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ASSESSING CARBON SEQUESTRATION POTENTIAL OF URBAN TREE SPECIES: A CASE STUDY IN ARANYA PARK, GANDHINAGAR, GUJARAT, INDIA

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ABSTRACT

Global warming is an issue of recent times. Key contributors to global warming include the burning of fossil fuels (such as coal, oil, natural gas, etc.) for energy, deforestation and industrial processor. Green house gases can be considered one of the most significant factor for global warming. Carbon dioxide is the most prominent greenhouse gas on the earth. Greenhouse gases and various human activities are primary sources of increasing earth's temperature. To combat this effect, carbon sequestration is a significant aspect. The process involves capturing and storing atmospheric carbon dioxide. It can be the only way to reduce carbon dioxide from the atmosphere. This research paper discusses about the carbon sequestration potential of trees from Aranya park, Gandhinagar, Gujarat, India. Random sampling quadrant method is used in the conduction of this study. Total 10 quadrants are taken in consideration of 50×50 m^2 area. The total area of the study is 400 hector. Total no. of species found in quadrant study is 25 and total no. of individual species is 1038. In the quadrant method, the most dominant species are *Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan and *Azadirachta indica* A. Juss., while the least dominant species are *Albizia lebbeck* (L.) Bth., *Casuarina equisetifolia* L., *Delonix regia* (Bojer ex Hook.) Raf., *Ficus religiosa* L., *Kigelia africana* (Lam.) Benth., *Mimusops elengi* L., *Murraya koenigii* L. Spreng, *Phyllanthus emblica* L., *Putranjiva roxburghii* Wall., *Roystonea regia* (Kunth) O. F. Cook, *Santalum album* L., *Tamarindus indica* L., *Tectona grandis* L.f, and *Terminalia bellirica* (Gaertn.) Roxb. The species which have more carbon sequestration potential are *Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan (1.79), *Albizia lebbeck* (L.) Bth. (3.07), *Azadirachta indica* A. Juss. (2.11), *Ficus benghalensis* L. (20.53), *Ficus religiosa* L. (7.52), *Kigelia africana* (Lam.) Benth. (3.13), and *Terminalia bellirica* (Gaertn.) Roxb. (5.58).

KEYWORDS: Global warming, Greenhouse gas, Carbon sequestration

INTRODUCTION

It is believed that rising levels of atmospheric carbon dioxide (CO_2) and other "greenhouse" gases [such as methane (CH_4), chlorofluorocarbons, nitrous oxide (N_2O), and tropospheric ozone (O_3)] are contributing to rising atmospheric temperatures by trapping specific wavelengths of radiation in the atmosphere. Some substances, however, may lower air temperatures (e.g., sulphur dioxide, particulate matter, stratospheric ozone). Since the late 1800s, the global averaged air temperature at the Earth's surface has grown by 0.3 to 0.6 degrees Celsius [1][2][3]. Trees accumulate carbon (C) in their leaves, branches, stems, bark, and roots and absorb the element from the environment by the mechanism of photosynthesis. Increasing the extent of forests and the cultivation of trees is a strategy we have to "offset" CO_2 emissions. Both natural and planted forests function as "sinks" for capturing CO_2 from the environment [4]. Carbon sequestration by trees from the atmosphere is determined by the amount of land used, the time spent growing, and technological advancement. There are two ways trees might help reduce carbon emissions. One method is direct carbon sequestration by regeneration and afforestation, which results in a carbon stock in standing trees. The other is the use of forest products as alternatives to fossil fuels or fossil fuel-intensive items like steel and concrete. In all cases, carbon offsets work by reducing emissions from fossil fuels that would otherwise be consumed [5].

Study area:

Figure 1: Study area

Gandhinagar city is located on the banks of Sabarmati river. It is also called as green city of Gujarat, because of diversity and types of vegetation. Gandhinagar has a tropical wet dry and humid climate and has dry deciduous forest type of vegetation. The average annual highest temperature is 40°C and average annual lowest temperature is 12.4°C, with three main seasons: Winter, Summer & Monsoon [6].

Aranya park is located in Gandhinagar city. Eastern part of Indroda nature park is known as Aranya park. It has variety

of tree species. Many other species of animals, including birds and reptiles can be found living in the 400 hectare wilderness that Indroda Nature Park has established in addition to the zoo's inhabitants. This comprises about 180 bird species, 65 of which are known to nest in this area. It is indeed a heaven for bird watchers. Also, there are several common venomous and non-venomous snakes in the park. According to a 2004 foundation census, there are 545 Nilgai, 475 common langurs, and 819 peafowl in the park's wildness. [7]

MATERIAL & METHODOLOGY:

Girth at breast height (GBH) and height of selected tree species were measured for estimation of biomass and carbon sequestration through the non-destructive method. Measurement of GBH and height was done systematically for estimation of biomass and carbon sequestration through non-destructive method.

Selection of tree species from different areas of Aranya park:

Quadrant method is used for data collection. The study area is vast and it is spread out in large area. That is why we have opted for quadrant method to study and measure carbon sequestration capacity of tree species. We have selected 10 quadrates of 50×50 m^2 by random sampling method.

Field survey:

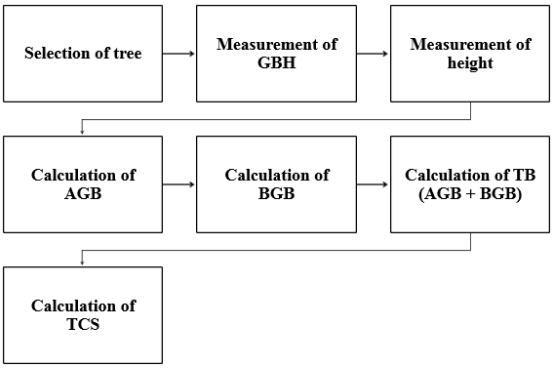
The field survey was done after the identification of the location and finalisation of the study area on the map of Aranya park. The selection of the study area was done in such a way that it represents almost all habitats (aquatic & terrestrial). Approximate height was noted of different tree species of the study area. The girth (GBH) of each tree species was measured by using a measure tape. Locations of the tree species were also noted using a GPS app to know the exact latitude & longitude of the tree species.

Materials:

Equipment used for the field work of this research project are listed below:

- Measure tape
- Clinometer
- Field diary
- Datasheets
- Pen/pencil
- Camera (High resolution mobile camera/DSLR)
- Software: Google Earth Pro

Flow chart of methodology:



Estimation and extrapolation of carbon sequestration:

The volume of tree was estimated by the following formula

$V = r^2h$

Where, (V = Volume, r = Radius, h = Height) in cubic meter (cm3)

Calculation of Above Ground Biomass (AGB):

The above ground biomass refers to all living biomass that is located above the soil. The predicted aboveground biomass based on diameter and height, the volume was estimated by dividing the biomass volume by wood density.

The estimate of the species' wood density from the web (www.fao.org) [8]

AGB (kg/tree) = Volume of tree (m3) × Wood density (g/m3)

Note: If the wood density is not available, then the Standard average value 0.6 gm/cm3 is considered for calculation.

The Below Ground Biomass (BGB):

The below ground biomass includes the entire biomass of live roots excluding fine roots having < 2 mm diameter. The below ground biomass was calculated by multiplying Above ground biomass by 0.26 factors as the Root:Shoot ratio was given by Ravindranath and Ostwald (2008) in their method. [9]

BGB (kg/tree) or (ton/tree) = AGB (kg/tree) or (ton/tree) × 0.26

Where, 0.26 = Root to Shoot ratio

Total Biomass:

The total biomass is the addition of the above and below ground biomass as described by Sheikh, et al. (2011), According to him Total Biomass is

Total Biomass (kg/tree) = AGB + BGB

Total Carbon:

TC = TB/2 or TB × 50%

Determination of the weight of carbon dioxide sequestered in the tree:

Carbon dioxide is formulated by three molecules which include one molecule of carbon and two molecules of oxygen. Oxygen and carbon have atomic weights of 16 and 12 respectively. The molecular weight of carbon dioxide is 44

$CO_2 = 1C + 2O = 1(12) + 2(16) = 44$

The ratio of CO_2 to carbon is 44/12 = 3.667 [10]

In the current study, total carbon sequestration in woody vegetation especially tree species were calculated using the non-destructive method in which the wood density of tree species was taken as per FAO. Moreover, if the wood density was not available, then standard average value of 0.6 gm/cm^3 was considered for the estimation of carbon sequestration. Wood density of some tree species was taken from a study done by Reyes, et al., (1992) [11].

The species wise density of different species found in Aranya udhyan is given below in the table.

Sr. no.	Scientific name	Vernacular name	Family	Wood density G/CM³ or T/M³
1	*Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan	Deshi baval	Mimosaceae	0.6
2	*Albizia lebbeck* (L.) Bth.	Kalo siras	Mimosaceae	0.66
3	*Azadirachta indica* A. Juss.	Neem	Meliaceae	0.69
4	*Cassia fistula* L.	Garmalo	Fabaceae	0.71
5	*Casuarina equisetifolia* L.	Saru	Casuarinaceae	0.83
6	*Delonix regia* (Bojer ex Hook.) Raf.	Gulmohar	Caesalpiniaceae	0.51
7	*Ficus benghalensis* L.	Vad	Moraceae	0.39
8	*Ficus religiosa* L.	Piplo	Moraceae	0.6
9	*Gmelina arborea* Roxb.	Sevan	Verbenaceae	0.45
10	*Holoptelea integrifolia* (Roxb) Planch	Palpaliya	Ulmaceae	0.6
11	*Kigelia africana* (Lam.) Benth.	Sausage tree	Bignoniaceae	0.6
12	*Millettia pinnata* (L.) Panigrahi	Karanj	Fabaceae	0.6
13	*Mimusops elengi* L.	Borsali	Sapotaceae	0.72
14	*Murraya koenigii* L. Spreng	Curry leaves	Rutaceae	0.6
15	*Peltophorum pterocarpum* (DC.) Backer ex K. Heyne	Tamraparni	Caesalpiniaceae	0.62
16	*Phyllanthus emblica* L.	Amla	Euphorbiaceae	0.6
17	*Polyalthia longifolia* (Sonn.) Thw.	Asopalav	Annonaceae	0.45
18	*Putranjiva roxburghii* Wall.	Putranjiva	Putranjivaceae	0.6
19	*Roystonea regia* (Kunth) O. F. Cook	Bottle palm	Arecaceae	0.6
20	*Santalum album* L.	Chandan	Santalaceae	0.6
21	*Senna siamea* Lam.	Kasod	Caesalpiniaceae	0.62
22	*Syzygium cumini* L. Skeels	Jambu	Myrtaceae	0.7
23	*Tamarindus indica* L.	Aamli	Caesalpiniaceae	0.75
24	*Tectona grandis* L.f	Sag	Verbenaceae	0.55
25	*Terminalia bellirica* (Gaertn.) Roxb.	Baheda	Combretaceae	0.72

Table 1: Vernacular name & wood densities of tree species

RESULT & DISCUSSION:

As both of the graphs given below suggest, some of the major carbon sequestrating species are: *Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan (1.79), *Albizia lebbeck* (L.) Bth. (3.07), *Azadirachta indica* A. Juss. (2.11), *Ficus benghalensis* L. (20.53), *Ficus religiosa* L. (7.52), *Kigelia africana* (Lam.) Benth. (3.13), and *Terminalia bellirica* (Gaertn.) Roxb. (5.58).

Acacia nilotica (L.) Del. Subsp. Indica (Bth.) Brenan and *Azadirachta indica* A. Juss. were found in all 10 quadrates. *Cassia fistula* L. species were found in 7 quadrates. *Ficus benghalensis* L. were found in 5 quadrates. *Holoptelea integrifolia* (Roxb) Planch and *Senna siamea* Lam. were found in 3 quadrates. *Gmelina arborea* Roxb., *Millettia pinnata* (L.) Panigrahi, *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne, *Polyalthia longifolia* (Sonn.) Thw. and *Syzygium cumini* L. Skeels were observed in 2 quadrates. While *Albizia lebbeck* (L.) Bth., *Casuarina equisetifolia* L., *Delonix regia* (Bojer ex Hook.) Raf., *Ficus religiosa* L., *Kigelia africana* (Lam.) Benth., *Mimusops elengi* L., *Murraya koenigii* L. Spreng, *Phyllanthus emblica* L., *Putranjiva roxburghii* Wall., *Roystonea regia* (Kunth) O. F. Cook, *Santalum album* L., *Tamarindus indica* L., *Tectona grandis* L.f, and *Terminalia bellirica* (Gaertn.) Roxb. were only observed in 1 quadrate. Carbon sequestration potential is happened to be 54.76 ton/ha/year of the study area Aranya park.

SR NO	SCIENTIFIC NAME	QUADRATES										TOTAL
		1	2	3	4	5	6	7	8	9	10	
1	*Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan	16	7	10	9	40	37	50	45	36	45	295
2	*Albizia lebbeck* (L.) Bth.	-	5	-	-	-	-	-	-	-	-	5
3	*Azadirachta indica* A. Juss.	14	20	8	33	30	26	22	50	45	40	288
4	*Cassia fistula* L.	6	11	-	30	28	24	43	30	-	-	172
5	*Casuarina equisetifolia* L.	-	-	9	-	-	-	-	-	-	-	9
6	*Delonix regia* (Bojer ex Hook.) Raf.	-	-	-	21	-	-	-	-	-	-	21
7	*Ficus benghalensis* L.	1	1	1	2	-	-	-	4	-	-	9
8	*Ficus religiosa* L.	-	-	3	-	-	-	-	-	-	-	3
9	*Gmelina arborea* Roxb.	-	-	-	-	-	5	-	-	3	-	8
10	*Holoptelea integrifolia* (Roxb) Planch	-	-	-	-	-	-	6	10	-	12	28
11	*Kigelia africana* (Lam.) Benth.	-	-	8	-	-	-	-	-	-	-	8
12	*Millettia pinnata* (L.) Panigrahi	-	-	-	-	-	-	5	-	-	10	15
13	*Mimusops elengi* L.	19	-	-	-	-	-	-	-	-	-	19
14	*Murraya koenigii* L. Spreng	-	-	10	-	-	-	-	-	-	-	10
15	*Peltophorum pterocarpum* (DC.) Backer ex K. Heyne	-	-	-	-	15	10	-	-	-	-	25
16	*Phyllanthus emblica* L.	4	-	-	-	-	-	-	-	-	-	4
17	*Polyalthia longifolia* (Sonn.) Thw.	-	-	10	-	-	15	-	-	-	-	25
18	*Putranjiva roxburghii* Wall.	8	-	-	-	-	-	-	-	-	-	8
19	*Roystonea regia* (Kunth) O. F. Cook	-	3	-	-	-	-	-	-	-	-	3
20	*Santalum album* L.	-	-	6	-	-	-	-	-	-	-	6
21	*Senna siamea* Lam.	-	-	-	20	25	10	-	-	-	-	55
22	*Syzygium cumini* L. Skeels	2	5	-	-	-	-	-	-	-	-	7
23	*Tamarindus indica* L.	-	-	5	-	-	-	-	-	-	-	5
24	*Tectona grandis* L.f	-	8	-	-	-	-	-	-	-	-	8
25	*Terminalia bellirica* (Gaertn.) Roxb.	-	-	2	-	-	-	-	-	-	-	2
Total no. of individual tree species	1038											

Table 2: Quadrate wise distribution of tree species

SR NO.	SCIENTIFIC NAME	NO. OF TREES	AVERAGE GBH(CM)	AVERAGE HEIGHT(M)	AVERAGE ORGANIC CARBON			CARBON SEQUESTRATION (TONNES)
					AGB	BGB	TB	
1	*Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan	295	102.47	15.06	188.88	49.10	237.99	1.79
2	*Albizia lebbeck* (L.) Bth.	5	130	15	333.02	86.58	419.60	3.07
3	*Azadirachta indica* A. Juss.	288	103.81	14.15	209.54	54.48	264.02	2.11
4	*Cassia fistula* L.	172	71.44	13.13	94.73	24.63	119.36	0.9
5	*Casuarina equisetifolia* L.	9	60	13	77.31	20.1	97.41	0.5
6	*Delonix regia* (Bojer ex Hook.) Raf.	21	63	11	72.12	18.75	90.88	0.4
7	*Ficus benghalensis* L.	9	398.77	14.88	1837.97	477.87	2315.84	20.53
8	*Ficus religiosa* L.	3	200	17	812.1	211.14	1023.24	7.52
9	*Gmelina arborea* Roxb.	8	42.5	7.87	12.74	3.31	16.05	0.13
10	*Holoptelea integrifolia* (Roxb) Planch	28	84.07	13.42	113.35	29.47	142.82	1.07
11	*Kigelia africana* (Lam.) Benth.	8	91.75	10	100.53	26.13	126.67	3.13
12	*Millettia pinnata* (L.) Panigrahi	15	56.66	11.33	43.46	11.3	54.76	0.4
13	*Mimusops elengi* L.	19	58.89	10.57	52.58	13.67	66.25	0.51
14	*Murraya koenigii* L. Spreng	10	83.8	16	134.18	34.88	169.07	1.24
15	*Peltophorum pterocarpum* (DC.) Backer ex K. Heyne	25	89.4	13	128.22	33.33	161.55	1.18
16	*Phyllanthus emblica* L.	4	72.5	13	81.6	21.21	102.82	0.75
17	*Polyalthia longifolia* (Sonn.) Thw.	25	65.4	11.6	44.44	11.55	55.99	0.57

18	*Putranjiva roxburghii* Wall.	8	83.25	14	115.87	30.12	146	1.07
19	*Roystonea regia* (Kunth) O. F. Cook	3	78.66	17	125.64	32.66	158.3	1.16
20	*Santalum album* L.	6	25	7	5.22	1.35	6.58	0.04
21	*Senna siamea* Lam.	55	82.48	12.42	104.32	27.12	131.44	1
22	*Syzygium cumini* L. Skeels	7	72.85	15.14	111.99	29.11	141.11	1.05
23	*Tamarindus indica* L.	5	72.4	14	109.55	28.48	138.03	1.01
24	*Tectona grandis* L.f	8	33.75	9.12	11.37	2.95	14.33	0.11
25	*Terminalia bellirica* (Gaertn.) Roxb.	2	153	18	603.86	157	760.86	5.58
Total carbon sequestration – 54.76 ton/ha/year								

Table 3: Physiological details of tree species

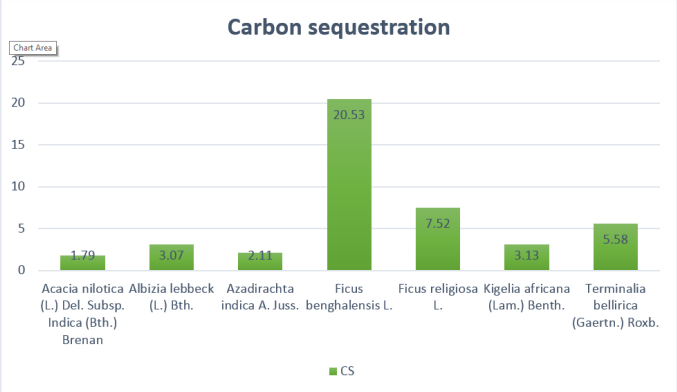


Figure 2: Bar chart of species wise carbon sequestration

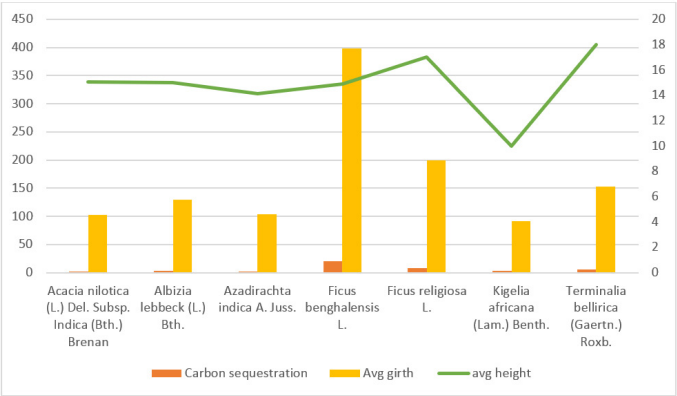


Figure 3: Comparison of carbon sequestration, Avg. girth & Avg. height of species

CONCLUSION:

Planting different tree species have a significance impact on human kind, environment, biodiversity and climate change. *Acacia nilotica* (L.) Del. Subsp. Indica (Bth.) Brenan, *Albizia lebbeck* (L.) Bth., *Azadirachta indica* A. Juss., *Ficus benghalensis* L., *Ficus religiosa* L., *Kigelia africana* (Lam.) Benth., and *Terminalia bellirica* (Gaertn.) Roxb. have larger girth, height and canopy they can be planted in larger numbers in residential area, public parks, botanical gardens, educational campuses & roadsides as well to reduce the atmospheric CO_2. We should plant diverse kind of trees as they are helpful- birds build their nest, some animals like squirrel, monkey, insects fed on fruits of trees. Trees also enhance the beauty of landscapes, provide recreational spaces and contribute to our mental well-being by reducing stress, anxiety and also improve mood. They also support various industries such as forestry, tourism, recreation, provide employment opportunities and economic benefits to communities as well.

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