573.138
37	Manilkara hexandra Roxb.	960.271	758.614	360.342
38	Melia azedarach L.	218.450	107.259	50.948
39	Michelia champaca L.	50.676	25.338	12.036
40	Mimusops elengi L.	1926.302	1425.463	677.095
41	Morus alba L.	234.126	141.178	67.060
42	Neolamarckia cadamba Roxb.	409.243	216.899	103.027
43	Peltophorum pterocarpum DC.	733.435	451.796	214.603
44	Phyllanthus emblica L.	71.022	41.903	19.904
45	Pinus roxburghii Sarg.	454.722	276.926	131.540
46	Platanus orientalis L.	3644.934	2150.511	1021.493
47	Plumeria alba L.	2.213	1.770	0.841
48	Polyalthia longifolia L.	350.307	197.573	93.847
49	Pongamia pinnata L.	317.708	193.484	91.905
50	Pterogota alata Roxb.	241.345	114.639	54.453
51	Pterospermium acerifolium L.	733.435	456.197	216.693
52	Putranjiva roxburghii Wall.	346.318	233.765	111.038
53	Roystonea regia Kunth.	185.368	-	-
54	Scheichera oleosa Lour.	129.356	130.649	62.058
55	Seema siamea L.	18.08	11.75	5.58
56	Syzygium cumini L.	1397.787	904.368	54.453
57	Tabebuia aurea Benth & Hook.	2.755	2.689	429.575
58	Tecoma stans L.	1.15	0.54	0.26
59	Tectona grandis L.	836.271	417.299	1.277
60	Terminalia arjuna Roxb	42.960	29.471	198.217
61	Terminalia bellirica Roxb.	49.759	32.194	13.999
62	Thevetia peruviana L.	4.658	-	-
63	Toona cilata M.Rome.	420.776	178.409	84.744

In the present study the volume, biomass and carbon stock of trees growing in the urban parks *i.e.* park-wise Table 1 and species wise Table 2 were estimated.

The total volume of the trees growing in the parks under study was found to be 80360.11 m³. Species-wise estimation of volume shown in Table 2, show maximum average volume of 65412.66 m³ of *Ficus benghalensis* followed by *Grewia robusta* with average volume of 6346.600 m³.

Biomass estimation

Total above ground biomass in 35 parks studied with total area of 35.91 ha was found to be 64020.50 t (1782.80 t / ha). Species-wise average value of biomass was found highest for *Ficus benghalensis* (32313.86 t) followed by *Eucalyptus sp.* (3,585.59 t) and minimum biomass was found to be of *Ficus racemose* (1.617). Highest value of biomass for *Ficus benghalensis* because this species is considered sacred and large trees of this species were found in Rajinder singh park ,Gole market park and Hari singh palace park.

Estimation of carbon stock

According to table 1, total area of parks studied was 35.91 ha and trees in these park stores 39112.50 t (1089.18 t / ha) of carbon. Rajinder Park stores a maximum of 31585.98 t of carbon followed by Gole Market Park which stores 1703.15 t of carbon. Liu and Li (2012) report 337,000 t (33.22 t/ha) of carbon stored by urban forests of Shenyang, China. Comparatively lesser value of carbon in trees of study area is because of their less biomass. Species-wise maximum value of carbon was found for *Ficus benghalensis* (15349.08) followed by *Eucalyptus sp.* (1703.157 t).

Conclusion

With the increasing concern about the climate change and global warming, there is need of sources which can help in mitigating the increasing effect of green house gases. Urban trees can play an important role in this by carbon storage and sequestration. From the results of the study it can be concluded that urban parks of the Jammu city contain a good diversity of trees and these trees play an important role in carbon storage.

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