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The Effect of Urban Green Spaces on Air Pollution Reduction: A Case of Ahmedabad

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Abstract. Ahmedabad city struggles with one of the highest ambient air pollution levels in India. To reduce the air pollutants, urban green spaces can be considered one of the best options. In the study, few physical variables, like plant stature and morphology, are considered. This paper covers the aspect of vegetation for analysing pollution mitigation. Four Urban Forest (UF) sites from four different zones, differentiated by the land use of each site, of the city of Ahmedabad have been selected, Physical variables of each of these Urban Forest sites were collected. Consequently, an air monitoring station was selected from within 4 km radius of these sites. The selected urban forests were introduced in 2019-20. Pollutant concentration data from before UF and after UF (2016-2021) of each site was extracted from all the stations. This data was then compared with the physical variables of UF to determine the AQI change in the area throughout the years. The findings showed improved the concentration of pollutant in each of the 4 sites. Factors like number of trees and tree species in each site played an important role in pollutant reduction. To understand the role of urban forests, NDVI analysis was conducted of the sites.

1 Introduction

The increased opportunities have drawn a huge amount of population from rural areas to urban areas leading to uncontrolled and unplanned urbanisation. According to Food and Agriculture Organisation (FAO), population in cities has increased by 40% in over a century (1913-2013) and it is going to rise another 15% in next 50 years [1]. This phenomenon of urbanisation is seen to be prominent in India. In Indian cities, forthcoming projects will draw people to urban areas because of the employment possibilities fostering an environment that is more conducive to energy consumption and has an adverse effect on land productivit [2]. As a result, there will be a reduction in the amount of green space available per person and a deterioration in the environment's quality. Due to their vital role in the well-being of mankind and the functioning of ecosystems, Urban Green Spaces (UGS) are among the most crucial parts of any urban environment. When metropolitan areas lose these green spaces, they become a major source of Greenhouse Gases (GHG) emissions and are more vulnerable to climate change's consequences [3]. The number of people living in cities will increase 39% by 2036 [4]. The cities will have to grow towards the peri–urban areas; creating a change in land-use and leading to transformation in hydrological, ecological, and socio-economic systems [5]. To counter the negative consequences of these changes, UGS plays a crucial part in preserving a secure and healthy environment for people to live.

The Indian government has laid emphasis on incorporating green spaces into the urban development process and the necessity for urban planning and development that is people-centric. There has been multiple mechanisms dedicated for green infrastructure - National Environment Policy, 2006; Forest Conservation Act, 1980; National Action Plan on Climate Change (NAPCC); AMRUT; National Mission for Green India; and Urban & Regional Development Plan Formulation and Implementation Guidelines (URDPFI) [3].

Ahmedabad is one of the fastest developing cities of India. But its prosperity has come at the expense of its greenery. Ahmedabad has lost 30.36 km^2 of green cover and 57.13 km^2 of open space. Between 2011 and 2020, the city's built-up area grew by 87.39 km^2. Due to this, the oxygen blanket has shrunk and the concretization has lead to dust envelopes. To counter this damage, various initiatives have been undertaken by government including Mission Million Trees, High Density Plantation Programme by Miyawaki method and Heat Action Plan (Climate Change and Environment Action Plan of Ahmedabad District).

The main objective of the paper is to understand how UGS has led to reduction in air pollution in Ahmedabad. For the same, four locations from different zones and having different land use have been selected. In these 4

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locations, NDVI from previous years is compared to understand the extent of pollution reduction. Additionally, the paper describes air pollution and addresses its causes, effects on health, and relationship to UGS.

2 Air Pollution

Urban areas concentrate many issues that affect human health [6]. But, according to World Health Statistics (WHO), air pollution poses the most significant health risk due to the concentration of emission sources, such as motor vehicles, and the poor air quality that results from this [7]. Around 90% of people worldwide are thought to reside in areas where the WHO air quality guidelines are not met [8]. This rise in air pollution might worsen the effects of climate change making it essential for municipalities to explore ways to mitigate air pollution.

The utilisation of urban greenspace is a concept that has grown in prominence lately for boosting the sustainability of cities in order to accommodate the growing urban population and for improving air quality [9]. Compared to other exposed surfaces, tree leaves more effectively collect airborne particles (through interception, impaction, or sedimentation) and absorb Carbon Dioxide (CO_2) and air pollutants including Ozone (O^3), Nitrogen Dioxide (NO_2), and Sulphur Dioxide (SO_2) mostly through leaf stomata (although certain gases are removed by the plant surface) [10]. Apart from improving air quality, multiple benefits can be assessed from urban greenspaces as discussed in 3.1.

2.1 Types of air pollutants and their sources

The environment contains a number of common air pollutants, such as:

a) Particulate matter is a variety of solid and liquid particle suspended in air. Particles having an aerodynamic width of less than 2.5 micrometres are referred to as fine particulate matter ($PM_{2.5}$) and those with an aerodynamic width of 2.5 to 10 micrometres are known as coarse particulate matter (PM_{10}) [11]. Some of the main sources of $PM_{2.5}$ pollution are dirt, emissions from burning biofuel and open waste, factory and car emissions, and home manufacturing power generation [12].

b) Nitrogen Dioxide - The primary source of nitrogen dioxide created by human activity is the combustion of fossil fuels (coal, petrol, and oil), particularly the petrol used in transportation. It can also be made by the production of nitric acid, the use of explosives, welding, the refinement of metals and oils, industrial manufacture, and food preparation.

c) Sulphur Dioxide - The main sources of the gas are fossil fuel power plants and industrial operations [13]. Sulphur-dioxide is also a by-product of a number of industrial processes, including the manufacturing of steel, fertiliser, and aluminium melting.

2.2 Impact of air pollution on human health

In India, open air pollution has risen to the 5th ranking cause of mortality in 2012, accounting for over 0.62 million cases of early excess death [14]. Air pollution was classified as an anthropological poison by the WHO's International Agency for Research on Cancer in 2013. In addition, exposure to air pollution increases both the short-term and long-term risks of respiratory and cardiovascular diseases [15]. It is responsible for all short, medium and long-term effects on anthropoid well-being [16]. The irritation of the eyes, throat, and nose as well as numerous breathing conditions including pneumonia and bronchitis are among the short-term impacts of air pollution. Lung cancer, heart problems, chronic respiratory conditions, and even damage the brain, liver, kidneys, or nerves are among the long standing repercussions of air contamination. Children, the elderly, and expectant women are more susceptible to have wellbeing issues related to airborne pollution. Despite the fact that gaseous air pollutants like NO_2 and SO_2 are a subject of growing concern for human health, it was shown that particulate matter was a more significant source of morbidity and death associated to air contaminant-related than gaseous air pollutants [14].

2.3 International Response and initiatives

United Nations Economic Commission for Europe (UNECE) implements the European Monitoring and Evaluation Programme (EMEP), an initiative that combines science and policy to address transboundary air quality issues. These programmes have begun to examine the connections between the two sectors and develop strategies for further lowering air pollution. The amount of air pollution in Europe has decreased because of this initiative. Under the patronages of the United Nations Framework Convention on Climate Change (UNFCC), representatives from more than 180 countries had assembled to discuss worldwide weather change mitigation measures. Similarly, under the partnership of Global Atmosphere Watch (GAW) (a programme of World Meteorological Organisation) System of Air Quality and Weather Forecasting and Research (SAFAR) was launched in India to get location specific data on air quality. Although there are several initiatives being made at the international level to address both policy areas, simultaneously, there is a lack of thorough and systematic studies that will capture these topics collectively and aid in developing a united approach.

3 Urban green spaces (Green Infrastructure)

Urban green spaces are open areas in cities that have a significant amount of vegetation and unpaved areas [17]. It includes parks, gardens, squares, cemeteries, allotment gardens and woodlands. The most widespread urban green infrastructure is considered to be urban forests which play an integral part in determining health of humans and environment. It lowers regional pollution by lowering particulate matter and moderate climate extremes. Because green infrastructure clearly emphasises socio-cultural, economic, and ecological benefits, it is a practical, robust, and sustainable method. They serve as the "cities' lungs" and "carbon stock reservoirs" as they can lower the amount of CO2 in the atmosphere [18]. The UNFCCC has acknowledged the value of plantation forestry as a strategy for reducing greenhouse gas emissions as well as the necessity of monitoring, protecting, and enhancing terrestrial carbon stores [19]. UGS provide a multitude of aids known as ecosystem services. The contribution that ecosystem services make to the welfare of people and other species allows us to identify them.

3.1 Ecosystem Services

Both directly and indirectly, UGS have a favourable influence on public's and other organisms' well-being. The beneficiaries of these services that humans enjoy, consume, or use, ecosystem services are characterised by their contribution to the welfare of humanity. There are multiple benefits gained from Urban Green Spaces is shown in Table 1.

Table 1: Ecosystem Services

Environmenta l Benefits	Ecological Benefits
	Pollution Control
Economic and Aesthetic Benefits	Energy Savings
	Property Value
Social and Psychological benefits	Recreation and well-being
	Human Health

3.2 Need for Green Cover as a Response to Air Pollution

Urban greenspaces offer a potential means of reducing ambient air pollution. They have a capacity to naturally filter air pollutants such as PM, NO_2 and SO_2. Two mechanisms exist for vegetation to reduce the concentration of air pollutants: stomatal absorption and deposition on plant surfaces, such as leaves and bark [20]. The degree of removal depends on air movement, transfer through boundary layer and capacity of surfaces to absorb. Different studies have found that the pollution levels are low in areas having higher concentrations of green spaces. There are different characteristics that impact the amount of effec vegetation has on mitigating air pollution. The primary physical properties of vegetation are the height and thickness of vegetation barriers. Since these physical design features have an impact on the quantity of pollutants carried, higher and thicker vegetation barriers offer greater reductions in pollutants concentration. Compared to other vegetation species, some have a greater capacity to improve the characteristic of the air. To ensure the goal of planting trees is achieved, various considerations should be made when choosing the species for this purpose [21]. Cone-bearing trees are more vulnerable to air pollution than trees with deciduous leaves, although they have a greater capacity for filtering. Trees that are deciduous are better at absorbing gases. Hence, the ideal alternative appears to be a mixture of species [22].

A study done by David Suzuki Foundation states that greenspace density and leaf types were the most significant factors influencing the link between greenspace and air quality [23]. More the leaf area, greater will be the reduction of air pollution. Study also suggests that larger trees are more effective than smaller trees at purifying the air. Larger leaf surface area trees, including conifers, have higher PM 2.5 removal effectiveness [24]. Since, purification of air is dependent on the leaf area, air filtration is higher in summer and spring because during these seasons' leaves stay on the trees [23]. The ability of plants to filter air is influenced by its location and structural characteristics. A park can filter out 85% of air pollution, and a roadway with trees may filter out up to 70% [25]. A diluter cover may allow the air to pass through and screen it while a thicker cover may simply stir up the air. The greening initiatives could be successful in reducing urban heat islands and enhancing air quality.

4 Study Area

According to the 2011 census, Ahmedabad, the largest city in Gujarat, had 5.6 million residents. It was founded in 1411 AD as a fortified town on the Sabarmati River's eastern bank. Hence, the city has excellent rail, road, and air connections to all of the major cities in the nation. It is India's seventh-largest city. The coordinates of the city are 21003'N and 72058'E. As a significant financial and industrial hub, the city also generates almost 60% of the overall productivity of the state (Action plan for control of air pollution in non-attainment city of Gujarat). On the eastern side of the city, there are several industrial sectors, the three biggest of which are Naroda, Vatva, and Odhav. Additionally, it has experienced exponential growth since becoming the commercial centre of the Gujarat state. The city's main commercial district is still located in the Old City, which is also on the eastern shore of the riverbank.

Ahmedabad is governed and administered by the Ahmedabad Municipal Corporation (AMC), and Ahmedabad Urban Development Authority (AUDA). In Ahmedabad city, six zones have been established by Municipal Corporation. In these zones, it concentrates on maintenance and operation. While, the design and regulation of these regions are handled by AUDA, which also identifies prospective growth areas for future development. The inclusion of greens in development plans has only been namesake and there were no city level or regional level open spaces in the city. Hence, in two decades, Ahmedabad's tree cover has decreased from 46% to 24%, and by 2030, it is predicted to reach 3% [26]. The lack of appropriate green space has contributed to increased pollution.

5 Methodology

The 4 urban forest sites selected inAhmedabad are adressed in Table 2 and marked in Fig 1, These are located in 4 different zones as per land use, highest size and

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proximity to monitoring station. The monitoring stations selected are located at highest 4km from the urban forests. Hence, the air quality data of these sites collected were compared between three years 2013, 2019 and 2023. Through this, the change in air quality can be analysed after the introduction of urban forests in 2019. Additionally, Normalized Difference Vegetation Index (NDVI) data was compared between the above three years to understand their correlation and the impact of urban forests in the area.

Table 2. Selected urban forests

Zone	Address	Area	Year of development
East	111, F.P. 156, besides Naxatra Bungalows	4700	2019-20
North	Oxygen Park, Besides South International School plot, Naroda	6170	2019-20
East	T.P. 45 F.P. 99 Opp. Girivar Bungalows	3500	2019-20
North- west	Oxygen Park, T.P. 41 Gota, F.P. 161 Nr. Ugati Lake, Science City Road	10828	2019-20

From urban forests, quantity of tree cover and tree species were identified to understand the air purifying power of a particular urban forest. This paper is able to cover only the aspect of vegetation for analysing pollution mitigation.

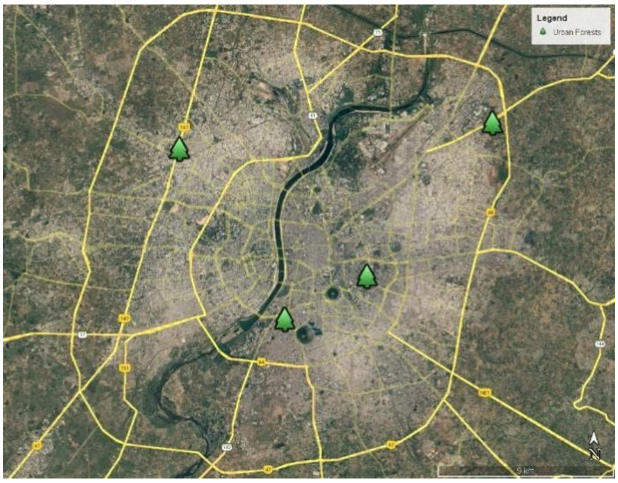

Figure 1: Selected urban forests from different zones of Ahmedabad

6 Air Quality in Ahmedabad

Ahmedabad has the maximum concentration of air pollution in Gujarat, according to the Gujarat Ecology Commission's report, "State of Environment Reports of Gujarat - 2012." The identical account states that from 2006 to 2010, Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM) concentrations at all monitoring facilities situated in residential regions were at excessive and grave contamination degrees, while SPM and RSPM concentrations at monitoring stations located in manufacturing regions were at medium to severe levels of pollution in accordance with the Central Pollution Control Board standard, 2005. The city is made up of about 3000 manufacturing structures, including 855 chemical-based producers, 511 manufacturing facilities, and 380 textile businesses. Inefficient brick ovens and trash smouldering in the area, as well as the open transportation of building materials like sand, mud and emissions from brick kilns close by, all play a part in the air quality in the city. Due to their prevalence exceeding established national requirements, PM_{10} and $PM_{2.5}$ have been named as the primary air pollutants. Road dust re-suspension, car emissions, construction operations, burning of home fossil fuels, and open burning of wood are the main causes of this (Action plan for control of air pollution in non-attainment city of Gujarat).

A worrisome quantity of NO_2 has also been noted. The main cause being vehicle emissions. Higher NO_2 levels are brought about by the use of outdated automobiles and traffic congestion. It has been noted that Ahmedabad's wintertime air quality deteriorates significantly due to the condensation of fine particulate matter in the lower atmosphere.

6.1 Sources of Air Pollution in the city

The amount of domestic fuel consumed by local residents affects the city's overall emissions (Source Apportionment Study of Ahmedabad city). The consumption of liquefied petroleum gas (LPG), piped natural gas (PNG), Wood, Kerosene, and Coal in slum and non-slum areas has been highlighted as the source of emission for the domestic sector. In terms of CO and PM emissions, respectively, it has been found that emissions from coal and wood are fairly substantial. The city's construction & demolition industry is expanding. The city's estimated emission load, which includes emissions from both the construction of new buildings and additions and modifications, is 8.9 tonnes per day (26). Additionally, the city's estimated road emission load is relatively high, and it appears to be a significant contributor to the city's overall emissions. Estimates place the city's daily road dust emission load at 19 tonnes, inc\luding emissions from both major and small roads (Source: Apportionment Study of Ahmedabad city).

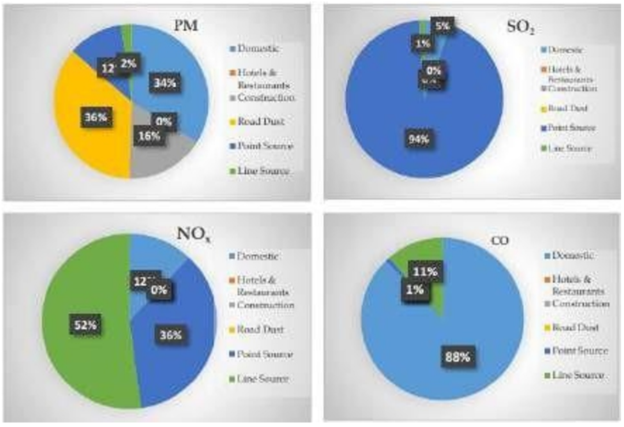

Figure 2: Sources of Air Pollutants (Source: Appointment Study of Ahmedabad City)

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Emissions from industries and crematorium is considered to be point source. For PM, SO_2, NO_2, and CO, the city's point source emissions total 6.2 tonnes per day, 50.6 tonnes per day, 12.48 tonnes per day, and 1.5 tonnes per day, respectively. The recipients are at a higher risk for health problems since the areas are close to or occasionally inside the boundaries of an industrial region that includes crematoria (Source: Apportionment Study of Ahmedabad city). In the city region, vehicular emissions are a substantial cause of air pollution. Even while individual vehicle emissions are often low, their consequences are nonetheless substantial for two key reasons. First, the city has a sizable population, which increases the number of automobiles on the motorway and subsequently increases emissions. Second, vehicle emissions are discharged close to the ground, increasing their influence on the populace in contrast to numerous residential and industrial pollutants. Vehicles are therefore important contributors of carbon monoxide (CO), nitrogen oxides (NO_2), hydrocarbons (HC), and particulate matter (PM) (Source: Apportionment Study of Ahmedabad city). Overall, road dust is reported to be the city's main contributor, followed by domestic, industrial, and building & demolition activities too. The Fig 2 shows the percentage contributions from each source to the four major pollutants.

7 Data Collection

7.1 Monitoring Stations

In Ahmedabad, there are more than 20 monitoring stations that are run and controlled by various organisations. 15 of the locations are run by the Gujarat Environmental Management Institute, 6 by the AMC, 1 by Torrent Power, and numerous more by the Gujarat Pollution Control Board (GPCB). In cooperation with the AMC, IITM, Pune is setting up 8 new ambient air quality monitoring stations for the brand-new System of Air Quality and Weather Forecasting and Research (SAFAR) Air Quality Index (AQI) system in Ahmedabad. (Protecting health from increasing air pollution in Ahmedabad, 2017) The local meteorological department provides the Central Pollution Control Board (CPCB) with ambient air and meteorological data for compilation and reporting. Additionally, the GPCB gathers data on ambient air contamination from all posts once a week for twelve hours, using that information to determine annual averages for air pollution levels. For all the stations in Ahmedabad under the National Air Quality Monitoring Programme (NAQM) and the State Air Quality Monitoring Programme (SAQM), these results are posted on the GPCB website.

Out of these monitoring stations, 4 were selected from 4 zones of Ahmedabad. For the analysis, secondary data was collected from GPCB website. The pollutant concentrations of PM10, PM2.5, NO2 and SO2 were measured from 2016-2021. Fig 3 shows the locations of the four Air Monitoring Stations surrounding the selected urban forests.

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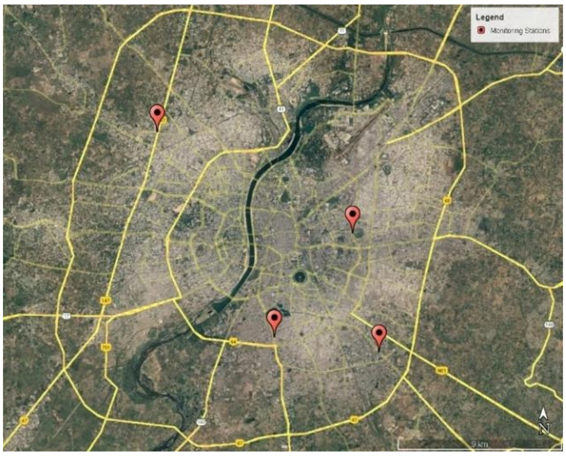

Figure 3: Air Monitoring Stations surrounding the selected urban forests

7.2 Urban Forests

Ahmedabad has much less green and open space per person than the WHO and URDPFI guidelines, which are 9 m^2 and 10-12 m^2 per person, respectively. Ahmedabad has lone 1.52 m2 of green and open space per individual (26). If open areas are not included and just green spaces are taken into account, this figure drops dramatically to just 0.78 m^2 per person [27]. The research indicates that Ahmedabad does poorly when compared to other Indian cities and is significantly below the per capita green space norms for global cities. Additionally, there are only 2.5% of the city's geographic area that act as green and open space. The city should have 14%–16% of its land designated for green and open areas, according to URDPFI norms.

To improve the scenario of greens in the city, 22 lakh trees are being planted by Ahmedabad's two municipal agencies. AMC is planting 21 lakh trees for ₹ 20 crores. 21 urban forests will be created throughout the city using these trees as the foundation. While AUDA is spending 16 crores to plant 1 lakh trees. Due to the fact that AUDA hired private companies to handle the plantation work, which included the installation of tree guards and two-year maintenance, its costs for planting 1 lakh trees might be up to 20 times more than those of AMC. At a cost of Rs 10 crore, 25,000 trees will be planted beside a 75-km section of the SP Ring Road and service roads, and 75,000 trees will be planted in 75 villages that fall under AUDA's purview. The selected urban forests are in 4 sq.km distance from air monitoring stations as per United States Environmental Protection Agency (USEPA) guidelines [28].

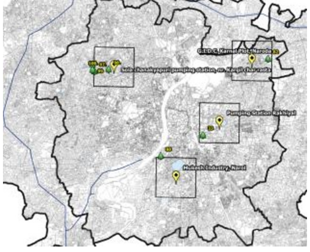

Figure 4: Air Monitoring Stations Buffer

8 Analysis and result discussion

8.1 Urban Forests

The air pollutant data is collected by monitoring stations across the city. The pollutant concentration of $PM_{2.5}$, PM_{10}, SO_2 and NO_2 for 4 sites are considered across 5 years: 2016-2017, 2017-2018, 2018-2019, 2019-2020 and 2021-2022. To understand the influence of urban forests on air quality, the contaminant intensity scenario was considered for before and after urban forests. The pollutant data is shown in the Table 3.

Table 3. Pollutant concentration of study area

		Naroda GIDC	Shardaben Hospital	Sola L.T. Chanakyapuri	Mukesh Industries Narol
2016-17	PM_{10}	114	112	112	114
	$PM_{2.5}$	36	36	35	36
	SO_2	13	12.8	12	14.7
	NO_2	28.4	28	27.5	33.3
2017-18	PM_{10}	156	154	159	155
	$PM_{2.5}$	50	50	51	50
	SO_2	14.6	13.9	14	16.2
	NO_2	27.3	28.3	29.2	31.1
2018-19	PM_{10}	220	219	248	257
	$PM_{2.5}$	69	67	77	79
	SO_2	17.9	17.3	18.9	19.6
	NO_2	28.6	28.8	27.6	33.8
2019-20	PM_{10}	110	103	108	123
	$PM_{2.5}$	28	25	27	30
	SO_2	18	19.1	19.9	19.2
	NO_2	21.9	22.2	23.5	23.6
2021-22	PM_{10}	118	119	123	133
	$PM_{2.5}$	26	26	27	31
	SO_2	13.4	13.6	13.6	15
	NO_2	17.3	17.6	17.4	19.5

From the table, the change in pollutant concentration can be observed throughout the years. The fine particulate matter ($PM_{2.5}$) levels can be seen rising in 2017-2018 and 2018-2019 before observing a drop in 2019-20. In 2019-20 the urban forests were introduced and COVID- 19 pandemic hit. After that, the $PM_{2.5}$ levels rose but were still in the lower spectrum. Similar trend can be observed in PM_{10} and NO_2. But for SO_2, the trend saw a rise till 2019-20 and then saw a drop in 2021-22.

Mukesh industries have observed highest pollutant concentration in all the years except for 2017-18. In this year, monitoring station at Sola L.T. Chanakyapuri overtook having high level of PM_{10} and $PM_{2.5}$ because of excessive vehicular traffic observed. When COVID hit, Sola monitoring station observed a drop due to reduced vehicular movement, but in the next year PM_{10} and $PM_{2.5}$ again saw a rise.

8.2 Air Quality Index (AQI) Comparison

The day-to-day air quality is recounted using the AQI. It notifies the cleanliness and contamination levels of air as well as any possible health hazards (National Weather Service, n.d.). Pollutant concentration rises together with a decline in air quality.

The CPCB states that the AQI scales from 0 to 500, with 0 denoting suitable air quality and 500 denoting critical air quality. Information for a least of three contaminants, one of which should be one or the other PM_{10} or $PM_{2.5}$, must be present in order to calculate AQI. Each pollutant has a different concentration in the AQI, which ranges from 0 to 500, and this has an impact on health.
Following is the equation to compute AQI:

$Ip = [IHi - ILo / BPHi - BPLo] (Cp - BPLo) + ILo$ (Oh, et al., 2012)

Where,
Ip = index of pollutant p
Cp = truncated concentration of pollutant p
$BPHi$ = concentration breakpoint i.e., greater than or equal to Cp
$BPLo$ = concentration breakpoint i.e., less than or equal to Cp
IHi = AQI value corresponding to
$BPHi$ ILo = AQI value corresponding to $BPLo$

Using the formula, Table 4 shows the values obtained for 5 years in 4 sites. The rise in AQI can be witnessed for the years 2017 and 2018. This can be attributed to the rise in construction activity and road widening happening around the city during that time period. Following 2018, the AQI is observed to have reduced by a huge percentage with the arrival of COVID-19 for 2 years. Additionally, urban forests surrounding these monitoring stations were introduced in 2019-2020. Hence when compared after COVID in 2021, the AQI showed a marginal decrease. The AQI value when compared to the pre-COVID years was less and overall showed a reducing trend as shown in the Fig 5.

Table 4. AQI value of 4 sites

	2016	2017	2018	2019	2020	2021
Naroda GIDC	109	137 (20%)	180 (24%)	107 (-68%)	107	112 (4%)
Shardaben Hospital	109	139 (22%)	173 (20%)	105 (-65%)	96 (-9%)	112 (14%)
Sola L.T. Chankyapuri	108	139 (22%)	199 (30%)	105 (-90%)	103 (-2%)	115 (10%)
Mukesh Industries, Narol	109	137 (20%)	207 (34%)	115 (-80%)	137 (16%)	122 (-12%)

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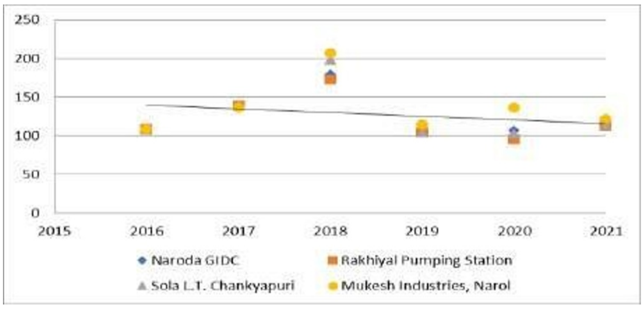

Figure 5: Trend of AQI

8.3 Vegetation Analysis

The size of the selected urban forests varied in different zones as seen in Table 3. Hence, the number of trees and tree species also differed in these sites. This causes differences in absorption of pollutant concentration.

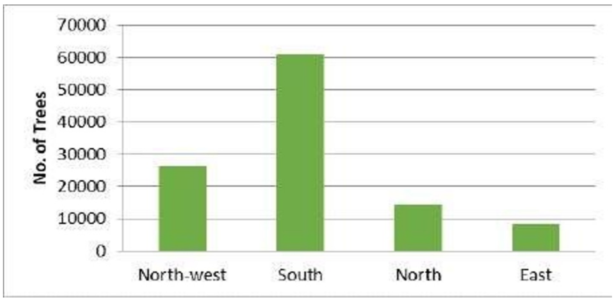

Figure 6: Number of trees in Urban Forests

To study the influence of vegetation composition on AQI, vegetation data was collected from all 4 sites. These four sites were then compared on the basis of total number of trees and tree species in urban forests. It was further compared to AQI of the year 2021. Area having high species variation and high number of trees would be able to purify air faster. Other factors also determine the value of AQI. In this instance, by comparing the number of trees and no. of species, it was determined that South has highest number of trees and second highest species variation. But the AQI recorded is also highest. This is attributed due to the high number of industries and Pirana dump present. Fig 7 exhibits the number of tree species in urban forest.

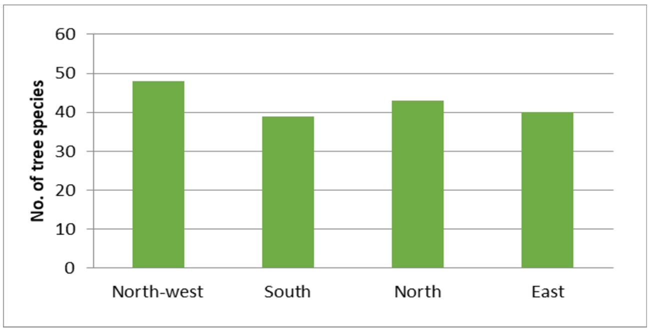

Figure 7: Noumber of tree species in urban forest

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9 NDVI Analysis

The Normalized Difference Vegetation Index (NDVI) is one approach for assessing the vegetation index of a certain location. Water, barren rock (including sand or snow), shrubs and grasslands, thick flora, or tropical rainforest are all described by index values between -1 and +1 (The range from 1 to 0.1 represents water, 0.1 to 0.2 represents Barren Rock, sand, and snow, 0.2 to 0.5 represents shrubs and grasslands, and 0.5 to 1 represents thick vegetation and tropical rainforest) (26).
The NDVI analysis and the collected data from Ahmedabad demonstrate the biased approach to development. The trend shows a decreasing trend of vegetation cover from 2015-2023, in Fig 8a, 8b, 8c, 8d. Although initiatives for greening of Ahmedabad have been introduced, on field it is yet not visible. As a result of urbanisation and industrialization, the city's green plant cover has been declining. The direct result of the shrinking vegetation demonstrates the city's rising pollution levels.

In the case of Ahmedabad, other air pollution-related factors are also noticable. A surge in the quantity of private automobiles, indiscriminate solid waste disposal and burning, and the emission of manufacturing waste into the air are some of the factors that contribute to rising air pollution. Such activities have an impact on air quality.

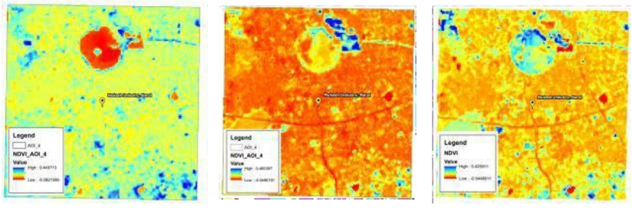

Figure 8a: GIDC Plot, Naroda (North Zone)

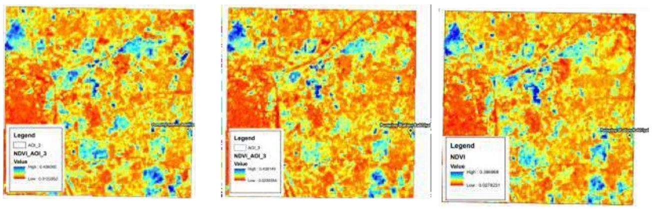

Figure 8b: Mukesh Industries (East)

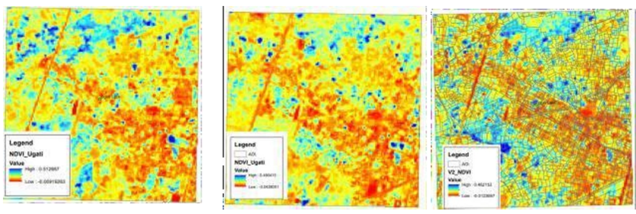

Figure 8c: Pumping Station Rakhiyal (East)

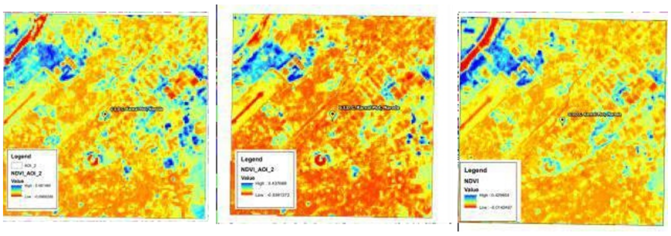

Figure 8d: Sola L.T. Chanakyapuri (North-West)
Figure 8a, 8b, 8c, 8d: NDVI images of the sites

10 Conclusion

The findings of the study strongly support the need for and suggestion for air quality improvement. The diagrams and records analyses demonstrate the degraded conservational condition and ecological disruption. This can be seen notably in the NDVI maps. It expresses how the environment has changed as a result of human involvement.

More significantly, the reduction in the amount of greenery has guided to a surge in the amount of air pollutants. Deforestation is already a problem, and the growth plan may not have taken any proactive measures to preserve and safeguard Ahmedabad's ecosystem.

When considering the state of Ahmedabad's air quality, the city needs to implement more environmentally friendly activities. To improve the overall environmental quality, enhanced green must take the lead. Thus, for reaching a suitable level of AQI, dense plant cover in the way of an urban forest and a quality choice of tree species that contribute to the supply of clean air would be one of the best alternative solutions. To effectively address this issue, it is necessary to firmly support the quest for high-quality greenery.

As mentioned in section 6.1, domestic fuel consumption is a major reason behind PM and CO pollution, mitigation measures to reduce the burning of biomass should be promoted. This can be done by ensuring natural gas reaches all residences. Older vehicles are also a major contributor to Particulate emissions. Hence, the renewal of these type of vehicles should be incentivised.

While there are multiple factors attributed to analysing AQI, the paper is not able to cover every aspect. With consideration of all the factors, the analysis can be improved.

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