Report on Proposed plantation scheme in and around Agra City

Central Pollution Control Board, Delhi, on the basis of values of Particulate Matter (PM10- Particle Matter Size less than 10 micron) in ambient air has identified 15 cities of Uttar Pradesh as Non-attainment cities. Agra is one of the fifteen non attainment city. U P Pollution Control Board prepared draft action plans for 15 non- attainment cities of Uttar Pradesh. The Action Plans comprises of 06 Major categories as given below:- a. Vehicle Emission Control

b. Suspension of Road Dust and Fugitive Emission Control

c. Control of Emissions form Biomass/ Crop residue/ Garbage/ Municipal Solid Waste burning

d. Control of Industrial Emissions

e. Control of Air Pollution from constructions and demolition activities.

f. Other Steps to Control Air Pollution.

The Action Plans comprises of 58 Short and long term Action Points. The short term (immediate) activities which don't need advance preparedness and are to be implemented by concerned department/ agencies immediately and the long term action points require preparedness including making of DPRs, Sanctions, Budget allocation and implementation. Two main action points of this plan to mitigate pollution are to prepare plan for creation of green buffers along the traffic corridors and Plantation of specific types of species of plants which are helpful in pollution control and Tree Plantation for mitigation of air pollution based upon location of pollution sources and Wind rose data.

ABOUT THE CITY:

Agra - has been immortalized as the City of the Taj. Taj Mahal is the universally admired masterpiece of the world's heritage. No other historical monument has evoked as much admiration from tourists, as the magnificent Taj. The city of Agra is built along the banks of the Yamuna, one of the premier rivers in the nation. The city is located at an average altitude of 561 feet above the sea level. Agra is surrounded by the city of Mathura on the North, to the South of Agra is Dhaulpur. Firozabad is located on the eastern side of the city of Agra and Fatehabad lies on the south-eastern side of Agra city. To the west of Agra lies Bharatpur.

The city of Agra forms a part of the great northern plains. On the basis of landmass, Agra is the third largest city in the state of Uttar Pradesh. It covers the total area of 4041 Sq. km and the total population of

Agra city is 27,51,021. There is about 35379 Hectare of Forest cover in the District. Agra is geographically located at 27°12' North latitudes and 78°12' East longitudes. It has an extremely strategic location on the confluence of three distinct geo-physical regions namely the plain of Uttar Pradesh, the plateau of Madhya Pradesh and the desert of Rajasthan. The city also falls in the center of the four-culture areas- Braj, Bundelkhand, Rajputana and western U.P.

Fig 1: Agra city map

CLIMATE OF THE CITY:

The area falls under sub-humid climate and characteristics of vegetation is grassland. The annual normal Rainfall (1961-1990) of the district comes to 731.5 mm. The maximum rainfall occurs during the monsoon period i.e. July, August and September having the normal value of 575.2 mm which is 79.35% of annual rainfall. August is the wettest month having the normal rainfall of 243.2 mm which is 33.55% of annual rainfall. The hottest month is June with average mean temperature of 45.8^{0}C followed by May with 45.7^{0}C and the coldest month is January with average mean temperature of 3.9^{0}C followed by December with 4.7^{0}C. The highest % of humidity occurs in the month of August with normal relative humidity of 81% followed by 75% in July. The

normal annual mean wind speed of the district is 3.2 Kmph with highest average wind speed is 5.1 Kmph in the month of June followed by 4.7 Kmph in July. The annual average pressure lies between 998.3hPa to 976.8hPa in last 16th year.

(Reference Government of India, Ministry of Earth Sciences, India Meteorological Department, Meteorological Centre, Lucknow)

SOIL TYPE:

The soil of Agra is loose, sandy and calcareous. The river Yamuna is the only river flowing through the metropolitan city of Agra. The river enters the city on its northern boundary and takes U-shape while crossing through the heart of the city. The area is characterized by alluvium, which is an admixture of gravel, sand, silt and clay in various proportions, deposited during the Quaternary period. The study area is a part of Indo-Gangetic alluvium of quaternary age and is made up of recent unconsolidated fluviatile formations comprising sand, silt, clay and grit (kankar) with occasional beds of gravel. There are some underground rocks of quartzite and sand stone of Vindhyan-series, in the west and south west of Agra. The topsoil is coarse and angular sand with small clay fraction. The sub-soil is sandy throughout. The stabilized topsoil is reddish brown with sand and clay mixed. Minimum depth of topsoil layer is 60 cm. Sand and silts are slightly alkaline to saline in nature. The topography of the area is flat. Saline soils are generally brown. Alkaline soils are grey and get sticky on wetting and hard on drying, acquiring a clotted structure.

EXISTING FOREST COVER:

Climate of Agra has a sub humid therefore nearby only medium dense and open forest with an area about 63 sq. km and 209 sq.km respectively. According to 2017 assessment the forest area of Agra and its nearby district are given bellow:

District Name	**Geographical Area**	**2017 Assessment**				**%GA**	**Change**	**Scrub**
		V. Dense Forest	**M. Dense Forest**	**Open Forest**	**Total**			
Agra	**4041**	**0**	**63**	**209**	**272**	**6.73**	**4**	**64**
Etah	2431	0	1	30	31	1.28	-3	0
Ferozabad	2407	0	5	44	49	2.04	0	24
Mathura	3340	0	4	56	60	1.8	5	3
Hathras	1840	0	1	22	23	1.25	-1	0
Bharatpur	5066	0	22	207	229	4.52	13	79

Only forest area found within the Agra city is **Taj Protected Forest** (27°10'35.13"N 78° 3'25.08"E) near Forest Colony towards the East direction (the present downwind direction of the prominent wind direction) which needs to be maintained as it will act as sink for the

pollutants being carried away with the wind. Similarly, **Soor Sarovar Bird Sanctuary** (27°14'48.72"N 77°50'44.80"E) is located towards North-west direction which is also the prominent Upwind direction of Wind and dense vegetation is also available in the areas near Atrauni (27°13'59.68"N 77°54'18.82"E) and Mohammadpur (27°13'38.60"N 77°55'50.85"E) towards North-west directions. There is an Industrial area (27°13'27.88"N 77°53'57.87"E) found between the earlier mentioned vegetated areas.

SENSITIVE AREAS OF THE CITY:

There are mainly two wetlands are located in Agra one is Keetham Lake in Agra-Mathura and another is in Bharatpur. Apart from these two wetlands there is one sensitive zone declared by Hon'ble Supreme Court of India known as **TAJ TRAPEZIUM ZONE**.

SUR SAROVAR: Sur Sarovar Bird Sanctuary is located just 3 km away from the Agra city towards North-west direction, also known as Keetham Lake, was established in 1991 by the Uttar Pradesh Forest Department. It is home to more than 165 species of resident birds & migratory birds. The sanctuary also has the population of more than 300 of pythons. It is also one of the biggest bear rescue centre of India for dancing bear. It is a small, but important bird sanctuary of Uttar Pradesh. It comprises of fresh water wetland, popularly known as Keetham jheel.

Fig 2: Google Map showing location of Sur Sarovar Bird Sanctuary/Keetham Lake

KEOLADEO GHANA NATIONAL PARK IN BHARATPUR : It is an important international bio-sphere known for its large and varied avifauna, both local and migratory. It is situated at approximately 37 kms from the boundary of Agra city towards West direction. By building small dykes and dams and diverting water from an irrigation canal, converted this low lying area into a fine wild fowl shooting preserve. In a few years, the new wetland surrounded by marginal forests was able to support thousands of water-birds. Commonly referred to as Bharatpur, the Park is a delight for bird watchers. Over 300 species of birds are found in this small park of 28.73 sq. kms. of which 11 sq. kms. are marshes and the rest, scrubland and grassland. Here and raised paths, camouflaged by babul trees and undergrowth make viewing easy. Every year Bharatpur waits with bated breath for the arrival of the Siberian cranes.

Fig 3: Google Map showing location of Keoladeo National Park/Ghana Bird Sanctuary

TAJ TRAPEZIUM- The supreme court of India delivered a ruling in December 2008 which demarcated an area called the 'Taj Trapezium', a 10,400 square kilometers wide area around the Taj within which certain laws and regulations with the aim of controlling pollution had to be strictly followed such as: use of only LPG as fuel in houses instead of wood and biomass used traditionally by the majority, prioritized supply of unleaded petrol and low sulphur diesel to retail outlets throughout Agra, ban on the use of coal/coke by industries within the trapezium with a mandate to switch over to natural gas or else be relocated outside the trapezium.

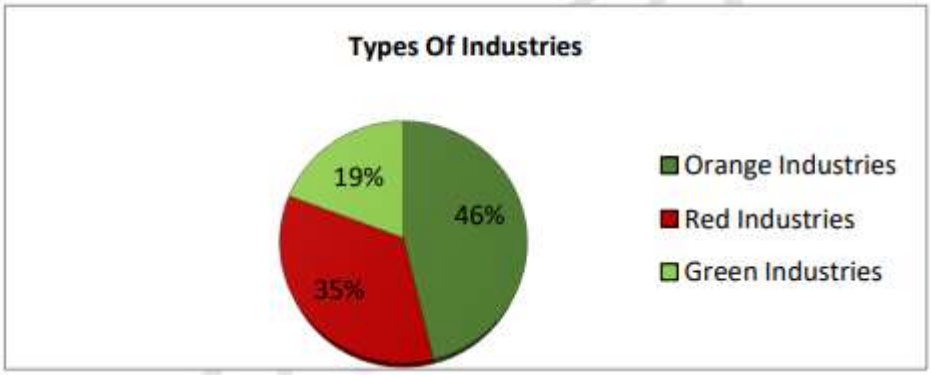
Taj Trapezium Zone (TTZ) is a trapezoid shaped, defined area of 10,400 sq km around the Taj Mahal. The Taj Trapezium which is in the form of trapezium bounded by Longitude 77°15'E on the West 78°30'E on the East and lines joining Latitude 27°45'N to Latitude 27° 30'N on the North and Latitude 26°45' to 27° 00'N. The TTZ constitutes 6 districts- Agra, Mathura, Hathras, Etah and Firozabad districts in Uttar Pradesh and Bharatpur district in Rajasthan.

Fig 4: Topo Map of TTZ

POLLUTION SOURCES:

The major contributors in the concentration of PM 10 are industries, vehicular emissions, road dust sweeping.

INDUSTRIES: In Agra about 553 industries in which 0.02% of large scale industries, 0.23% Medium scale, 0.29% Small scale and 93.96% of Household industries.



As per desk inventory of UPPCB, there are about 69 air polluting industries located in Agra including Cupola, induction furnace, chemical, rubber and engineering etc. In the 20 Km radial distance of Taj, the coal and coke burning is prohibited by district administration. There are about 180 glass-based industries manufacturing mainly glass bangles, glass beads, glass rods, glass tubes/shell, glass wares and glass blocks. DG sets are installed in almost all the glass industries in Firozabad District, which are mostly based on natural gas. Apart from the organized sectors of air pollution, there are a large number of small scale/ cottage/household activities which contribute towards air pollution.

The most prominent and major source of air pollution is **Mathura Oil Refinery** in Mathura city which is situated at approx. 24 kms in the North-west direction from the Agra city and also effects the air quality of Agra city. But, it has installed all required air pollution control system with adequate stack height as per norms. The stack emissions monitored have been found within the prescribed norms.

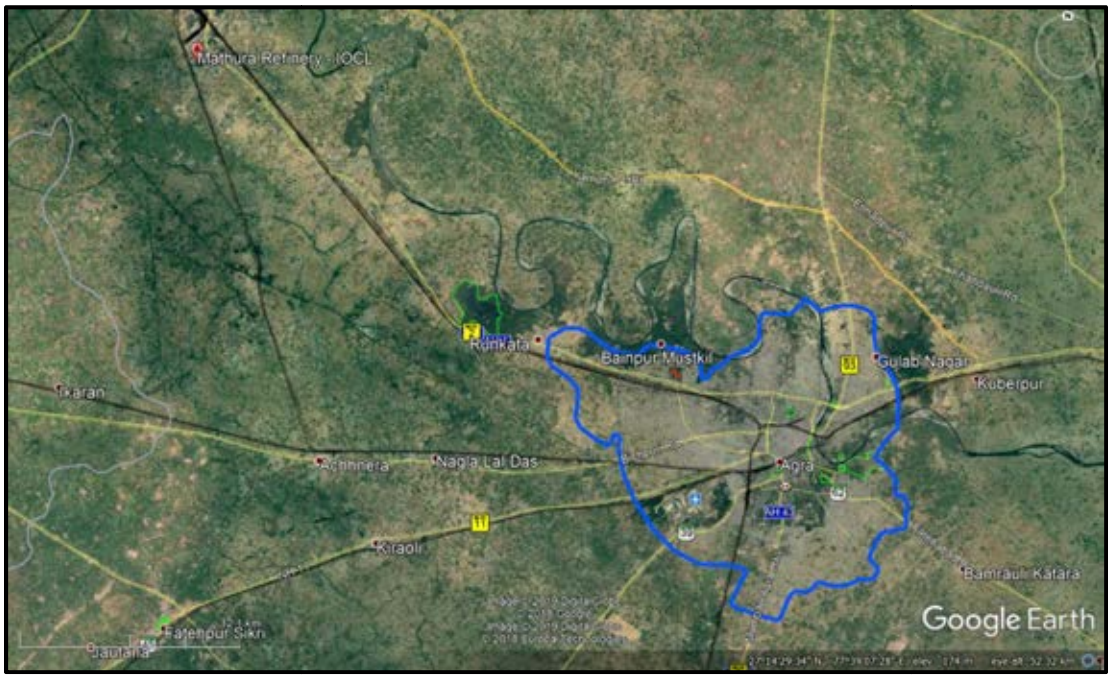


Fig 6: Map Showing Industrial Locations in TTZ

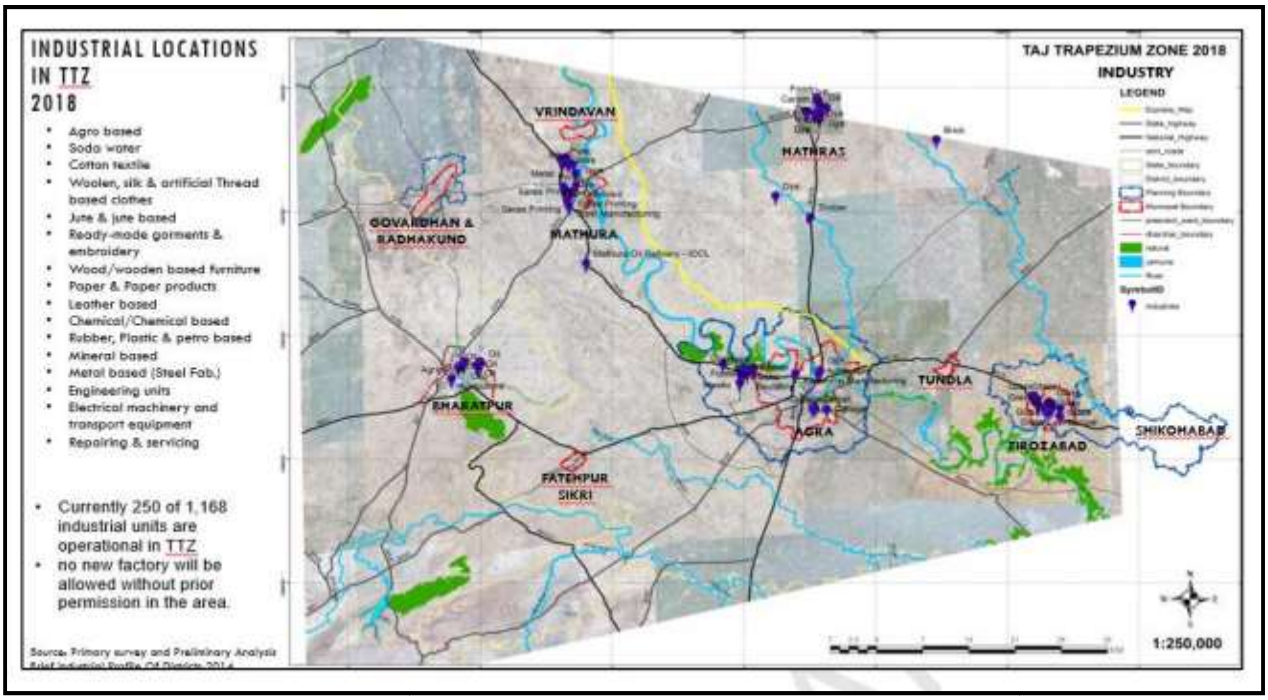


Fig 6: Map Showing Industrial Locations in TTZ

(Source: Brief Idustrial Profile of Uttar Pardesh 2014, Primary Survey 2018 and Preliminary Analysis)

OTHER SMALL SCALE SETUPS: As in Agra, besides Foundries, there are nearly 120 Petha (sweet item) manufacturing units, and also more than 2000 halwaiis, 500 kumhars and bharbhujas, which use coal, cow dung, wood and agro-wastes. Average wood consumption in each Petha unit is found to be 5 kg/day, whereas coal used is about 4 kg/hr. Thus, the total daily consumption of all the Petha units is estimated to be about 500 kgs of wood and 4.7 tons of coal. As mentioned in the minutes of meeting of TTZ Authority dated 06-06-2018, no petha unit is operational on coal based fuel and they all have adapted LPG as fuel to control air pollution.

VEHICLES: Other than industries, vehicular population is the major contributor to air pollution in Agra. Over the past five years i.e. during 2012-2017, vehicle registration has grown at a rate of 17%. During the same period, registration of four wheelers (4W) comprising of cars, vans, jeeps have increased at a rate of 31% and two-wheelers (2W) at a rate of 16%. The total number of registered vehicles in the year 2017 was 89986 which is at a rate of over 245 vehicles per day. It is also significant to note that non-transport vehicles (2W-scooter, moped, motorcycles and 4W-cars, vans, jeeps) contribute to the maximum share of registered vehicles i.e. 94.3% and the transport vehicles (heavy duty trucks, light commercial vehicles, buses-stage/contract carriages/ private, taxis, passenger autos) contribute a share of 5.7%. Further, eighty-one per cent of these registered non-transport vehicles are two wheelers and twelve percent are four-wheelers. CRRI carried out a study in 2002 in which the

floating number of vehicles which enter and leave the city was 72300 (81%), whereas 19% (16950) passed though the city.

As a result of this unmitigated increase in the non-transport / personalized vehicles, the city roads has been witnessing growing vehicular traffic and the physical infrastructure hasn't been able to keep pace with this growth in demand. This rapid motorization has led to severe congestion problems, longer journeys and higher per capita trips.

Being a tourist city, Agra attracts a large of intercity vehicular trips. Thus, the pollution loads due to these trips have been estimated separately. The traffic volume count at outer cordon points has been used for estimating these emissions.

The major terminals in the city are very chaotic. For example, the Raja ki Mandi station has various issues like on-street parking, encroachments by temporary vendors on both sides of the road, congested road conditions and others. Similar conditions were observed near ISBT where the boarding/ alighting of passengers was observed along the carriageway causing congestion. No designated spaces are earmarked for parking of autos and cars. These terminals are the points of major congestion and due to this problem contribute in the rising level of air pollutants.

DG SETS: The DG Sets are an essential component of industrial/commercial setups. DG sets are used as a source of standby power supply. Use of DG Sets, in whole TTZ area, especially in Agra is considered as a major source of air pollution. Irregular supply of electricity in the region forces the consumers to use DG sets for commercial as well as domestic purposes. DG sets are also deployed as alternative electricity source in many Health Care Facilities (HCFs), which include all types of hospitals, nursing homes, clinics, pathological labs etc. DG Sets are also installed in some commercial places such as banks and hotels. All these DG sets deployed in HCF and commercial sectors are used as standby, to be used in case of power break down/ power failure. All these DG Sets are operated on diesel, commercially available in the open market. But in compliance with the orders passed by Hon'ble Supreme Court, TTZ Authority monitors the uninterrupted power supply. The DG sets installed in Agra city along with Mathura and Firozabad are gas based and comply with the prescribed E(P) Rules and the DG sets in these districts installed in commercial and other places which use diesel as fuel also comply with the norms prescribed in E(P) Rules.

ROADS: Major roads including SH, NH and MDRs within the Agra that carry the most of the traffic of vehicles and become the major emission points of the gaseous air pollutants which are being emitted by vehicle exhausts. Those major emission points will be identified of the roads listed below and shall be selected for plantation. The conditions of the roads in the TTZ, in general, are either not adequate or not in proper condition,

thus movement of traffic on such roads leads to significant dust pollution. The list of major roads which pass through the city are given in the table below:

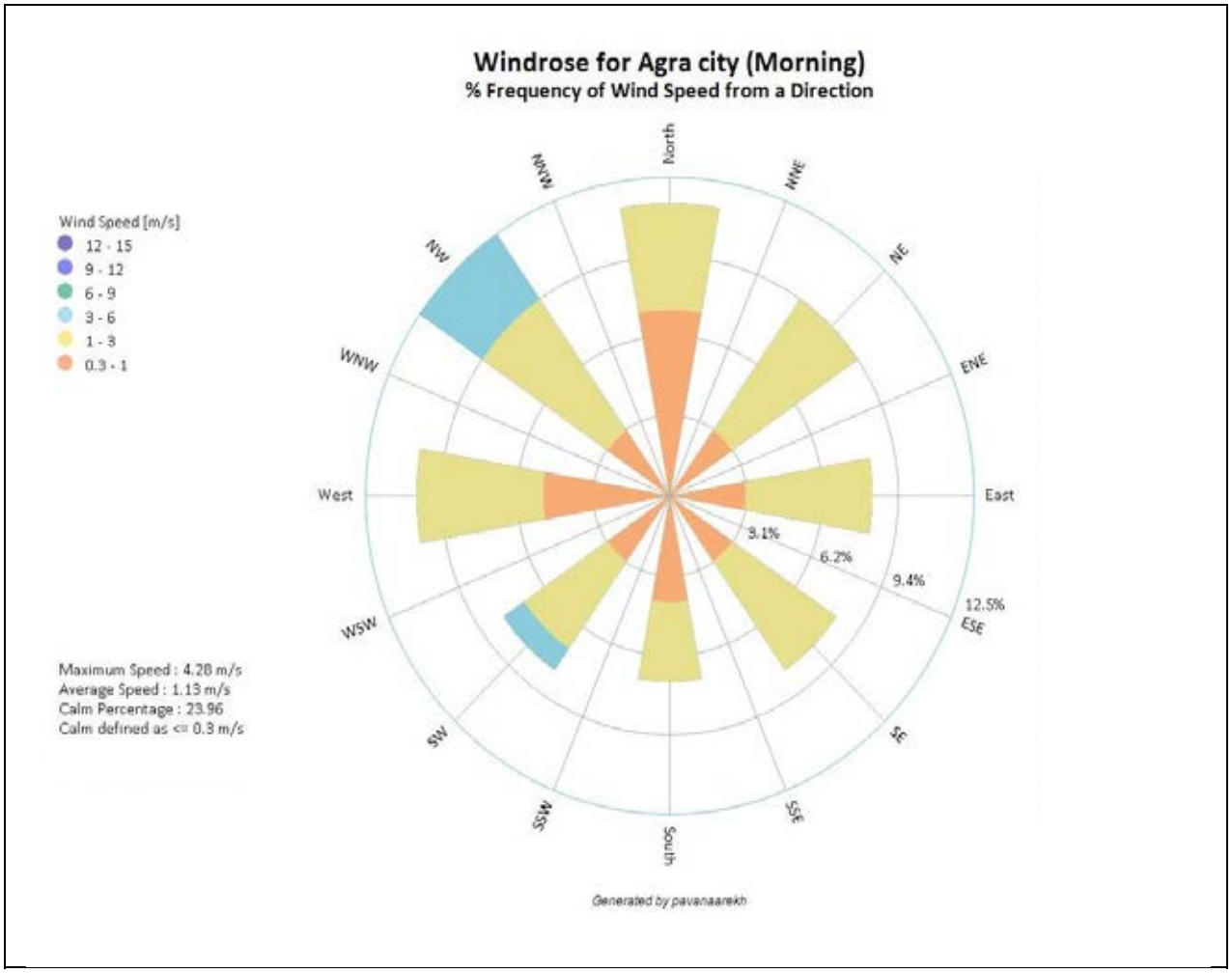
S.No.	District Name	Category Name	Sub Category Name	Name Of Road	Road Number	Length (in km.)
1	AGRA	Road	State Highway	CHANDAUSI DEWAI ALIGARH AGRA JAGENAR TATPUR MARG	SH0039	80.492
2	AGRA	Road	State Highway	AGRA WAAH KACHAURAGHAT MARG	SH0062	71.890
3	AGRA	Road	Major District Road	AGRA SHAMSHABAD RAJA KHEDA MARG	MD113W	26.222
4	AGRA	Road	Major District Road	SHIKOHABAD WAAH MARG	MD077W	8.200
5	AGRA	Road	Major District Road	KIRAWALI KAGAROL KHAIRAGARH SAIYA MARG	MD127W	36.091
6	AGRA	Road	Major District Road	SAIYA IRADATNAGAR SHAMSHABAD FATEHABAD MARG	MD130W	39.185
7	AGRA	Road	Major District Road	WAAH UDI MARG	MD138W	15.400
8	AGRA	Road	National Highway	DELHI KOLKATA ROAD	NH0002	43.9881
9	AGRA	Road	National Highway	AGRA ALIGARH MORADABAD ROAD	NH0093	12.500
10	AGRA	Road	National Highway	AGRA GWALIOR ROAD	NH0003	30.932
11	AGRA	Road	National Highway	AGRA JAIPUR BIKANER ROAD	NH0011	42.339

As per the CPCB's report, Agra is one of the Critically Polluted Industrial Cluster. The overall CEPI score (Comprehensive Environmental Pollution Index) for Agra is 76.58. To improve the decreasing air quality of Agra and TTZ cities a comprehensive plantation scheme should to be implemented to curb the increasing Air Pollution Index and various health hazards especially respiratory diseases in elderly and children. Plantation scheme of the city should be designed according to wind direction, wind speed, frequency which is the key factors in circulating the Particulate matter, dust particles and other pollutants.

WINDFLOW PATTERN- WINDROSE:

Windrose diagram showing wind blow patterns of Agra city on the basis of the average of last 16 years Meteorological data.

(Government of India, Ministry of Earth Sciences, India Meteorological Department, Meteorological Centre, Lucknow)



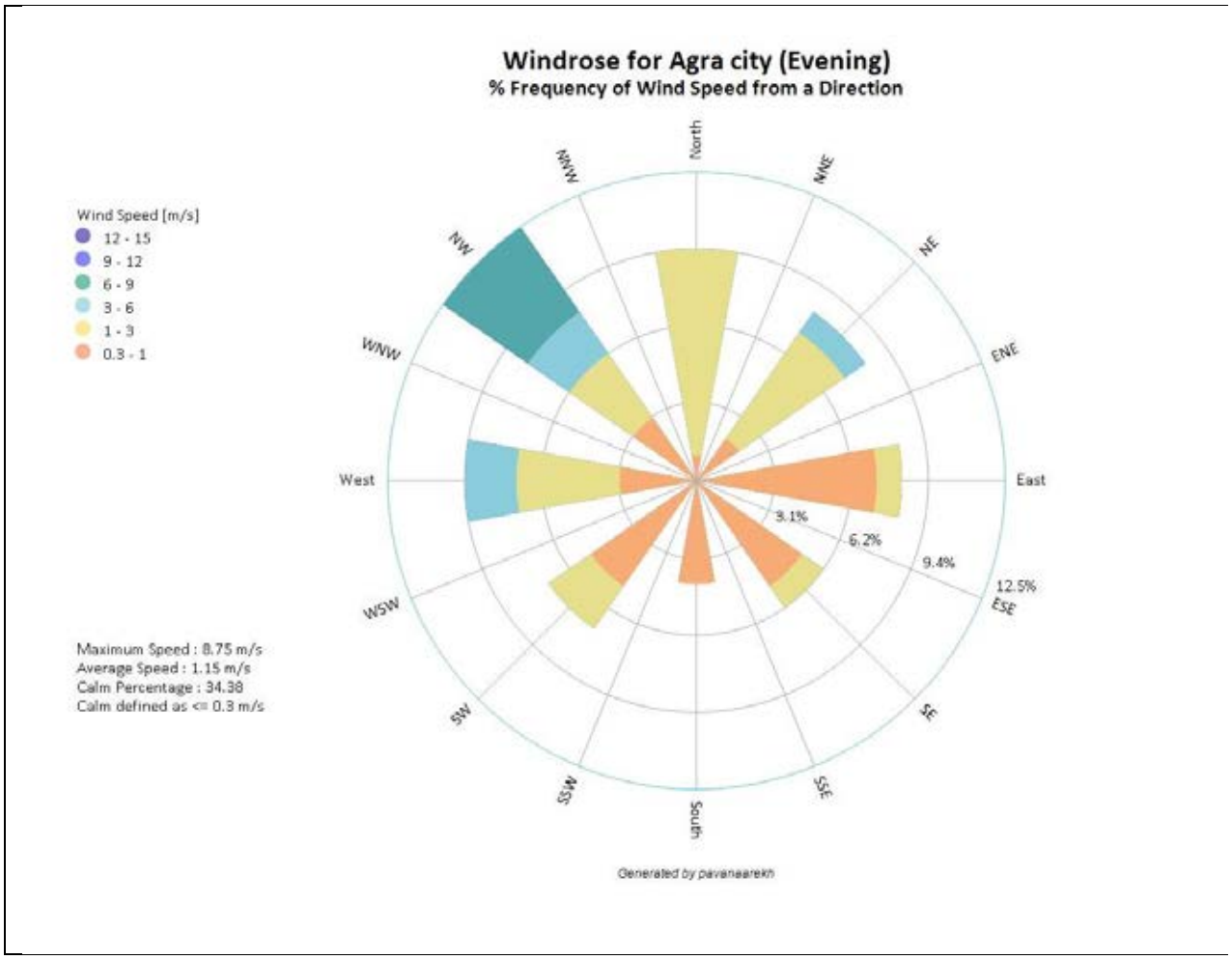
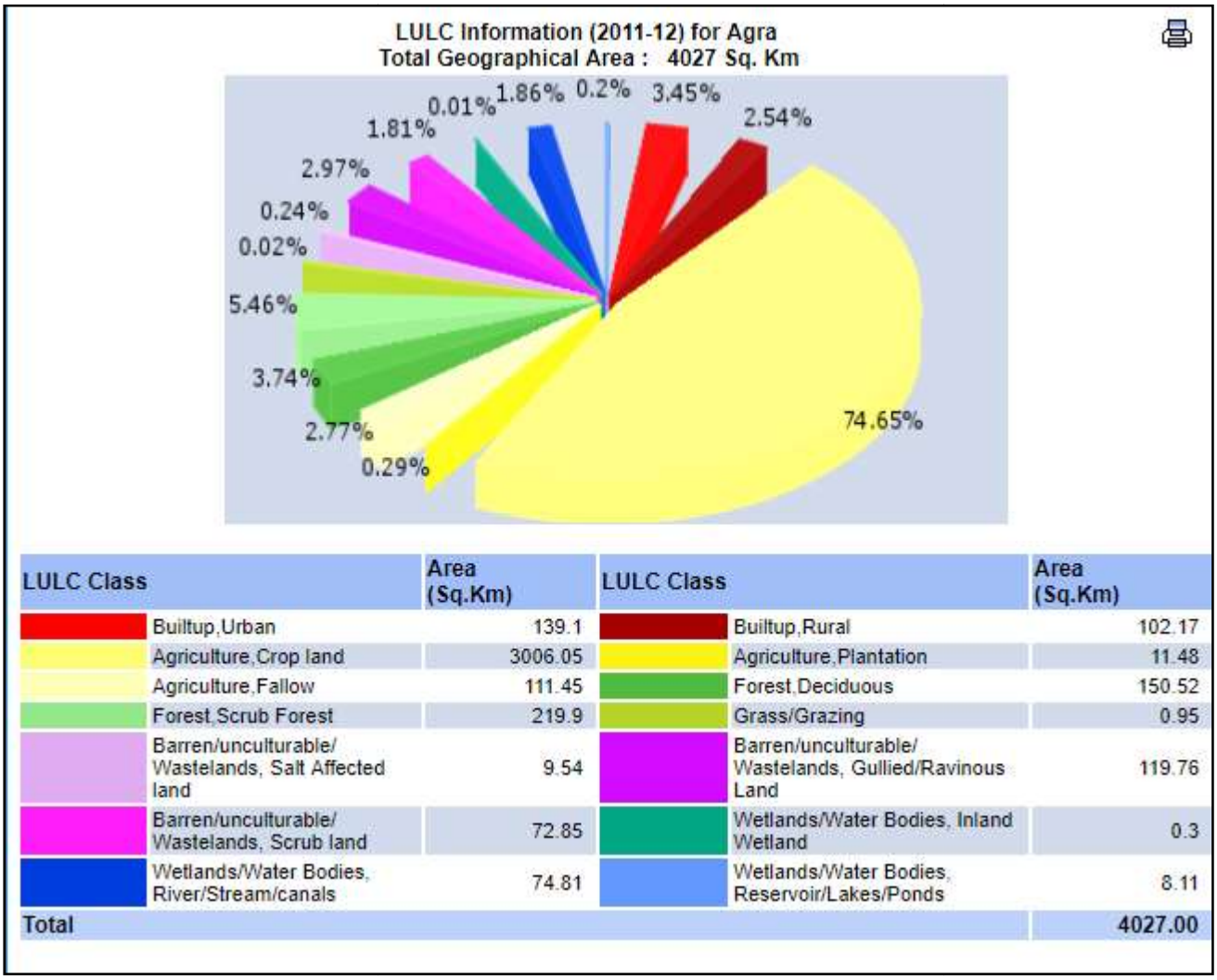


Fig 7. Shows yearly average wind blow pattern during Morning & Evening time

According to the windrose diagram plotted on the averaged data of wind's frequency in particular direction of 16 last years at two different hour *viz.* at 8:30 hours & 17:30 hours monitored in a day, the prominent wind direction from which wind blows during morning time is North-west direction as it has the maximum percentage of frequency of wind speed and next direction in line which has the maximum percentage of frequency is South-west direction. Hence, in last 16 years maximum time wind has blown from North-west direction that too with the most wind speed. Similarly during evening time, the same trend has been observed only with a slight variation that second direction which has the maximum percentage of frequency of wind speed is from West direction.

Based on the prominent wind directions from which wind blows in last 16 years which are North-west, West and South-west will be Upwind direction and the downwind direction of wind becomes South-East, East and North-East. So, these upwind and downwind directions shall be selected for carrying out Plantation.



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	139.1	Builtup,Rural	102.17
Agriculture,Crop land	3006.05	Agriculture,Plantation	11.48
Agriculture,Fallow	111.45	Forest,Deciduous	150.52
Forest,Scrub Forest	219.9	Grass/Grazing	0.95
Barren/unculturable/ Wastelands, Salt Affected land	9.54	Barren/unculturable/ Wastelands, Gullied/Ravinous Land	119.76
Barren/unculturable/ Wastelands, Scrub land	72.85	Wetlands/Water Bodies, Inland Wetland	0.3
Wetlands/Water Bodies, River/Stream/canals	74.81	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	8.11
Total			4027.00

Fig.8: LULC for Agra

Description of Land use/Land cover distribution of Agra

Category	Agriculture				Barren/uncultivable/ wastelands			Built up		Forest	Grass/ Grazing	Wetlands/water bodies		
	Crop Land	Current Shifting Cultivation	Fallow	Plantation	Gullied / Ravinous land	Salt affected land	Scrub land	Urban	Rural	Scrub Forest	Grass/ Grazing	Inland wetlands	River/ Streams/Canals	Water bodies
Area (in sq.km)	3006.05	--	111.45	11.48	119.76	9.54	72.85	139.10	102.17	219.90	0.95	0.30	74.81	8.11

(Source- https://bhuvan-app1.nrsc.gov.in/2dresources/thematic/LULC502/MAP/UP.pdf)

As per the district wise distribution of Land use/Land cover of Uttar Pradesh data(2011-2012) available in **Bhuvan- Indian Geo Platform of ISRO,** for **Agra** there is 3006.05 sq. km land as crop land out of total geographical area of the district and 111.45 sq.km land is Fallow Land and 11.48 sq.km is already under Plantation, which should be maintained. There is also 72.85 sq.km land left as Scrub land which comes under wasteland category. There is Forest land also available in the district as Scrub forest which is 219.90 sq.km out of total geographical area . Therefore, Barren/uncultivable/waste land available in the upwind and downwind directions of the wind shall be identified for developing green belt to curb the rising level of air pollutants in the city.

TREE PLANTATION STRATEGY:

Objectives of Tree Plantation Strategy

- ✓ Climatic amelioration
- ✓ Check in air & noise pollution
- ✓ Check in soil erosion and reduce water logging
- ✓ Moderating the effect of wind and incoming radiation
- ✓ Aesthetics, shade and ornamentation.

Actions which can be taken in account to curb the emission of dust and other particulate matter in the district:

- Proposal for speeding up the process of developing green belt around the Construction sites of townships and Buildings being constructed towards prominent downwind direction of wind as they have already obtained EC from SEAC/SEIAA and to also produce the 6-monthly Compliance report.
- Development of green belt around the existing brick kiln sites and other air polluting sources located within the city.
- Proposal for developing wind break between residential and industrial area.
- Other places which found suitable for proposing plantation- Forest colony and Gulab Nagar (Towards East direction) and Runakta and along NH 2 (towards West direction).
- Plantation of Trees on around Kuberpur Sanitary Landfill Site and identified Brick kilns may also be done.
- To identify the proposed developments plan for the city like URBAN AND RURAL PLANNING DEPARTMENT , UTTAR PRADESH has developed Master Plan- 2001-2021 for Agra City which is given below. This Master plan will help in identifying the available places for proposing plantation scheme as to avoid any contradiction in both the schemes.

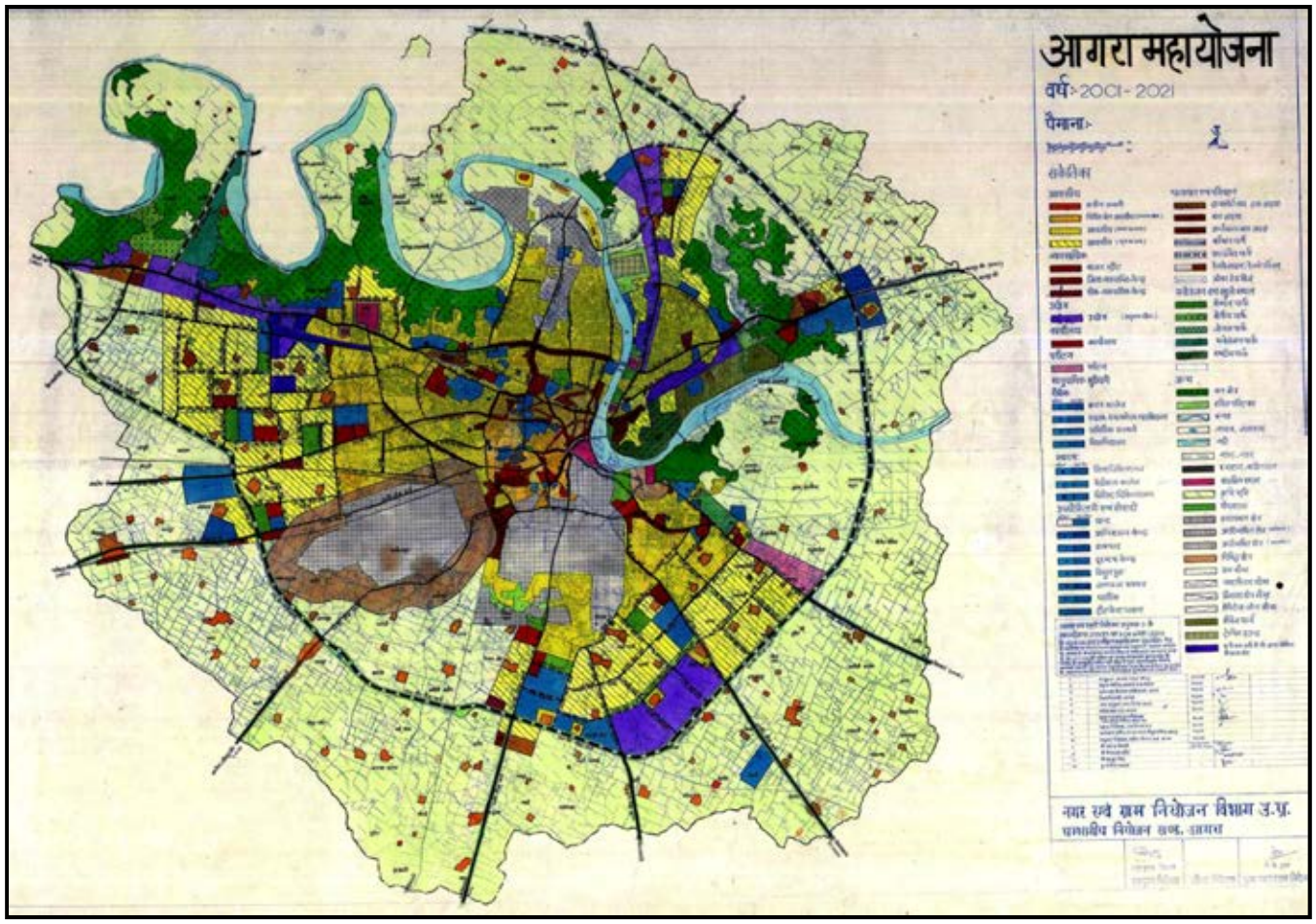


Fig.9: Master Plan for Agra city

Following sites have been identified on the basis prominent Upwind and downwind windflow pattern on which plantation is proposed to curb the rising level of PM 10 in the Taj city. In addition to these sites, following the direction prominent windflow pattern, sites will be identified within the city between the habitation to create small oxygen pockets which will also help in lowering the rising level of pollutants being emitted from the major congestion points of the city.

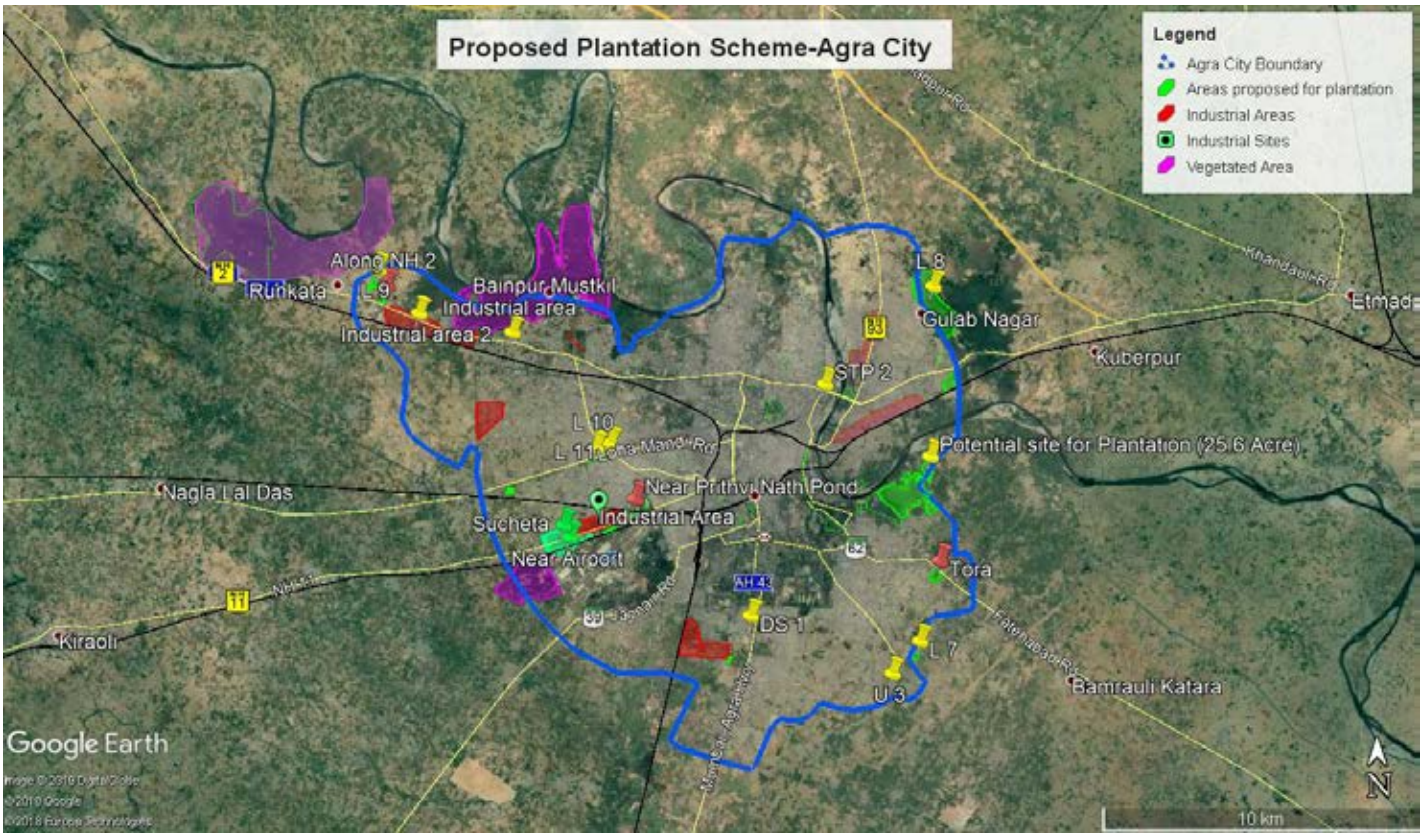


Fig.9: Satellite imagery showing Polluting sources and Proposed Plantation on Potential sites located on the outskirts and within the Agra City

Sites identified for proposing Plantation towards Upwind and Downwind directions

TOWARDS UPWIND DIRECTION North-west, West and South-west				**TOWARDS DOWNWIND DIRECTION** South-East, East and North-East			
SR. NOS.	**IDENTIFIED SITE**	**COORDINATES**	**AREA (IN Hectares)**	**SR. NOS.**	**IDENTIFIED SITE**	**COORDINATES**	**AREA (IN Hectares)**
1.	Near G.D. Goenka	27°10'41.78"N 77°55'44.37"E	5.42	1.	Gulab Nagar, Vidhya Nagar	27°13'54.88"N 78° 3'50.16"E	145
2.	Near Airport	27° 9'38.49"N 77°56'51.50"E	8.80	2.	Sahadra	27°12'30.21"N 78° 4'13.21"E	20.6
3.	Sucheta	27° 9'50.81"N 77°56'44.31"E	53.7	3.	Forest Colony	27°11'0.70"N 78° 3'46.68"E	133

4.	Near Prithvi Nath Pond	27°10'17.82"N 77°58'7.24"E	2.73+4.41	4.	Tora	27° 9'14.11"N 78° 3'57.65"E	10.6
5.	Deoretha 100 Ft Bypass Road	27°11'10.51"N 77°57'21.47"E	0.72	5.	Bagda	27° 7'51.82"N 78° 3'34.50"E	3.39
6.	Bichpuri Road	27°11'14.70"N 77°57'38.01"E	0.55	6	Mehtab Bagh	27°10'47.54"N 78° 2'41.25"E	5.18
7.	Runakta	27°14'12.76"N 77°53'10.59"E	8.92	7	Sri Nikunj Colony	27° 8'1.84"N 78° 2'58.20"E	6.19
8.	Along NH 2	27°13'56.47"N 77°53'19.72"E	3.30	8	Mohanpura	27°10'14.52"N 78° 0'26.40"E	0.76
9.	Hastinapuri	27° 8'9.67"N 78° 0'16.73"E	27.7				
10	Pushpa Vihar Colony	27°12'14.37"N 77°59'15.47"E	3.0				
11.	Kunwar Colony	27°12'32.41"N 77°59'41.07"E	6.39				
12.	Lawyer's colony	27°12'53.60"N 77°59'31.49"E	3.29				
13	Jagdish Pura	27°11'35.51"N 77°58'35.52"E	1.51				

As per the locations identified towards the prominent upwind and downwind directions given above in the table, total area proposed for plantation and maintenance of the vegetation towards upwind directions- North-west, West and South-west directions is approximately 123.3 ha similarly towards downwind directions- South-East, East and North-East directions is approximately 324.72 ha.

Existing Status of Industrial Areas in the District Agra

There are 6 industrial areas identified by UPSIDC/DIC Agra, within those industrial areas vacant plots are available which could be used for development of Green Belt. Though there are 69 operational Air Polluting Industries and fuel used by them is mostly Natural Gas, hence these 69 industries would not contribute in air pollution.

S. No.	Name of Ind. Area	Latitude	Longitude	Land acquired (In Acre)	Land developed (In Acre) 0.4049	No of Plots	No of allotted Plots	No of Vacant Plots	No. of Units in Production
1	EPIP Export Promotion Park	27°12'1.11"N	77°55'15.28"E	101	61.10	269	263	6	42
2	Sikandra Site A B			66.15	48.07	116	116	-	110
3	Sikandra Site C	27°13'25.57"N	77°54'10.50"E	182.45	107.50	307	307	-	170
4	Foundry Nagar	27°13'30.82"N	78° 2'46.03"E	180.40	153.76	265	265	-	198
5	Leather Park	27° 9'4.33"N	77°50'36.90"E	283.20	59.56	98	-	98	00
6	I.E. Nunhai	27°12'4.58"N	78° 3'15.02"E	73.5	73.5	192	192	0	189

Source:- UPSIDC/ DIC, Agra

As plants are universal sink for air pollutants, they trap the carbon dioxide and store it within them as reserve food material. Plants being the initial acceptors of air pollutants act as a scavenger to the pollutants. Leaves provide surface area for impingement, absorption and adsorption of air pollutants as well settlement for dust particles in the atmosphere equally. Few plants are sensitive to certain air pollutants while others are tolerant. The plants sensitive to pollutants act as pollution indicators while the plants tolerant to pollutants act as sink. While selecting the species for pollution control the following are the important characteristics that should be considered. Plants should be evergreen, large leaved, rough bark, indigenous, ecologically compatible, low water requirement, minimum care, high absorption of pollutants, resistant pollutants, agro-climatic suitability, height and spread, canopy architecture, growth rate and habit (straight undivided trunk), aesthetic effect (foliage, conspicuous and attractive flower colour), pollution tolerance and dust scavenging capacity. Hence, plantation needs to be done on haul routes to curb air pollution in respect to dust emission.

Selection of Plants for Greenbelts:

Main limitation for plants to function as scavenger of pollutants are- Plants interaction to air pollutants, sensitivity to pollutants, climatic conditions and soil characteristics. While making choice of plants species for plantation in green belts, due consideration has to be given to the natural factor of bio-climate. Character of plants mainly considered for affecting absorption of pollutant gases and removal of dust particle are as follows.

Major Pollutants	Varieties of Trees	Varieties of Bushes
Particulate Matter	*Cassia siamea* (Kassod tree), Siris, Chitwan, Kadamb, Neem, Sheesham, Mahua, Amaltas, Ficus (Peepal and Banyan)	Kadi Patta, Croton, Tecoma stans, Cassia glauca, Dhak
Sulphur oxides	Siris, Arroo, Chitwan, Kadamb, Neem, Bamboo, Mahuli, Semal, Mahua, Tamarind, Ficus	Amla, Dhak, Subabool,
Nitrogen oxides	Chilbil, *Mangifera indica* (aam), Siris, Mahua, Jamun, Neem, Sheesham	Mahuli, Subabool, Dhak,

For absorption of gases:

- Tolerance towards pollutants in question, at concentration, that are not too high to be instantaneously lethal
- Longer duration of foliage
- Freely exposed foliage
- Adequate height of crown
- Openness of foliage in canopy
- Big leaves (long and broad laminar surface)
- Large number of stomatal apertures

For Removal of Suspended Particular matter:

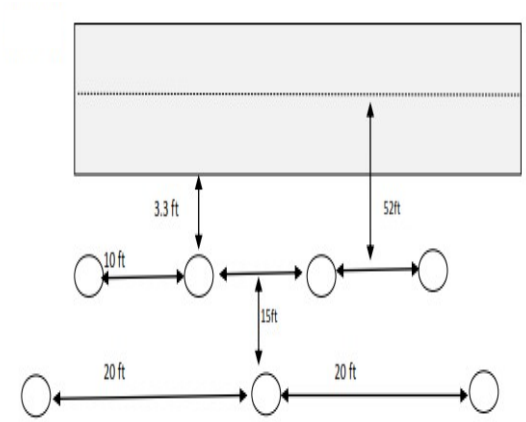
- Height and spread of crown.
- Leaves supported on firm petiole
- Abundance of surface on bark and foliage
- Roughness of bark
- Abundance of axillaries hairs
- Hairs or scales on laminar surface
- Protected Stomata

Selection of Plants for Greenbelts:

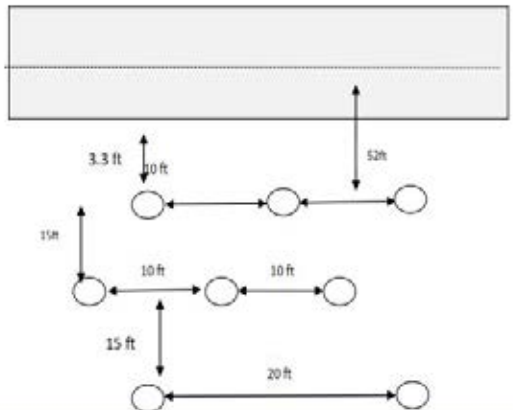
The main limitation for plants to function as scavenger of pollutants are, plant's interaction to air pollutants, sensitivity to pollutants, climatic conditions and soil characteristics. While making choice of plants species for plantation in green belts, due consideration has to be given to the natural factor of bio-climate. Character of plants mainly considered for affecting absorption of pollutant gases and removal of dust particle are as follows.

a. **Plantation pattern:**

- The first row along the highways will be of small to medium size ornamental trees
- Subsequent rows depending on the availability of width will comprise of ornamental and/or shade bearing species of medium height more than those in the first row.
- In rural sections the last row shall always be shade bearing tall trees.
- Plantation shall be done in a staggered (zigzag) manner.



(Option 1) Two-row Plantation



(Option 2) Three-row Plantation

Plantation pattern

Specification	I row	II row	III row
Spacing between plant to plant	10 ft	10 ft	20 ft
Canopy Shape & Size	Cylindrical/oblong with small CSA	Round/oblong with medium CSA	Spreading with medium CSA
Spacing between rows	-	15 ft	15 ft
Size of the pits	60 X 60 X 60 cm	60 X 60 X 60 cm	60 X 60 X 60 cm
Height of the plant	1.5 m to 2 m	More than 2m	More than 3m

To develop a plantation matrix various characteristics of plant species are taken into considerations like tolerance factor, ecologically compatible, growth rate of plant species, canopy surface area, leaf area, stomatal index, canopy shape, flowering seasonality and utility etc. and score obtained by varieties of species of trees and bushes naturally found in that region. The species which scored high are preferred over the species scored less for the plantation to curb air pollution

Matrix for plant selection

S.No.	Characteristic	Score	Remarks
1.	Tolerance/stressed	1/0	Any species which have shown tolerance for primary pollutants of vehicular emission will be rated tolerant and given a fixed score of 1 mark and sensitive species are given 0 mark.
2.	Evergreen	1/0.5/0	Evergreen tree/shrubs have been given 1 marks, semi deciduous have been given 0.5 marks and deciduous have got 0 mark.
3.	Growth rate	1/0.5/0	Growth rate of trees/ shrubs have been classified in to three categories. Fast- 1 mark for the trees which grow in a very short span of time. Quick 0.5 mark for the trees which grow in a very short span of time. Slow-0 mark for the trees which grow in a very short span of time.
4.	Canopy surface	1	Trees/ shrubs with highest canopy surface have been given 1 mark and others have been rated relative to the tree /shrubs with highest CS.
5.	Leaf area	1	Trees/ shrubs with highest leaf area have been given 1 mark and others have been rated relative to the tree /shrubs with highest LA.
6.	Stomatal index.	1	Trees/ shrubs with highest stomatal index have been given 1 mark and others have been rated relative to the tree /shrubs with highest SI.
7.	Canopy shape-Spreading/Round /oblong/Flat crown/Conical	1/0.75/0.5/0.25/0	Spreading-1 mark Round -0.75 mark Oblong-0.5 mark Flat crown-0.25 mark Conical-0 mark
8.	Flowering seasonality	0.5	Tree/shrubs having the round year flowering season have been given 0.5 marks and others have been rated relative to them.
9.	Utility	1	Trees with highest recorded uses have been given 1 mark and others have been rated relative to the tree /shrubs with highest uses.
10.	Total	8.5	

Recommended Species for Various Soil Types:

Selection of suitable plant species for the plantation downwind direction to curb the dust emitted in the city and upwind direction to ensure the entry of filtered wind into the city is the key of successful plantation programme. Given below are the few species suitable for plantation according the soil types found in that region.

Suitable species for different soil types.

Soil Type	Suitable Species
Clay Soil	*Azadirachata indica, Pongamia pinnata, Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Delbergia latifolia, Delbergia sissoo*
Red soil with 10 ft minimum soil depth	*Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Delbergia latifolia, Azadirachata indica, Pongamia pinnata, Ailanthus exceisa*
Red soil with 5 ft minimum soil depth	*Tectona grandis, Swietenia mahagoni, Santalum album, Pterocarpus marsupium, Delbergia latifolia, Azadirachata indica, Melia dubia, Ailanthus exceisa*
Alluvial soil	*Tectona grandis, Swietenia mahagoni, Pterocarpus marsupium, , Melia dubia, Delbergia latifolia, Neolamarckia cadamba, Pongamia pinnata*
Uncultivable soil	*Azadirachata indica, Albezia lebbeck, Delbergia sissoo, Ailanthus exceisa, Pterocarpus santanalius*
	Terminalia arjuna, Casurina junghuniana, Pongamia pinnata

Plants experience physiological changes before getting damaged when the leaves are exposed to air pollutants. The tolerant species are preferred over the sensitive species for plantation. To analyze the species, various variables are used like Air Pollution Tolerance Index (APTI) which is based on biochemical parameters, Anticipated Performance Index (API) which is based on biological and socio-economic aspect of a plant. The carbon trapping and dust accumulating potential also varies from species to species.

APTI score of different trees and their efficacy in Pollution control.

S.Nos.	**Botanical Name**	**Family**	**Common Name**	**APTI**	**Effective in Control**
1.	*Cassia siamea*	Caesalpiniodeae	Kassod tree	10.41	Dust
2.	*Albizia lebbeck*	Fabaceae	Siris tree	15.9	Air pollution
3.	*Alstonia scholaris*	Apocynaceae	Chitwan tree (Blackboard tree)	6.6	Dust
4.	*Neolamarckia cadamba*	Rubiaceae	Kadamb tree (Burflower tree)	15.5	Dust
5.	*Azadirachta indica*	Meliaceae	Neem tree	18.73	Dust, air pollution and Noise

					pollution
6.	*Dalbergia sissoo*	Papilionaceae	Sheesham	16.59	Air pollution Noise pollution
7.	*Madhuca indica*	Sapotaceae	Mahua	22.57	Air pollution
8.	*Mangifera indica*	Anacardiaceae	Mango	20.80	Air pollution
9.	*Bougainvillea spectabilis*	Nyctaginaceae	Booganbel	20.32	Air pollution
10.	*Nerium indicum*	Apocynaceae	Kaner	18.94	Air pollution
11.	*Ficus benghalensis*	Moraceae	Banyan	15.92	Air pollution, noise pollution
12.	*Ficus religiosa*	Moraceae	Peepal	12.41	Air pollution, noise pollution

Impact of Green Belt Development:

According to the UN World Health Organization (WHO), about 90% of the global population living in cities in 2014 was exposed to particulate matter that exceeded the WHO air quality guidelines. The UN agency estimates that outdoor air pollution caused three million premature deaths in 2012, with the vast majority occurring in low- to middle-income nations. The WHO Health Statistics 2016 says air pollution is "caused by inefficient energy production, distribution and use, especially in the industrial, transportation and building sectors, and by poor waste management". It adds that transport systems based primarily on individual motorised transport can lead to further deterioration in air quality. As everyone within an urban area breathes the same air, the pollution does not discriminate - both rich and poor are exposed to the dangers. But, it adds, people living near the source or busy roads are more exposed and more affected. The WHO says that the air quality in many cities is not monitored, making it difficult to get an accurate understanding of the global impact of air pollution. However, planting trees in an urban setting is not without potential pitfalls. One is regarding the flow of air in heavily polluted streets, particularly ones with large volumes of traffic. Thick canopies can limit the circulation of air, trapping the poor quality air at low levels, where people breathe.

Trees help by removing (sequestering) CO_2 from the atmosphere during photosynthesis to form carbohydrates that are used in plant structure/function and return oxygen back into the atmosphere as a byproduct. Roughly half of the greenhouse effect is caused by CO_2. Therefore, trees act as carbon sinks, alleviating the greenhouse effect. On average, one acre of new forest can sequester about 2.5 tons of carbon annually. Young trees absorb CO_2 at a rate of 5.9 kg per tree each year. Trees reach their most productive stage of carbon storage at about 10 years at which point they are estimated to absorb 21.8 kg of CO_2 per year.

Trees also reduce the greenhouse effect by shading houses and office buildings. This reduces the need for air conditioning by up to 30 percent which in turn reduces the amount of fossil fuels burned to produce electricity. The combination of CO_2 removal from the atmosphere, carbon storage in wood and the cooling effect makes trees extremely efficient tools in fighting the greenhouse effect. Planting trees remains one of the most cost-effective means of drawing excess CO_2 from the atmosphere.

References:

1) Taj Trapezium Zone Preparation of Vision Document, First Draft Report, Volume I, July 2018.