Assessing the gap between vehicular carbon emission and sequestration potential in urban areas using E-cognition and primary data analysis, Bhopal, Madhya Pradesh

Abstract: India is now the 3rd largest emitter of greenhouse gases in the world, with around 7.3% share of its name, with many of these gases originating in urban areas. Urbanization hasled to the overtake of open and green spaces by road networks and built-up areas which have resulted in the elevation ofmany climate threats like urban heat islands and severe impacts on urban livability.Policies on mitigating the carbon footprint of big cities are being developed, and one of the measures is promoting urban parks and greenery to offset net greenhouse gas emissions. Studies show that urban greenery can work as a carbon reservoir and enhance the livability index of urban areas, but support for such claims and their efficacy is still lacking.This study is devised to check the efficiency and potential of green spaces, urban parks and trees in sequestering CO_2 directly from the atmosphere and removing other pollutants present in an urban environment. Taking a zoned-out area demarcating some wards for Bhopal, Madhya Pradesh, with variable traffic volume and different green cover, as a case, the authors integrated various methods to estimate carbon emissions, their impact, and sequestration. This study involves the use of E-cognition for object recognition using high-resolution satellite imagery. The methodology will involve various analyses initiating from traffic volume survey for vehicular carbon emissions analysis, followed by,the calculation of carbon sequestration based on object recognition and conduction of physical surveys to identify the biomass and various species of trees present. This study focuses on the gap analysis between the vehicular carbon emissions and carbon sequestration capability of the trees. Furthermore, understanding how urban greenery helps reduce emissions and its effects while elevating the social and ecological environment of urban spaces further elevating urban livability. The results of the research will provide an insightful view of the importance of urban parks and greenery in offsetting urban emissions. The study's findings can also guide policymakers and stakeholders in implementing effective carbon-offset strategies through parks and urban afforestation. Furthermore,studies can be done to reduce carbon emissions and urban heat island formation on road networks, by making them more manageable.

Comment [p1]: WHEN WRITING THE SUMMARY, YOU SHOULD EXPRESS IT VERY BRIEFLY FROM THE INFORMATION YOU OBTAINED.
THE READER SHOULD BE ABLE TO BRIEFLY UNDERSTAND THE CONTENT AND RESULTS OF THE ARTICLE FROM THE SUMMARY OF THIS STUDY AND GUIDE THE READER.

Keywords:Carbon Sequestration, Carbon Emission, E-cognition, Urban Areas

1 INTRODUCTION

Bhopal, the capital city of Madhya Pradesh in India, is known for its rich cultural heritage, but it is facing environmental pollution challenges that have grave consequences for its residents' health. Characterized by elevated levels of industrialization, urbanization, and population growth, which has led to increased emissions of carbon dioxide (CO2) and other greenhouse gases along with the historic Bhopal gas catastrophe in 1984. The environmental and health impacts of high pollution levels in Bhopal are alarming, as it contributes to the city's poor air quality, with grave consequences for the health of its residents. Additionally, the elevated carbon levels also contribute to global warming and climate change, which threaten the well-being of both the city and the planet.

There are several sources of carbon emissions in Bhopal, including factories, power plants, and transportation. The worst areas in terms of AQI (Air Quality Index) are TT Nagar and Sector D industrial area. There are several urban parks, green covers, and afforested areas that can act as a carbon sink and offset the overall footprint of the city. This paper aims to find this gap between emissions and sequestration of carbon in two urban areas of Bhopal. The paper's objectives are 1) Estimating carbon sequestration in an urban area, 2) Estimating vehicular carbon emissions in an urban area, 3) Finding gap between carbon sequestration and carbon emissions.

2 LITERATURE REVIEW

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GREEN WEDGE, GREEN BELT, GREEN BELT PROJECTS ETC. THE LITERATURE SHOULD BE ENRICHED WITH THE COMMENTS OF PEOPLE WHO HAVE STUDYED EXAMPLE ECOLOGICAL CITY APPROACHES

2.1 CLIMATE CHANGE

Climate change is a complex and important subject that is having a wide-ranging impact on the planet. Urbanism is particularly affected by climate change, as cities are responsible for a massive portion of global greenhouse gas emissions and are also highly vulnerable to the impacts of climate change. In 2021, the average worldwide concentration of CO_2will be topped 416 ppmv. The pace of growth in CO_2 levels is also increasing from 0.7 ppmv per year in the early 1960s to 2.0 ppmv per year between 2000 and 2010, this rate increased. A study by the Indian Institute of Science, Bangalore, on the GHG footprint of major cities in India calculated GHG emissions by various cities. (Ramachandra, T. V.; Aithal, Bharath H.; Sreejith, K., 2015). To address climate change, urban design can contribute to reducing greenhouse gas emissions through strategies such as promoting sustainable transportation options, designing buildings that are more energy-efficient, and prioritizing green spaces and urban forests. Low-income and marginalized populations are often more exposed to the effects of climate change due to a lack of resources such as air conditioning, green areas, and transportation choices. Urban planners and designers must ensure that climate change policies are fair and benefit all people in the community, regardless of income or color.

Comment [p3]:
EXPLAINING THE SUBJECT OF GREEN SYSTEMS AND CLIMATE CHANGE IN A SINGLE SENTENCE DECREASES THE POPULARITY OF THIS ARTICLE. SOME MORE DETAILS CAN BE GIVEN.

2.2 CARBON SEQUESTRATION AND ITS METHODS

ABIOTIC SEQUESTRATION

Geological injection- The sealing effectiveness of low-permeable sequences (caprock) underneath prospective storage reservoirs is a significant challenge for all storage solutions. CO2 is preferably supplied in a supercritical condition to maximize pore space usage (scCO2). When formation water encroaches on or invades the CO2 plume, CO2 is trapped as residual gas. Additionally, it can react with native minerals to cause mineral entrapment and partially dissolve into the aqueous phase, causing solubility trapping.

Hydrodynamic trapping- This technique is essential for storage sites and stops CO_2 from leaking through the caprock while waiting for other trapping methods to act.

Mineral trapping- This process can be advantageous or harmful depending on the lithologies' structure, mineralogy, and hydrogeology. It is important to understand how these opposing forces will affect society.

BIOTIC SEQUESTRATION

Oceanic sequestration- When seaweed reaches the deep ocean, it sequesters carbon and prevents it from interacting with the atmosphere for millennia. Seaweed grows in shallow and coastal locations and may carry considerable amounts of carbon there, while algae release carbon into the atmosphere more quickly than terrestrial plants. Algae has been suggested as a form of short-term carbon storage that may serve as a feedstock for biofuels.

Forests- Reforestation and limiting deforestation can boost carbon sequestration in four main ways: expanding the size of the current forest, boosting existing forests' carbon density, increasing the use of forest products to replace fossil fuel emissions, and lowering carbon emissions brought on by deforestation and environmental deterioration.

Urban forestry and parks- Urban vegetation's effectiveness in reducinggreen areas provide several physiological, and recreational urban vegetation's effectiveness in reducing, and psychological advantages from a social standpoint, as well as raising awareness of the environment and promoting action against climate change.

2.3 VEHICULAR CARBON EMISSIONS

87% of the total CO2 equivalent emissions from the transportation sector came from road transportation, which is the predominant method of transportation in the nation. By contrast, the aviation industry's share of the total CO2 equivalent emissions was only 7%. The remaining 1% came from the navigation sector and 5% from the railway sector. According to the National Transport Development Policy Committee (NTDPC), the number of people using roads for passenger and freight transportation would increase fivefold between 2030 and 2031. The nation's total GHG emissions will be significantly impacted by this expansion. The Indian government has already made several steps to encourage sustainable modes of transportation in the nation after realizing the necessity to separate the increase of GHG from the expansion of transportation. Launched in 2008, the National Acon Plan on Climate Change (NAPCC) incorporates sustainable mobility as part of the National Mission on Sustainable Habitat, acknowledging the significance of lowering greenhouse gas emissions from transport. The sources of emissions for road transport encompass a wide range of light-duty autos, including cars and light trucks; heavy-duty vehicles, such buses and tractors; and on-road motorbikes, which include mopeds, scooters, and three-wheelers.

2.4 CARBON MANAGEMENT

Carbon management is necessary because carbon emissions play a significant role in global warming, which has far-reaching effects such as sea level rise, an increase in the frequency and intensity of severe weatherconditions as well as loss of biodiversity. To manage carbon efficiently, businesses and governments must calculate their carbon footprint, or the volume of greenhouse gases produced by their operations and discharged into the environment. Carbon sequestration in living plants and soils is likely to have an immediate net positive effect on atmospheric carbon dioxide, plus a positive effect on biodiversity and other ecosystem services. The protection of existing mature forests keeps the living plant carbon out of the atmosphere and preserves the current level of biodiversity. (Huston, Michael A.; Marland, Gregg, 2003)

3 SITE PROFILE and METHODOLOGY

Comment [p4]: STUDY AREA AND METHOD ONE TITLE

3.1 WARD 27 AND WARD 46, BHOPAL

Ward 27 comprisesNehruNagar, Kotra and edges with hotel Taj and IIFM. Ward 46 is around T.T Nagar, with major landmarks near it such as DB Mall, Chinar Park, etc.

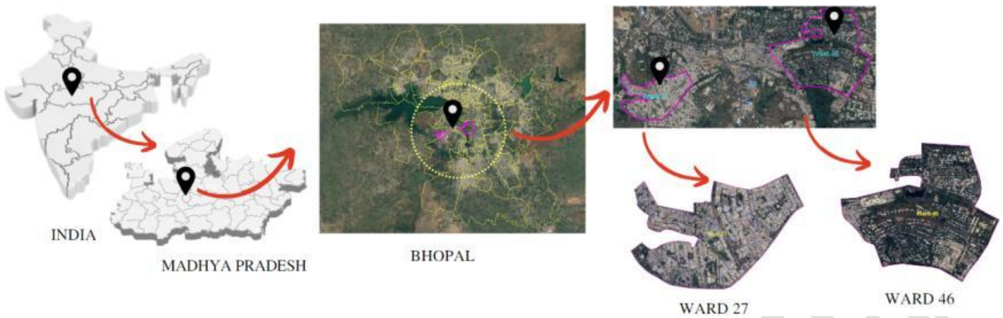

Fig 1: location of study area (Ward 27 & Ward 46)

A comparative chart of ward 27 and ward 46 about the locational qualities, similarities and differences is given below:

FACTORS	WARD 27	WARD 46
Land use (predominantly)	Residential, Commercial and Mixed	Residential and Public/ Semi Public
Green Cover	Less dense	Heavily dense
Connectivity	Well connected	
Settlement	Well Planned (some slum formation exists)	Well Planned
Social Infrastructure	Adequate	
Physical Infrastructure	Moderately laid	Well laid
Road Infrastructure	Planned cul de sacs	
Major landmark	IIFM	Forest Department
Income levels	LIG/ EWS/ MIG/ HIG	LIG/ MIG/ HIG

Table 1: Comparative chart of wards

Ward 27 has Main Road 3 and Kotra Sultanabad road passing through the ward. Ward 46 hasMain Road 3, Main Road 2 and Char Imli road passing through it.

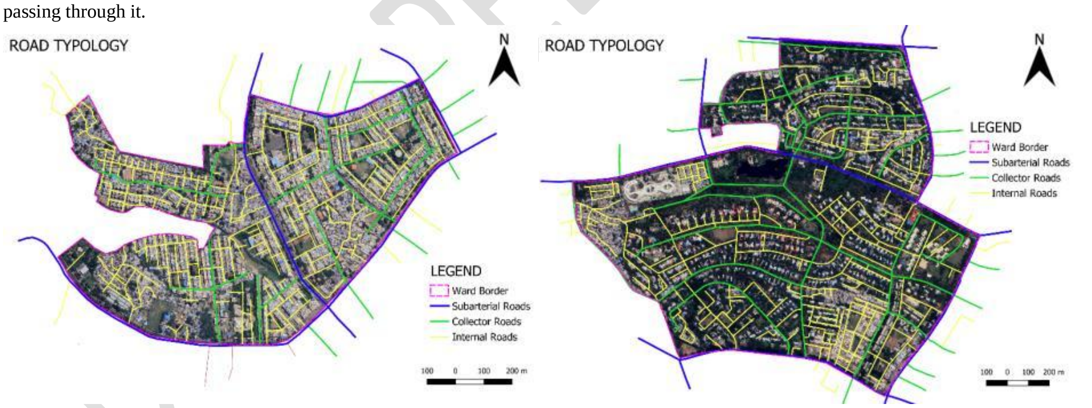

Fig 2: Road typology of study area (Ward 27 & Ward 46)

4 METHODOLOGY 3.2

The methodology adopted includes Traffic-Volume survey that was conducted first and constitutes remote survey done by authors; the chart below shows the Methodology that was followed:

Comment [p5]: 3.2 Methodology

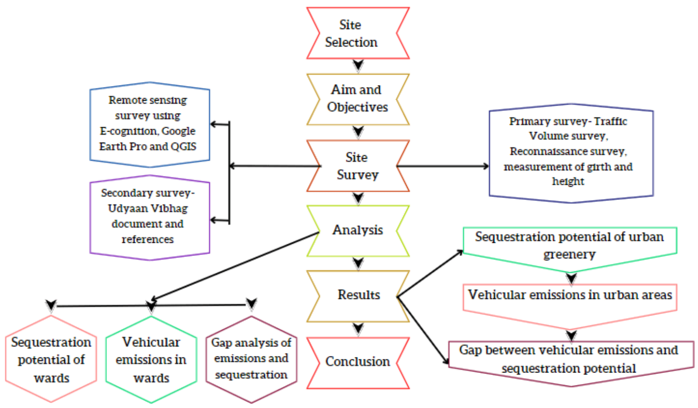

Fig 3: Methodology Chart

4.1 Working through E cognition

E-Cognition, an advanced geospatial tool, represents a milestone in the domain of land cover classification, due to its efficient and accurate object recognition algorithms. This software eases the process by automating the intricate process of identifying and classifying objects within remotely sensed images, facilitating unprecedented efficiency in handling extensive datasets. With a unique capacity for multi-resolution analysis and multi-spectral analysis, E-Cognition excels in discerning land cover features across varying scales, while its incorporation of contextual analysis enhances precision through the consideration of spatial relationships among objects.

E-Cognition is a pivotal tool to classify land cover within Ward 27 and 46, utilizing high-resolution imagery. The methodology encompasses a systematic process commencing with multiresolution analysis, ensuring a nuanced understanding of land cover features across various scales. Subsequently, the application of multi-spectral analysis refines the classification process, taking advantage of the software's ability to discern spectral characteristics. To enhance the precision of classification, a judicious selection of samples is input into the system, facilitating a more accurate and contextually relevant categorization of land cover. This leads to the generation of highly accurate, classified land cover maps.Furthermore, object recognition within E-Cognition is used to identify treetops with the objective of accurately quantifying the tree population in the classified land cover map. The system to discern and isolate individual tree canopies, contributing to a more precise assessment of the tree count within the studied areas of Ward 27 and Ward 46. The resultant tree count becomes an essential metric, playing a crucial role in calculating CO2 sequestration potential.

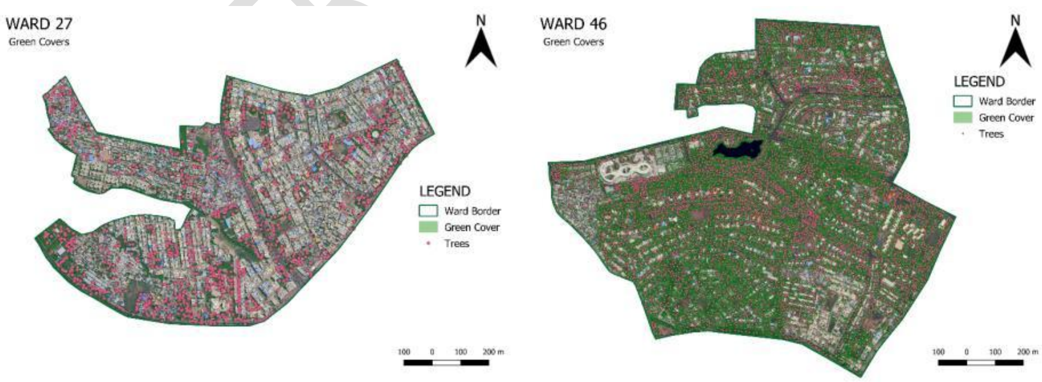

Fig 4: Green cover and identified trees map (Ward 27 & Ward 46)

In Ward 27, where the total area spans 0.76 square kilometers, 1031 trees collectively cover a green expanse of approximately 0.154 square kilometers, representing 20.3% of the ward. Conversely, Ward 46, with a larger total area of 1.93 square kilometers, with 6291 trees encompassing an extensive 0.905 square kilometers, constituting 46.8% of the ward's landscape.

Comment [p6]: 3.2.1 **Working through E cognition**

4.2 Physical survey

Comment [p7]: 3.2.2.

Sample research was undertaken in two wards in Bhopal with different characteristics to determine the gap between the total carbon dioxide emissions from the vehicular sector and total carbon absorbed by the trees of the study area. Firstly, the trees in the park were mapped and identified for this investigation. The tree's girth was measured using a 5-meter measuring tape, and its height was measured using a distro meter. All the trees were mapped and numbered according to species.

Over three days, the survey was carried out in ward 27 and ward 46, during which reconnaissance survey was done, species were identified, and measurements of the identified species were taken. The tree's height was measured with a Laser disto-meter, a laser used to aim at the canopy's highest point. It was aimed upright at the eye level of the surveyor, and the additional height of the surveyor was added to the final height then the tree's girth was measured at 1.3 m from the base, appropriate assumptions were made, and the final height and girth were noted. For each species, a mean height and girth were calculated by taking the mean of all the readings (it will be comprehensive to note different heights and girths of distinct species with quantity). The species were identified using Google Lens and the iNaturalist app. The residents also assisted in improving the identification of some species.

The traffic- volume survey was done over two days, at peak hours and non-peak hours. 15 points were taken in each ward, while survey was conducted for 5 minutes per point at both peak and non-peak hours. The results were averaged to estimate yearly CO_2 emissions.

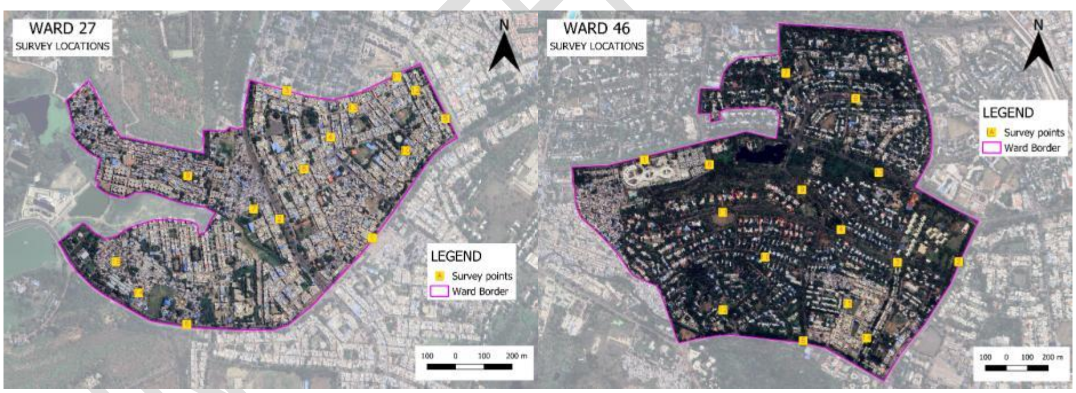

Fig 5: location of points for Traffic- Volume Survey (Ward 27 & Ward 46)

4.3 METHOD FOR ESTIMATING CURRENT CO2 SEQUESTRATION

Comment [p8]: 3.2.3

The amount of CO_2 sequestered in each tree, following is the process (to be followed in chronological order) can be estimated as follows (reference Eq 1-6):

Calculate the total (green) weight of the tree

For trees withDiameter< 11 inches:

(Eq...1a)

$$\textit{Weight of tree above ground} = 0.25(\textit{Diameter of trunk})^2(\textit{Height of tree})$$

For trees withDiameter >= 11 inches:

(Eq...1b)

$$\textit{Weight of tree above ground} = 0.15(\textit{Diameter of trunk})^2(\textit{Height of tree})$$

Note: Weight in pounds; Diameter in inches; Height in feet.

(Note: These two equations could be seen as an "average" of all the species' equations.)

The root system of the tree weighs about 20% of the weight of the tree above ground.
(Eq...2)

*Total Weight of Tree = 120% * Weight of tree above ground*

To calculate the dry weight of the tree
(Note: The average tree has 72.5% dry matter and 27.5% moisture.)
(Eq...3)

*Dry Weight of Tree = 72.5% * Total Weight of Tree*

To calculate the weight of carbon in the tree
The average carbon content is 50% of the tree's total volume.
(Eq...4)

*Weight of Carbon in Tree= 50% * Dry Weight of Tree*

To calculate the weight of carbon dioxide sequestered in the tree
(The ratio of CO2/C is 43.99/12.001=3.66)
(Eq...5)

*Weight of CO_2 sequestered in Tree= 3.7 * Weight of Carbon in Tree*

To calculate the weight of carbon dioxide sequestered in the tree annually
(Eq...6)

Weight of CO_2 sequestered in Tree per year = Weight of CO_2 sequestered in Tree/ Age

4.4 METHOD FOR ESTIMATINGVEHICULAR CO_2 EMISSIONS
The table below shows the emission coefficient (kg CO_2/km) of the different types of vehicles:

Vehicular Typology	Emission Coefficient (kg Co2/ km)
2- Wheeler	0.0396
3- Wheeler	0.1178
4- Wheeler	0.2055
Bus	1.0774
Heavy Loading Vehicles (eg. Truck)	1.2773

Table 2: Emission coefficient of different types of vehicles

To determine vehicular emissions the following are the equations:
(Eq...7)

*(No.Of 2-wheelers * 0.0396) + (No.Of 3-wheelers * 0.1178) + (No. Of 4-wheelers * 0.2055) + (No.Of bus * 1.0774) + (No. Of Heavy loading vehicles * 1.2773)*

6 RESULTS AND ANALYSIS

6.1 CALCULATION OF TOTAL CO2 SEQUESTERED

Comment [p9]: 4. result and findings

a short general description please.

Comment [p10]: 4.1 calculation of total co2 sequestered

The table below contains information about our sample oftrees of wards 27 and 46, including the identified species, girth, height, and results by applying formulas to calculate the CO2 sequestration of the site.

Table 3: Total carbon sequestration of Ward 27

S. No.	Common Name	Botanical Name	Girth (inches)	Diameter (inches)	Height (feet)	Green weight	Green weight including roots	Dry weight	Carbon content	Co2 sequestered (lbs)	No. of trees	Total Co2 Sequestered (lbs)	Total Co2 Sequestered (Kgs)
1	Amaltas	Golden shower	5.25	1.67	36.28	25.35	30.42	22.05	11.03	40.43	126	5094.14	2312.74
2	Amla	Phyllanthus emblica	83.86	26.71	33.26	3558.38	4270.06	3095.79	1547.90	5675.06	25	141876.38	64411.88
3	Ashoka	Saraca asoca	38.69	12.32	22.21	505.87	607.04	440.10	220.05	806.78	956	771277.92	350160.18
4	Bamboo	Bambusa vulgaris	7.87	2.51	38.81	61.01	73.21	53.08	26.54	97.30	403	39212.25	17802.36
5	Banyan Tree	Ficusbengalensis	117.72	37.49	31.39	6618.12	7941.75	5757.77	2878.88	10554.85	277	2923692.67	1327356.47
6	Bhirra	Chloroxylon	59.06	18.81	42.09	2233.15	2679.78	1942.84	971.42	3561.51	25	89037.86	40423.19
7	Bottle brush	Callistemon	35.83	11.41	26.63	520.08	624.10	452.47	226.24	829.45	25	20736.17	9414.22
8	Copperpod	Peltophorum pterocarpum	114.17	36.36	45.37	8997.64	10797.17	7827.95	3913.97	14349.80	252	3616149.04	1641731.66
9	Drumstick	Moringa Oleifera	45.28	14.42	45.37	1414.91	1697.90	1230.98	615.49	2256.56	25	56414.06	25611.99
10	Gular	Ficus racemosa	36.75	11.70	26.36	541.57	649.88	471.16	235.58	863.71	75	64778.48	29409.43
11	Gulmohar	Delonix regia	78.74	25.08	48.65	4588.98	5506.77	3992.41	1996.20	7318.69	50	365934.31	166134.18
12	Horsetail She-oak	casuarina equisetifolia	41.34	13.17	32.77	852.00	1022.41	741.24	370.62	1358.81	126	171210.19	77729.42
13	Indian cork	Millingtonia hortensis	69.34	22.08	39.74	2906.62	3487.94	2528.76	1264.38	4635.59	151	699974.63	317788.48
14	Jackfruit	Artocarpusheteroph yllus	34.25	10.91	29.63	881.48	1057.77	766.89	383.44	1405.82	25	35145.46	15956.04
15	Jamun	Syzygium cumini L	74.02	23.57	43.88	3657.23	4388.67	3181.79	1590.89	5832.69	151	880736.92	399854.56
16	Kanji	Millettia pinnata	92.13	29.34	50.29	6493.66	7792.39	5649.48	2824.74	10356.35	101	1045991.68	474880.22
17	Kedondong	Garuga floribunda	38.99	12.42	33.85	782.98	939.57	681.19	340.59	1248.72	101	126120.90	57258.89
18	Maharukh	Ailanthus altissima	90.55	28.84	46.58	5811.08	6973.30	5055.64	2527.82	9267.75	202	1872085.55	849926.84
19	Mango	Mangiferaindica	68.90	21.94	43.93	3172.72	3807.26	2760.27	1380.13	5059.98	126	637557.73	289451.21
20	Neem	Azadirachta indica	74.13	23.61	32.20	2692.35	3230.82	2342.35	1171.17	4293.87	101	433680.89	196891.12
21	Palash	Butea monosperma	31.50	10.03	44.29	1114.07	1336.89	969.24	484.62	1776.77	377	669840.96	304107.80
22	Palm	Arecaceae	9.84	3.13	13.36	32.81	39.37	28.54	14.27	52.33	327	17110.68	7768.25
23	Paras pipal	Thespesia populnea	38.98	12.41	21.55	498.09	597.71	433.34	216.67	794.37	75	59577.87	27048.35
24	Pipal	Ficusreligiosa	78.62	25.04	36.69	3450.30	4140.35	3001.76	1500.88	5502.67	277	1524239.71	692004.83
25	Pseudo Ashoka	Polyathialongifolia	46.30	14.74	29.56	964.01	1156.81	838.68	419.34	1537.43	629	967046.30	439039.02
26	Red cotton tree	Bombax ceiba	53.15	16.93	38.56	1657.04	1988.44	1441.62	720.81	2642.71	126	332981.13	151173.43
27	Royal Palm	Roystonearegia	49.21	15.67	55.21	2034.34	2441.20	1769.87	884.94	3244.44	75	243333.16	110473.26
28	Safed Siris	Albiziaprocera	78.74	25.08	71.62	6755.23	8106.27	5877.05	2938.52	10773.51	101	1088124.36	494008.46
29	Shahtoot	Morus alba	15.75	5.02	17.25	108.45	130.14	94.35	47.17	172.96	25	4323.92	1963.06
30	Shisham	Dalbergia sissoo	98.97	31.52	35.53	5294.04	6352.85	4605.82	2302.91	8443.15	151	1274916.16	578811.93
31	Silver Oak	Grevillea robusta	57.48	18.31	34.44	1731.06	2077.27	1506.02	753.01	2760.76	25	69019.09	31334.67
32	Subabul	Leucaena leucocephala	35.68	11.36	29.49	951.81	1142.17	828.08	414.04	1517.99	50	75899.45	34458.35
33	Tamarind	Tamarindus indica L	54.33	17.30	19.47	874.41	1049.29	760.73	380.37	1394.54	277	386287.56	175374.55
34	Tasmanian blue gum	Eucalyptus	72.05	22.94	62.36	4925.00	5910.00	4284.75	2142.37	7854.58	453	3558126.39	1615389.38
TOTAL											6291	24267533.96	11017460.42

Table 4: Total carbon sequestration of Ward 46

6.2 CALCULATION OF TOTAL CO2 EMISSIONS OF SURVEY AREA

The tables belowshow total emissions from different vehicle type, 15 points per ward were surveyed to find the number of vehicles and then were put in the equation to find the total emissions of 5 minutes, later we can calculate average daily and yearly emissions.

Ward 27											
Vehicular Typology											
Survey Points	2- Wheeler		3- Wheeler		4- Wheeler		Bus		Heavy Loading Vehicles		Total Emissions (kg CO2)
	Count	Emissions	Count	Emissions	Count	Emissions	Count	Emissions	Count	Emissions	
Point 1	188	7.4448	32	3.7696	59	12.1245	9	9.6966	4	5.1092	38.1447
Point 2	141	5.5836	27	3.1806	36	7.398	7	7.5418	1	1.2773	24.9813
Point 3	64	2.5344	3	0.3534	13	2.6715	5	5.387	4	5.1092	16.0555
Point 4	49	1.9404	0	0	14	2.877	0	0	7	8.9411	13.7585
Point 5	68	2.6928	5	0.589	22	4.521	1	1.0774	1	1.2773	10.1575
Point 6	123	4.8708	18	2.1204	64	13.152	5	5.387	9	11.4957	37.0259
Point 7	35	1.386	3	0.3534	1	0.2055	0	0	2	2.5546	4.4995
Point 8	55	2.178	2	0.2356	16	3.288	0	0	6	7.6638	13.3654
Point 9	34	1.3464	5	0.589	7	1.4385	0	0	2	2.5546	5.9285
Point 10	47	1.8612	0	0	11	2.2605	0	0	1	1.2773	5.399
Point 11	71	2.8116	4	0.4712	9	1.8495	4	4.3096	3	3.8319	13.2738
Point 12	11	0.4356	1	0.1178	2	0.411	1	1.0774	2	2.5546	4.5964
Point 13	21	0.8316	2	0.2356	4	0.822	0	0	3	3.8319	5.7211
Point 14	11	0.4356	2	0.2356	2	0.411	0	0	2	2.5546	3.6368
Point 15	10	0.396	1	0.1178	1	0.2055	0	0	0	0	0.7193
										Total Emissions	197.2632

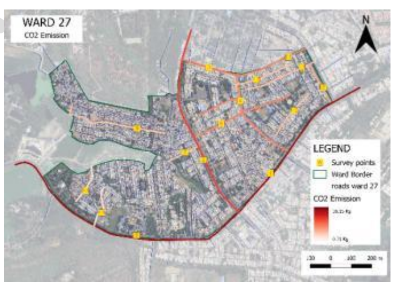

Table 5: Carbon emission calculation of ward 27Fig 6: Carbon emission mapof Ward 27

S. No.	Common Name	Botanical Name	Girth (inches)	Diameter (inches)	Height (feet)	Green weight	Green weight including roots	Dry weight	Carbon content	Co2 sequestered (lbs)	No. of trees	Total Co2 Sequestered (lbs)	Total Co2 Sequestered (Kgs)
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2	Amla	Phyllanthus emblica	83.86	26.71	33.26	3558.38	4270.06	3095.79	1547.90	5675.06	4	22700.22	10305.90
3	Ashoka	Saraca asoca	38.69	12.32	22.21	505.87	607.04	440.10	220.05	806.78	157	126663.84	57505.38
4	Bamboo	Bambusa vulgaris	7.87	2.51	38.81	61.01	73.21	53.08	26.54	97.30	66	6421.86	2915.52
5	Banyan Tree	Ficusbengalensis	117.72	37.49	31.39	6618.12	7941.75	5757.77	2878.88	10554.85	46	485522.97	220427.43
6	Bhirra	Chloroxylon	59.06	18.81	42.09	2233.15	2679.78	1942.84	971.42	3561.51	4	14246.06	6467.71
7	Bottle brush	Callistemon	35.83	11.41	26.63	520.08	624.10	452.47	226.24	829.45	4	3317.79	1506.28
8	Copperpod	Peltophorum pterocarpum	114.17	36.36	45.37	8997.64	10797.17	7827.95	3913.97	14349.80	42	602691.51	273621.94
9	Drumstick	Moringa Oleifera	45.28	14.42	45.37	1414.91	1697.90	1230.98	615.49	2256.56	4	9026.25	4097.92
10	Gular	Ficus racemosa	36.75	11.70	26.36	541.57	649.88	471.16	235.58	863.71	12	10364.56	4705.51
11	Gulmohar	Delonix regia	78.74	25.08	48.65	4588.98	5506.77	3992.41	1996.20	7318.69	8	58549.49	26581.47
12	Horsetail She-oak	casuarina equisetifolia	41.34	13.17	32.77	852.00	1022.41	741.24	370.62	1358.81	21	28535.03	12954.90
13	Indian cork	Millingtonia hortensis	69.34	22.08	39.74	2906.62	3487.94	2528.76	1264.38	4635.59	25	115889.84	52613.99
14	Jackfruit	Artocarpusheteroph yllus	34.25	10.91	29.63	881.48	1057.77	766.89	383.44	1405.82	4	5623.27	2552.97
15	Jamun	Syzygium cumini L	74.02	23.57	43.88	3657.23	4388.67	3181.79	1590.89	5832.69	25	145817.37	66201.09
16	Kanji	Millettia pinnata	92.13	29.34	50.29	6493.66	7792.39	5649.48	2824.74	10356.35	16	165701.65	75228.55
17	Kedondong	Garuga floribunda	38.99	12.42	33.85	782.98	939.57	681.19	340.59	1248.72	16	19979.55	9070.71
18	Maharukh	Ailanthus altissima	90.55	28.84	46.58	5811.08	6973.30	5055.64	2527.82	9267.75	33	305835.76	138849.43
19	Mango	Mangiferaindica	68.90	21.94	43.93	3172.72	3807.26	2760.27	1380.13	5059.98	21	106259.62	48241.87
20	Neem	Azadirachta indica	74.13	23.61	32.20	2692.35	3230.82	2342.35	1171.17	4293.87	16	68701.92	31190.67
21	Palash	Butea monosperma	31.50	10.03	44.29	1114.07	1336.89	969.24	484.62	1776.77	62	110159.52	50012.42
22	Palm	Arecaceae	9.84	3.13	13.36	32.81	39.37	28.54	14.27	52.33	54	2825.62	1282.83
23	Paras pipal	Thespesia populnea	38.98	12.41	21.55	498.09	597.71	433.34	216.67	794.37	12	9532.46	4327.74
24	Pipal	Ficusreligiosa	78.62	25.04	36.69	3450.30	4140.35	3001.76	1500.88	5502.67	45	247620.17	112419.56
25	Pseudo Ashoka	Polyathialongifolia	46.30	14.74	29.56	964.01	1156.81	838.68	419.34	1537.43	103	158355.75	71893.51
26	Red cotton tree	Bombax ceiba	53.15	16.93	38.56	1657.04	1988.44	1441.62	720.81	2642.71	21	55496.85	25195.57
27	Royal Palm	Roystonearegia	49.21	15.67	55.21	2034.34	2441.20	1769.87	884.94	3244.44	12	38933.31	17675.72
28	Safed Siris	Albiziaprocera	78.74	25.08	71.62	6755.23	8106.27	5877.05	2938.52	10773.51	17	183149.64	83149.94
29	Shahtoot	Morus alba	15.75	5.02	17.25	108.45	130.14	94.35	47.17	172.96	4	691.83	314.09
30	Shisham	Dalbergia sissoo	98.97	31.52	35.53	5294.04	6352.85	4605.82	2302.91	8443.15	25	211078.83	95829.79
31	Silver Oak	Grevillea robusta	57.48	18.31	34.44	1731.06	2077.27	1506.02	753.01	2760.76	4	11043.05	5013.55
32	Subabul	Leucaena leucocephala	35.68	11.36	29.49	951.81	1142.17	828.08	414.04	1517.99	8	12143.91	5513.34
33	Tamarind	Tamarindus indica L	54.33	17.30	19.47	874.41	1049.29	760.73	380.37	1394.54	45	62754.30	28490.45
34	Tasmanian blue gum	Eucalyptus	72.05	22.94	62.36	4925.00	5910.00	4284.75	2142.37	7854.58	74	581239.19	263882.59
TOTAL											1031	3987722.02	1810425.80

Comment [p11]: EUCALYPTUS AND AİLLANTUS ALTİSSİMA ETC.
THE CARBON SEQUENCE ORDER OF TREE SPECIES SHOULD BE BRIEFLY EXPLAINED WITH A DESCRIPTION.

Comment [p12]: 4.2...............

Comment [p13]: 1.TABLE EXPLANATION TEXT IS REQUIRED

2.MAP IS NOT READABLE

3.POİNT 1 AND POİNT PLEASE EXPLANATİON

Total Emissions (5 minutes) of Ward 27 = 197.2632 Kgs
Average total emissions (1 minute) = 39.45264 Kgs
Average total emissions (1 hour) = 2,367.1584 Kgs
Average total emissions (1 day) = 56,811.8016 Kgs

Average yearly total emissions of ward 27= 2,07,36,307.584 kg, or 20,736.3 Tonnes

Ward 46											
Vehicular Typology											
Survey Points	2- Wheeler		3- Wheeler		4- Wheeler		Bus		Heavy Loading Vehicles		Total Emissions (kg CO2)
	Count	Emissions	Count	Emissions	Count	Emissions	Count	Emissions	Count	Emissions	
Point 1	205	8.118	31	3.6518	115	23.6325	1	1.0774	0	0	36.4797
Point 2	205	8.118	40	4.712	189	38.8395	1	1.0774	3	3.8319	56.5788
Point 3	56	2.2176	3	0.3534	19	3.9045	0	0	2	2.5546	9.0301
Point 4	43	1.7028	11	1.2958	37	7.6035	0	0	1	1.2773	11.8794
Point 5	248	9.8208	27	3.1806	133	27.3315	0	0	1	1.2773	41.6102
Point 6	198	7.8408	21	2.4738	123	25.2765	2	2.1548	49	62.5877	100.3336
Point 7	53	2.0988	10	1.178	61	12.5355	0	0	6	7.6638	23.4761
Point 8	95	3.762	24	2.8272	63	12.9465	1	1.0774	5	6.3865	26.9996
Point 9	12	0.4752	3	0.3534	8	1.644	0	0	1	1.2773	3.7499
Point 10	55	2.178	12	1.4136	22	4.521	0	0	4	5.1092	13.2218
Point 11	32	1.2672	10	1.178	21	4.3155	1	1.0774	1	1.2773	9.1154
Point 12	23	0.9108	2	0.2356	16	3.288	0	0	0	0	4.4344
Point 13	267	10.5732	35	4.123	175	35.9625	2	2.1548	37	47.2601	100.0736
Point 14	41	1.6236	9	1.0602	21	4.3155	0	0	2	2.5546	9.5539
Point 15	8	0.3168	1	0.1178	3	0.6165	1	1.0774	0	0	2.1285
										Total Emissions	448.665

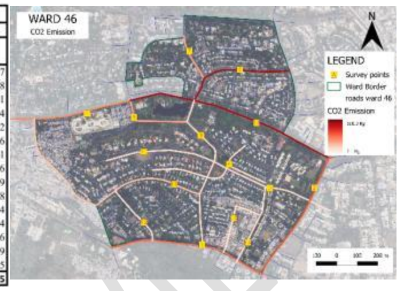

Table 6: Carbon emission calculation of ward 46Fig 7: Carbon emission map of Ward 46
Total Emissions (5 minutes) of Ward 46 = 448.665 Kgs
Average total emissions (1 minute) = 89.733 Kgs
Average total emissions (1 hour) = 5,383.98 Kgs
Average total emissions (1 day) = 1,29,215.52 Kgs

Average yearly total emissions of ward 46 = 4,71,63,664.8 Kgs or 47,163.7 Tonnes

6.2 CALCULATION OF GAP IN CARBON EMISSION AND CARBON SEQUESTRATION

The gap analysis is done to understand the potential of green spaces to sequester carbon from emissions. Here, ward 27 has less green cover according to the classification through E-cognition and is thus able to sequester only 8.73% of the CO_2 emissions per year. Ward 46 has a dense green cover and has potential to sequester 23.36% of CO_2 emissions per year.

	Carbon Emission yearly (in Tonnes)	Carbon Sequestration Yearly (in Tonnes)	GAP (in Tonnes)	Percentage (%) Sequestrated
WARD 27	20,736.30	1810.43	**18,925.87**	**8.73%**
WARD 46	47,163.70	11017.46	**36,146.24**	**23.36%**

Table 7: Gap Analysis

Ward 46 has yearly carbon emissions of 56.03% more than ward 27 and has 83.57% more carbon sequestration potential than ward 27. Therefore, indicating the positive outcomes of green cover and how they mitigate urban carbon emissions.

7 CONCLUSIONS

Green cover has always been a problem solver for urban areas and has reduced the burden caused by rapid urbanization. They impact the natural and artificial environment of a city, also impacting the public life in social and mental well-being aspects. Urban areas face major challenges of CO_2 emissions, which is major Greenhouse gas and among the various sectors, the vehicular sector is the leading contributor to CO_2 emissions. The study has successfully estimated the gap between the vehicular carbon emissions and potential of urban greenery to sequester orstore carbon. Urban greenery not only reduces urban heat but also serves as small habitats of biodiversity, by creating a bridge between carbon emissions and carbon sequestration. A fully grown tree sequestration represents the amount of carbon stored over the years. As discussed in this case, various aspects of carbon sequestration were noticed and the potential of the park for sequestration by the conduction of both surveys and various tools. The validation of the tools was done along with determining the accuracy level and gives an insight into accuracy of tools that uses remotely sensed images and tools. Further work could be done to estimate the potential of trees at city level and their potential to mitigate sector-wise emissions.

Comment [p14]: 4.3

Comment [p15]: solution and discussion

Comment [p16]: THE RESULTS SHOULD BE DISCUSSED WITH DIFFERENT SAMPLING AREAS OR STUDIES.

The importance of sink areas
deforestation

etc..........................pleaseyouresearch, compare

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