CARBON SEQUESTRATION BY DIFFERENT SPECIES OF TREES IN TANDO JAM, PAKISTAN

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خلاصہ

ٹنڈوجام شہر میں درختوں کی مختلف انواع کے وجود کی شناخت کے لیے سروے کیا گیا۔ یہ مطالعہ درختوں کی اونچائی، ڈی بی ایچ، اے جی بی، بی جی بی، بایوماس اور کاربن کے حصول کے نتائج کو ظاہر کرتا ہے۔ مطالعہ آرک میپ 10.7.1 اور کلاؤڈ کمپیوٹنگ پروگرام گوگل ارتھ انجن کے ذریعے NDVI فارمولہ استعمال کرکے 1990 سے 2020 تک ٹنڈوجام شہر میں پودوں میں کمی کو ظاہر کرتا ہے۔ شہر میں درختوں کی آبادی 7308 ہے اور صرف 20 پر جاتیوں کی نشاندہی کی گئی ہے۔ Azadirachta indica غالب نسل ہے جس کی آبادی 2451 ہے، جبکہ Tamarindus indica سب سے کم تعداد میں ہے (صرف 11 درخت)۔ اونچائی کے لحاظ سے، Eucalyptus camaldulensis کی سب سے بڑی اونچائی 2043 سینٹی میٹر ہے اور سب سے کم اونچائی یعنی 617.82 سینٹی میٹر ہے۔ مزید برآں، Ficus religiosa میں 108.91 سینٹی میٹر بڑا قطر اور کم از کم قطر 25.92 سینٹی میٹر کاسیا فسٹولا میں دیکھا گیا۔ (6194 Kg) Cordia myxa کے مقابلے میں Conocarpus erectus tress میں 1021680 Kg بایوماس کی بڑی مقدار ہوتی ہے جس میں بالترتیب 510840Kg اور 3074Kg کاربن سیکوسٹریشن ہوتی ہے۔

Abstract

Survey was conducted in Tandojam city for the identification of different trees species existence. This study reveals the results of trees height, DBH, AGB, BGB, BIOMASS & carbon sequestration. The study shows decline in vegetation in TandoJam city from 1990 to 2020 by using NDVI formula through ArcMap 10.7.1 and cloud-computing program Google Earth Engine. In city the populations of trees are 7308 and only 20 species were identified. Azadirachta indica being the dominant specie having population of 2451, while Tamarindus indica having lowest number (11 trees only). In terms of height, Eucalyptus camaldulensis has largest height of 2043 cm and lowest height i.e. 617.82 is attributed to 617.82 cm. Moreover, 108.91 cm being larger diameter in Ficus religiosa and minimum diameter was of 25.92 cm was seen in Cassia Fistula. Conocarpus erectus tress possess bulk amount of biomass of 1021680 Kg as compared to Cordia myxa (6194 Kg) having carbon sequestration of 510840 Kg and 3074 Kg respectively.
Keywords: Sequestration, biomass, forest, NDVI, DBH

Introduction

Trees are natural carbon reservoir on Earth. They store huge amount of carbon when they get matured. Carbon is stored and present in the trees as long as they are alive. Carbon sequestration is a mechanism for the removal of carbon from the atmosphere by storing it in the biosphere (Chavan and Rasal, 2012). Carbon sequestration is the phenomenon for the storage of carbon dioxide (CO_2) from the atmosphere to mitigate global warming (Kowalska *et al.,* 2020). Climate change is affecting globally due to anthropogenic activities i.e deforestation, greenhouse gases from industries and causing earth warmer (IPCC 2007, Montagnini and Nair 2004). The effective and best natural system to sequester the carbon is by trees. Carbon dioxide has increased from 280 ppm to 400 report by ESRL/NOAA, 2015 (Ajani and Shams, 2016). In 2018 it has reached to 408 ppm (NASA). Report by Scripps institute of Oceanography *California* revealed that carbon concentration is 415.09 ppm in 2019 May. Carbon stocks are the environmentally sustainable against climate change (Jantz *et al.,* 2014). Climate change mitigation through forest carbon stock, another important Goal 15: Life on Land in combination with SDG 13 is providing a pool of strategies to achieve forest conservation (Shafique *et al.,* 2021)

Literature indicates an example that was estimated from 2002 to 2008 about 54630 tons of carbon was found sequestered when 115,200 indigenous trees were planted in South African city Tshwane (Stoffberg *et al.,* 2010). Carbon dioxide is the main cause of global warming and in the atmosphere concentration of carbon is increasing due to human activities, burning of fossil fuels, industrial activity and deforestation of trees and forest. It has been observed that concentration of carbon is increased since industrial revolution from 280 ppm to 354 ppm till 1190 and in 2015, 400 ppm was observed. Tree canopies provide a cooling effect on microclimate specifically by shading the ground surface and indirectly through transpiration (Subedi, *et al.,* 2010). According to NOAA latest carbon ppm was recorded in April, 2020 was 412.55 ppm.

Methodology

Study Area

Tandojam is a municipal committee and town of Hyderabad district Sindh, Pakistan. Geographically it lies on 25°25′40.21″N 68°31′40.40″Eand it is about 18 KM from Hyderabad city. Area of Tandojam is 6 km² i.e. 2 sq. Miles and it is 75 feet above sea level. According to Pakistan census 2017 report Tandojam has a population of about 78,989 while in 1998 it was 26,446. TandoJam has a desert climate. In TandoJam, the average annual temperature is 27.7 °C | 81.9 °F. The rainfall here is around 171 mm year.

Table 1. Landsat Data Acquisition Details for Mean Annual NDVI

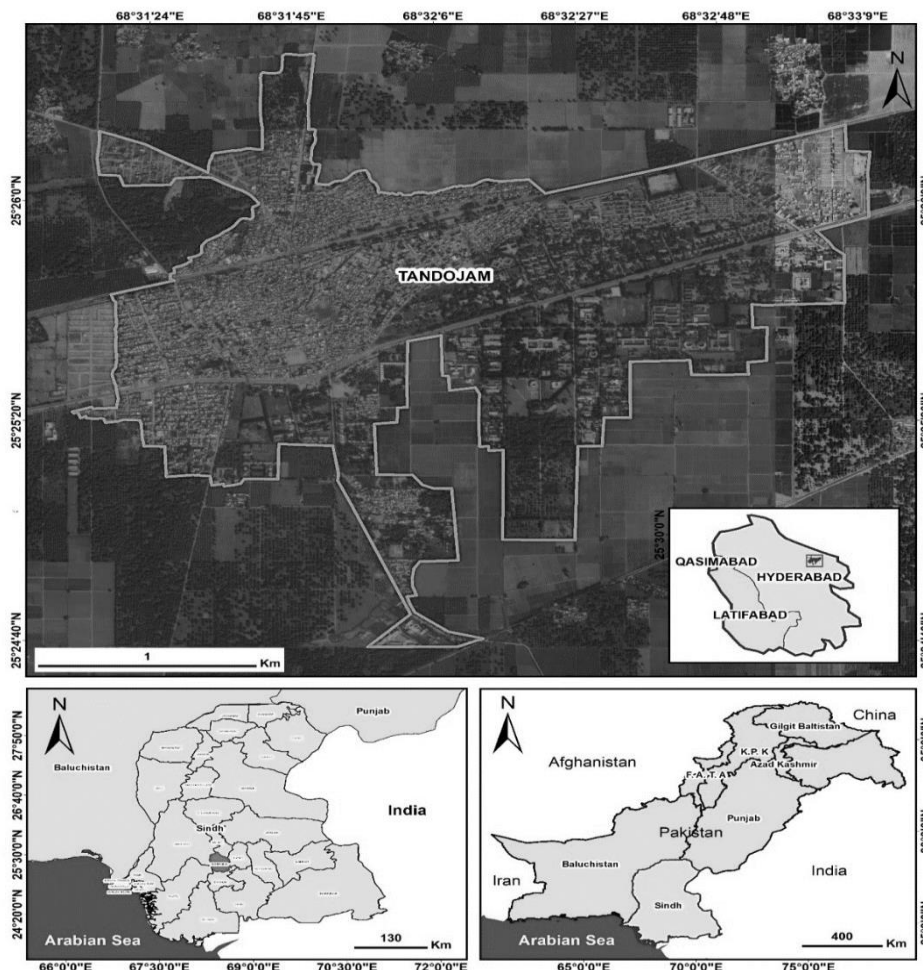| Year	Date / Months	Landsat
1990	January 1st to December 31st	Landsat 5 (TM)
2000	January 1st to December 31st	Landsat 8 (OLI/TIRS)
2010	January 1st to December 31st	Landsat 8 (OLI/TIRS)
2020	January 1st to December 31st	Landsat 8 (OLI/TIRS)

Fig.1. Study area of Tandojam city

Field Survey

Field survey was conducted from various locations in TandoJam city for the identification of the trees and trees were randomly selected for the calculation of carbon sequestration of trees.

GIS Data Collection for the Calculation of NDVI

NDVI was calculated by using formula equation 1

$$NDVI = \frac{NIR - RED}{NIR + RED} \text{ Equation -------------- (1)}$$

Where NIR: near Infrared Band, RED: Red Band

For calculation of NDVI, Landsat data acquired from January to December for the following the years to take the average of annual NDVI. Landsat 8 (Operational Land Imager/Thermal Infra-Red Scanner - OLI/TIRS) Landsat 5 (Thematic Mapper - TM) was used. Specifications for the bands of each satellite are listed in table 2.

Table 2. Satellite Bands Specifications

Bands No.	Bands Name	Wavelength (µm)	Resolution (m)
Landsat 5 (TM)			
Band 1	Blue	0.45 - 0.52	30
Band 2	Green	0.52 - 0.60	30
Band 3	Red	0.63 - 0.69	30
Band 4	Near-Infrared (NIR)	0.76 - 0.90	30
Band 5	Short Wave-Infrared (SWIR 1)	1.55 - 1.75	30
Band 6	Thermal	10.40 - 12.50	120
Band 7	Short Wave-Infrared (SWIR 2)	2.08 - 2.35	30
Landsat 8 (OLI/TIRS)			
Band 1	Coastal aerosol	0.43-0.45	30
Band 2	Blue	0.45-0.51	30
Band 3	Green	0.53-0.59	30
Band 4	Red	0.64-0.67	30
Band 5	Near Infrared (NIR)	0.85-0.88	30
Band 6	SWIR 1	1.57-1.65	-
Band 7	SWIR 2	2.11-2.29	-
Band 8	Panchromatic	0.50-0.68	15
Band 9	Cirrus	1.36-1.38	30
Band 10	Thermal Infrared (TIRS 1)	10.60-11.19	100
Band 11	Thermal Infrared (TIRS 2)	11.50-12.51	100

Data was acquired for the calculation of NDVI index by Google Earth Engine. Four GEE Code Editor Scripts were used to extract Normalized Difference Vegetation Index (NDVI) data from satellite images obtained from Landsat 5 and 8, one for each of the selected year as shown in figure 3.
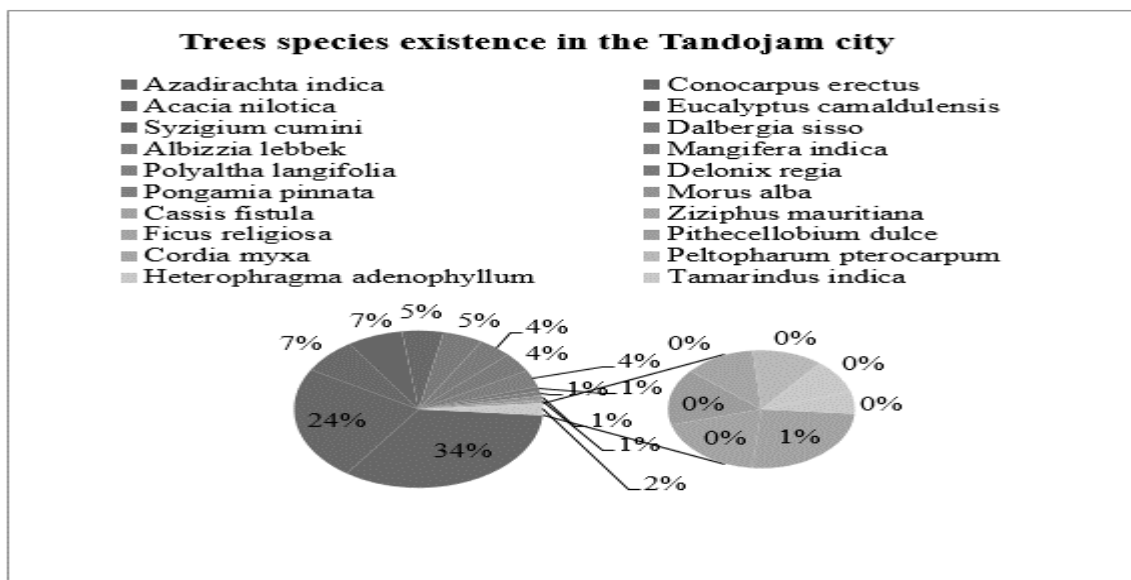

Fig.2. Existence of trees species in various location of Tandojam city

Calculation of the height and circumference of the trees

Circumference of the tree trunk was measured by using measuring tape at 1.3 m above the surface. DBH of tree was then converted into diameter of the tree using equation 2

D =C/π equation 2

Where D = diameter

C = circumference

π = ratio of the circumference of the tree to its diameter

Names of the trees were identified from the experienced Gardener of the university and with the help of botanist and Horticulture department of Sindh Agriculture University, Tandojam.

Biomass of the trees was calculated after taking their heights and diameters at (DBH) Breast Height (Chavan *et al.,* 2010). Height of trees were measured by means of Thumb with your arms stretched output your thumb at the top of the tree and move until the bottom of your hand appears at the base of the tree then rotate your arm making sure that the bottom of your hand is still at the base of the tree place a marker such as a friend where your thumb appears to be and measure that distance and that will be the height of the tree. Circumference of trees was measured by using Measuring tape.

Biomass Calculation

Non-destructive method was used for biomass calculation i.e. AGB above ground biomass of tree parts such as leaf, flowers, fruits, shoots and branches is calculated as under AGB = tree volume multiply by wood density (Pandya *et al.,* 2013).

Equation 3 biomass calculation

$V = \pi r^2 h$ Equation 3

Whereas: V=volume of tree, r = radius of tree bole at breast height and h= height of tree.

Wood densities of selected species were obtained from (Global Wood Database and world agro forestry) and was found respectively by multiplication of AGB with 0.26 which is (default value) taken as the ratio of root to shoot, the below ground biomass BGB= above ground biomass ton/tree multiply by (0.26) and Biomass= below + above ground biomass (Hangarge *et al.,* 2012)

Calculation of Carbon Sequestration

For the calculation of the biomass, Biomass= BGB+AGB of the tree was calculated by dividing 2 this was done on the basis of fact that the trees have an average fifty percent carbon in their Biomass. Carbon Sequestered= Biomass/2 (Sheikh *et al.,* 2011).

Results and Discussion

Total 20 species were identified and 7308 trees exist in the city area. Pie chart in figure: 2 and Table: 3 show all species and number of trees existence in the city. However highest number of trees were of Azadirachta indica specie about 34% (2451) while lowest number of trees were of Tamarindus indica specie about 0.15% (11). Figure: 2 shows the changes in vegetation from 1990 to 2020 while figure: 3 shows the percentage of vegetation cover and changes in Tandojam city. Vegetation in the city changed from every 5 to 10 years due to population, development and human's impacts i.e. cut down of the trees. New housing schemes and construction without proper plan is leading to cut down of the trees and vegetation. Height, circumference and wood densities of the trees were put in the Microsoft Excel Sheet for the calculation of above and below ground biomass, biomass, total biomass and carbon sequestered. Standard wood densities were taken from (worldagroforestry.org) and global wood density database. Many of the circumferences and height of the trees were not measured due to presence of trees in homes and due to security and privacy reasons by owners of the houses and other areas in the city. Table 4 shows the above and below ground biomass, total biomass and carbon sequester of all species of trees and it shows the Mean, Minimum and Maximum biomass (Total + AGB and BGB).
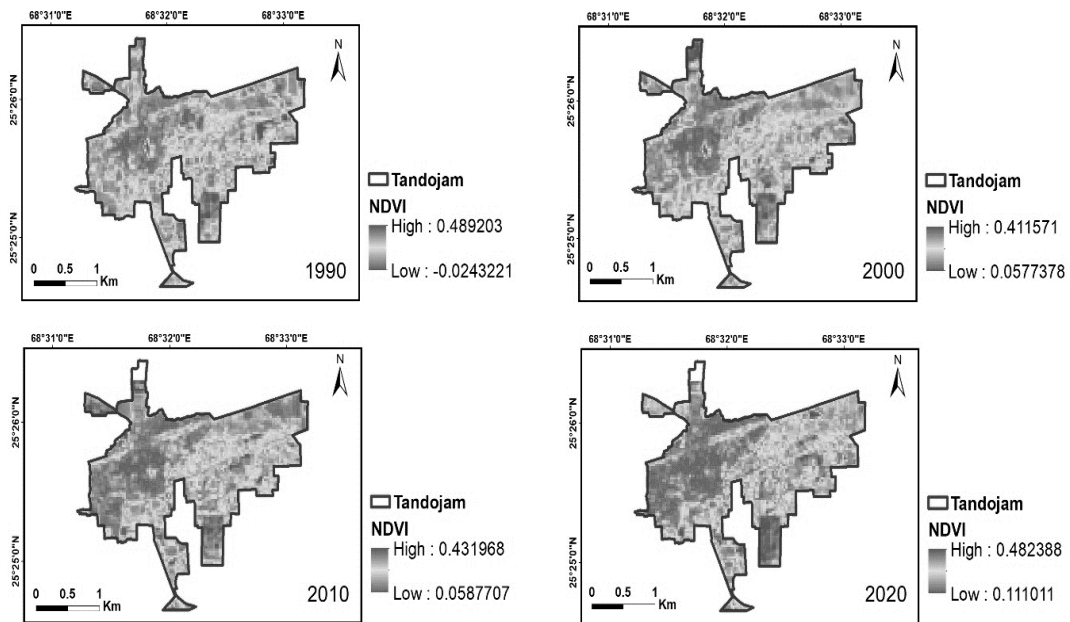
Fig.3. NDVI of Tandojam city obtained ArcGIS 10.7.1 (Licensed, provided by Esri).

CO_2 sequester of all species of trees. Highest biomass and carbon sequester was estimated in the Conocarpus erectus specie while lowest biomass and carbon sequester was estimated in the Tamarindus indica. Table 5 shows the average DBH, height, AGB, BGB, biomass and carbon sequestration of the individual trees species.

Vegetation Cover (%) in Tandojam (1990-2020)

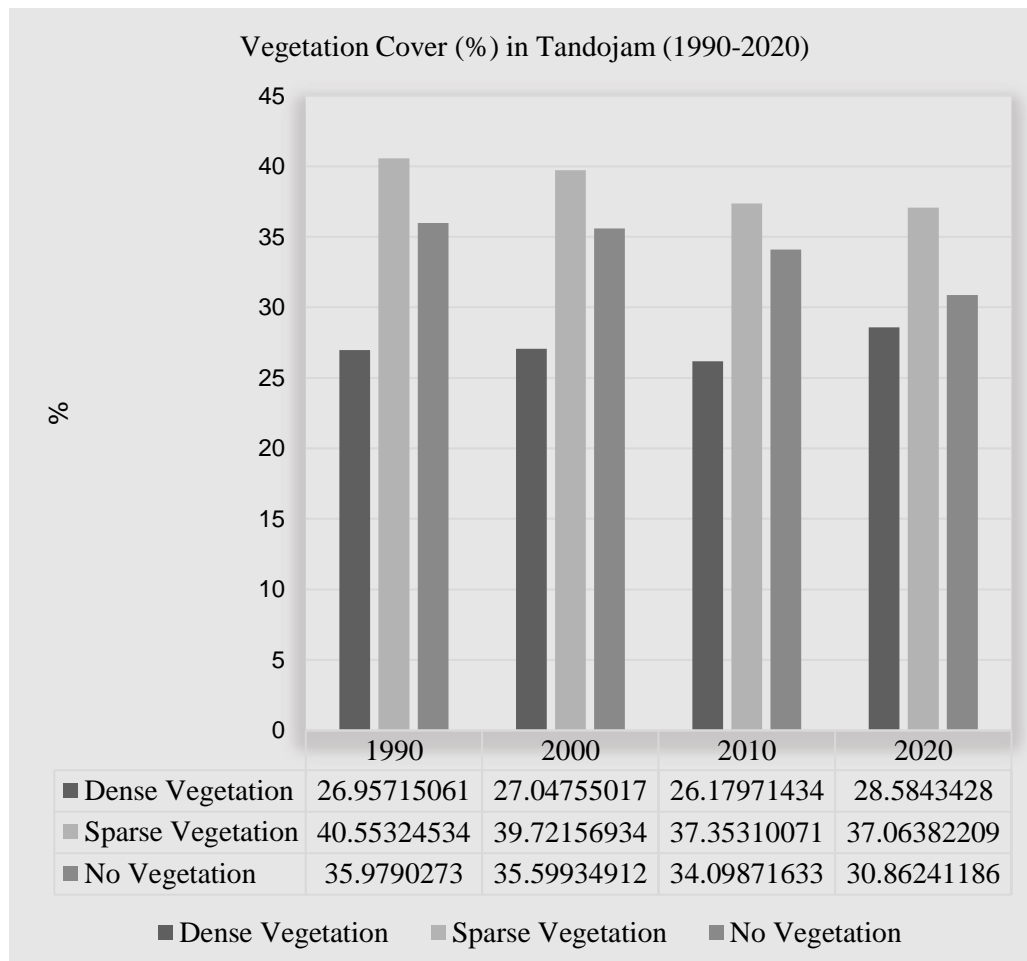|	1990	2000	2010	2020
Dense Vegetation	26.95715061	27.04755017	26.17971434	28.5843428
Sparse Vegetation	40.55324534	39.72156934	37.35310071	37.06382209
No Vegetation	35.9790273	35.59934912	34.09871633	30.86241186

Fig.4. % of vegetation cover in Tandojam city in year 1990 - 2020

Table 3. Name and Population of the trees in Tandojam study area

S#	Name of Trees			Total No. of Trees	Percentage
	Sindhi/Urdu/local	English	Botanical		
1	Nim/neem	Neem	Azadirachta indica	2451	33.53%
2	Cono/	Conocarpus	Conocarpus erectus	1722	23.56%
3	Baburr/babool	Keekar	Acacia Nilotica	532	7.27%
4	Sufeda/bedmushk	Eucalyptus	Eucalyptus camaldulenisis	528	7.22%
5	Jamoon/jamun	Jambolana	Syzygium cumini	391	5.35%
6	Taalhi/talhee	Sheesham	Dalbergia sisso	380	5.19%
7	Sarenh/	Lebbeck tree	Albizia lebbeck	318	4.35%
8	Amb/aam	Mango	Mangifera indica	295	4.03%
9	Ashoke/	Ashoka	Polyalthia longifolia	256	3.50%
10	Gulmohar/	Gold mahar	Delonix regia	72	0.98%
11	Sukhchain	Indian Beach Tree	Pongamia pinnata	67	0.91%
12	Toot/	Mulberry	Morus alba	66	0.90%
13	Amaltaas/	Golden shower tree	Cassia fistula	49	0.67%
14	Ber/	Jujube	Ziziphus mauritiana	46	0.62%
15	Pippul/pippal	Sacred bodhi tree	Ficus religiosa	35	0.47%
16	Jhangjalebi/	Madras thorn	Pithecellobium dulce	28	0.38%
17	Gedurrii/lesoorii		Cordia myxa	22	0.30%
18	Pilmohar	Yellow flame tree	Peltophorum pterocarpum	22	0.30%
19	Beeripatta	-	Heterophragma adenophyllum	17	0.23%
20	Gidaamrii/imlee	Tamarind	Tamarindus indica	11	0.15%
Total				**7308**	**100.0**

Table 4. Total AGB, BGB, BIOMASS and Carbon Sequester by individual trees in study area

Sr.No.	Local name	Scientific names	Trees Measured	BIOMASS (Kg)			Carbon sequester (Kg)
				AGB	BGB	TOTAL	
1	Neem	Azadirachtaindica	311	730150.03	189839	919988	459994.1
2	Conocarpus	Conocarpus erectus	287	810857.51	2108225.4	1021680.31	510840.28
3	Babool	Acacia nilotica	59	72539.46	18860.73	91399.72	45699.86
4	Bedmushk	Eucalyptus camaldulensis	106	444146.62	115477.71	559624.75	279812.41
5	Jamun	Syzygium cumini	124	146899.22	38193.8	185093.03	92546
6	Taalhi	Dalbergi asisso	98	130452.81	33917	164370.54	82185.27
7	Sarenh	Albizzia lebbek	66	229119.07	59571	288690.03	144345.01
8	Aam	Mangifera indica	58	105576.79	27450.2	133026.76	66513
9	Ashoka	Polyalthia langifolia	29	17091.61	4443.8	21535.43	10767.71
10	Gulmohar	Delonix regia	20	7576.84	1970	9546.82	4773.41
11	Sukhchain	Pongamia pinnata	29	21946.61	5706.1	27652.73	13826.37
12	Toot	Morus alba	20	6059.32	1575.4	7634.75	3817.37
13	Amaltas	Cassia fistula	24	10467.48	2722	13189.03	6594.51
14	Ber	Ziziphus mauritiana	20	20006.61	5201.7	25208.33	12604.16
15	Peepal	Ficus religiosa	13	130132.37	33834	163966.79	81983.40
16	Jhangjalebi	Pithecellobium dulce	24	27546.86	7162.2	34709.05	17354.52
17	Lesoorii	Cordia myxa	6	4880.89	1269	6149.92	3074.96
18	Pilmohar	Peltopharum pterocarpum	20	78947.71	20526	99474.12	49737.06
19	Beeripatta	Heterophragma adenophyllum	17	6825.98	1774.8	8600.75	4300.37
20	Imlee	Tamarindus indica	11	2793.89	726.41	3520.31	1760.15
Total			1342	30004017.68	1591901.16	3785061.1	1888712.55
Mean			-	1500200.88	79595.05	189253.05	94435
Maximum			-	810857.51	2108225.4	1021680.31	510840.28
Minimum			-	2793.89	726.41	3520.31	1760.15

Table 5. Average height, DBH, above and below biomass, Biomass and Carbon Sequester in the study area

S. No.	Trees species name	Avg. height (cm)	Avg. DBH (cm)	Avg. AGB (kg)	Avg. BGB (kg)	Avg. Biomass (kg)	Avg. CO$_2$ Seq. Seq.
1	Azadirachta indica	1201.82	55.43	2355.32	612.38	2967.70	1483.85
2	Conocarpus erectus	1771.02	49.87	2825.28	734.57	3559.86	1779.93
3	Acacia Nilotica	1124.84	40.20	1229.48	319.67	1549.14	774.57
4	Eucalyptus camaldulenisis	2043.56	57.76	1996.63	1089.41	5279.47	2639.73
5	Syzygium cumini	1329.20	42.06	1184.67	308.01	1492.68	746.34
6	Dalbergia sisso	1024.51	37.98	1331.15	346.09	1677.25	838.62
7	Albizzia lebbek	1559.64	69.26	3471.50	902.59	4374.09	2187.04
8	Mangifera indica	1064.67	57.80	1789.43	465.25	2254.69	1127.34
9	Polyaltha langifolia	978.04	32.51	589.36	153.23	742.60	371.30
10	Delonix regia	760.35	31.20	378.84	98.5	477.34	238.67
11	Pongamia pinnata	1025.72	36.85	756.77	196.77	953.54	476.77
12	Morus alba	617.82	27.76	302.96	78.77	381.73	190.86
13	Cassia fistula	749.05	25.92	436.14	113.41	549.54	274.77
14	Ziziphus mauritiana	904.95	36.87	1000.33	260.08	1260.41	630.20
15	Ficus religiosa	1533.15	108.91	10010.18	2602.61	12612.83	6306.41
16	Pithecellobium dulce	105.48	45.97	1147.78	298.42	1446.21	723.10
17	Cordia myxa	981	39.31	813.48	211.5	1024.98	512.49
18	Peltopharum pterocarpum	1377.69	72.65	3947.38	1026.3	4973.70	2486.85
19	Heterophragma adenophyllum	801.94	31.51	401.52	104.4	505.92	252.96
20	Tamarindus indica	1536.72	37.49	253.99	66.03	320.02	160.01

Conclusion

Conclusively, this contemporary study includes the identification of tree species and the overall population of trees in Tando Jam city. The survey was done in the city for the identification of species. 20 species were identified and the population of trees in the city was 7308 with dominant species Azadirachta indica 2451 trees and low quantity of tree species was of Tamarindus indica 11 trees only. This study also shows the decline in vegetation in Tando Jam from 1990 to 2020. Fluctuation in vegetation was observed from 1990 to 2020. In the city central area and Mir colony, Jam Ghar, and Railway area it was observed that trees were cut down and too much low vegetation due to growth in population and human developments. Furthermore, the highest height of the tree was of Eucalyptus camaldulensis 2043 (cm), and the lowest height was of Morus alba 617.82 (cm). The highest average diameter measured in Ficus religiosa was 108.91 (cm) and the lowest diameter in Cassia fistula was 25.92 (cm). The highest total biomass estimated in the Conocarpus erectus tree species was 10, 21680 (Kg) and carbon sequestration was about 5, 10840 (Kg). The lowest biomass was estimated in the Cordia myxa tree about 6194 (Kg) and the carbon sequestered was 3074 (Kg).

Acknowledgement

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