



# PLANNING AND DESIGNING OF GREEN PATCH TO REDUCE THE CARBON EMISSION



**SHUBHAM KUMAR N**  
**DHANDHUKIYA**  
**18 IF 803**

# PLANNING AND DESIGNING OF GREEN PATCHES FOR CONTROL OF CARBON EMISSION

By

**Shubhamkumar N Dhandhukiya**  
**ID No.:18IF803; Enrollment No.:180080757002**

## **Institutional Guide**

Prof .Jagruti P. Shah  
Assistant Professor,  
Structural Engineering Department,  
B.V.M. Engineering college,  
Vallabh Vidyanagar

## **External Guide**

Dr. Aarti N Pamnani  
Senior Professor,  
Civil Engineering Department,  
B & B Polytechnic college,  
Vallabh Vidyanagar

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The Master of Technology in **Infrastructure Engineering and Technology**

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**BIRLA VISHVAKARMA MAHAVIDYALAYA**  
(ENGINEERING COLLEGE)  
AN AUTONOMOUS INSTITUTE  
VALLABH VIDYANAGAR - 388120  
GUJARAT, INDIA

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This is to certify that research work embodied in this dissertation entitled “**Planning and Designing of Green Patches for Control of Carbon Emission** ” was carried out by **18IF803: Shubhakumar N Dhandhukiya**, at Birla Vishvakarma Mahavidyalaya (Engineering College) An Autonomous Institution for partial fulfilment of Master of Technology in **Infrastructure Engineering & Technology** degree to be awarded by Gujarat Technological University. This work has been carried out under our supervision meets the requirement of Gujarat Technological University.

Date :

Place : BVM Engineering college, Vallabh Vidyanagar

---

**Prof. Jagruti P. Shah**

Assistant Professor  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

**Dr. Aarti N Pamnani**

Senior Professor,  
Civil Engineering Department,  
B & B Polytechnic college,  
Vallabh Vidyanagar.

---

**Dr. Arvind K. Verma**

Head of Department  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

**Dr. Indrajit N. Patel**

Principal  
B.V.M. Engineering College,  
Vallabh Vidyanagar.



**BIRLA VISHVAKARMA MAHAVIDYALAYA**

(ENGINEERING COLLEGE)

AN AUTONOMOUS INSTITUTE

VALLABH VIDYANAGAR - 388120

GUJARAT, INDIA

# COMPLIANCE CERTIFICATE

This is to certify that research work embodied in this dissertation entitled “**Planning and Designing of Green Patches for Control of Carbon Emission**” was carried out by **18IF803: Shubhakumar N Dhandhukiya**, at Birla Vishvakarma Mahavidyalaya (Engineering College) An Autonomous Institution for partial fulfilment of Master of Technology in Infrastructure Engineering & Technology degree to be awarded by Gujarat Technological University. He has compiled to the comments given by the Dissertation-I as well as Mid semester Thesis Reviewer to our satisfaction.

Date :

Place : BVM Engineering college, Vallabh Vidyanagar

---

**Prof. Jagruti P. Shah**

Assistant Professor  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

**Dr. Aarti N Pamnani**

Senior Professor,  
Civil Engineering Department,  
B & B Polytechnic college,  
Vallabh Vidyanagar.

---

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B.V.M. Engineering College,  
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---

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B.V.M. Engineering College,  
Vallabh Vidyanagar.



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GUJARAT, INDIA

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Date :

Place : BVM Engineering college, Vallabh Vidyanagar

---

**Prof. Jagruti P. Shah**

Assistant Professor  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

**Dr. Aarti N Pamnani**

Senior Professor,  
Civil Engineering Department,  
B & B Polytechnic college,  
Vallabh Vidyanagar.

---

**Dr. Arvind K. Verma**

Head of Department  
Structural Engineering Department,  
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Vallabh Vidyanagar.

---

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Principal  
B.V.M. Engineering College,  
Vallabh Vidyanagar.



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(ENGINEERING COLLEGE)  
AN AUTONOMOUS INSTITUTE  
VALLABH VIDYANAGAR - 388120  
GUJARAT, INDIA

# THESIS APPROVAL CERTIFICATE

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Date :

Place : BVM Engineering college, Vallabh Vidyanagar

---

**Prof. Jagruti P. Shah**

Assistant Professor  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

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GUJARAT, INDIA

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Date:

---

Shubham Kumar N Dhandhukiya

---

**Prof. Jagruti P. Shah**

Assistant Professor  
Structural Engineering Department,  
B.V.M. Engineering College,  
Vallabh Vidyanagar.

---

**Dr. Aarti N Pamnani**

Senior Professor,  
Civil Engineering Department,  
B & B Polytechnic college,  
Vallabh Vidyanagar.



**BIRLA VISHVAKARMA MAHAVIDYALAYA**  
(ENGINEERING COLLEGE)  
AN AUTONOMOUS INSTITUTE  
VALLABH VIDYANAGAR - 388120  
GUJARAT, INDIA

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**Shubhamkumar N Dhandhukiya**

**Id No: 18IF803**

## ABSTRACT

Average 21st century concentrations of urban air pollutants linked to cardiorespiratory disease are not declining, and commonly exceed legal limits. Even below such limits, health effects are being observed and may be related to transient daytime peaks in pollutant concentrations. To provide health safety environment. To reduce the carbon level at industrial area. Designing and planning of green patch in working area.

In India number of states should be developed and infrastructure as soon as possible developing in India. In Gujrat same as to develop in our globally and suitably develop. In Gujarat number of districts should economics with industry work and to import and export the raw material in other state. Vadodara district one of the sets and developing industry in Gujarat. In Vadodara district many industries but we have selected the Makarpura GIDC on bases of our study work.to work bases of our objectives. To suggest parameters to maintain available air level. To identify different pollutants in atmosphere for related GIDC zone. To study different plans for green patch planning to control the pollutant. To analyse the effect of reduction of pollutants by, change in planning. To suggest parameters for maintaining air levels.

In this phase of the dissertations we summaries the work of to find out-put problem of the study area base on some research paper and to collect data base on site selection. Final work done to collect the data like temperature of the area, which type of pollutant should be affect in the area and air quality, which are the pollutant affect for human health and residential area, to identify plant which absorb more carbon and to reduce carbon level in surrounded area.

**Key word:** - carbon reduction, Green patch, Air pollution removal, Air quality, Ecosystem services, Urban forests.

# TABLE OF CONTENT

Title.....	i
Certificate.....	ii
Compliance certificate .....	iii
Paper publication certificate .....	iv
Thesis approval certificate .....	v
Declaration of originality.....	vi
Acknowledgement .....	vii
Abstract.....	viii
Table of content .....	ix
List of figures.....	xii
List of tables.....	xiv
List of charts .....	xv
CHAPTER 1 INTRODUCTION .....	1
1.1 Background.....	1
1.2 Research Background.....	3
1.3 Problem Statement.....	4
1.4 Justification of Study .....	6
1.5 Aim & Objectives.....	7
1.6 Scope of Work.....	7
1.7 Methodology.....	8
1.8 Chapters .....	9
CHAPTER 2 LITERATURE REVIEW .....	10
2.1 Introduction .....	10
2.2 Carbon Footprint .....	10
2.3 Carbon Footprint In Cities.....	11
2.4 Definitions .....	13
2.4.1 Air Pollution.....	13
2.4.2 Primarily air pollutants: - .....	14
2.4.3 Secondary pollutants: - .....	14
2.4.4 Carbon monoxide: - .....	14
2.4.5 Nitrogen dioxide (NO <sub>2</sub> ): - .....	14
2.4.6 Sulphur dioxide (SO <sub>2</sub> ): - .....	14

2.4.7	Carbon monoxide: - .....	14
2.4.8	Volatile organic compounds: - .....	15
2.4.9	Aerosols or particulate matter (PM). .....	15
2.5	Method of calculating current CO <sub>2</sub> sequestration in tree. ....	15
2.6	Current Carbon Sequester in Tree. ....	16
2.6.1	Tree in Separate Area.....	16
2.6.2	Tree Classification. ....	17
2.6.3	Tree at Different Age. ....	17
2.6.4	Determine the dry weight of the tree .....	17
2.6.5	Determine the weight of carbon in the tree.....	17
2.6.6	Determine the weight of CO <sub>2</sub> sequestered in the tree per year .....	17
2.7	Critical Literature Review .....	22
2.8	Major Finding.....	27
<b>CHAPTER 3 STUDY PROFILE AREA.....</b>		<b>28</b>
3.1	Geographical location.....	28
3.2	Metrology Profile .....	30
3.3	Demographical Profile.....	31
3.4	Economical Profile. ....	32
3.4.1	Economic Drivers of Industry.....	33
3.5	Infrastructure Profile.....	34
3.5.1	Road .....	35
3.5.2	Rail.....	36
3.5.3	Air .....	36
3.5.4	Present Development. ....	36
3.6	About Study Area Profile. ....	37
3.6.1	Study Area Description.....	38
3.6.2	Selection of Site. ....	40
<b>CHAPTER 4 DATA COLLECTION .....</b>		<b>42</b>
4.1	Tools and Technique (for study area).....	42
4.1.1	Ratio of Pollutant .....	43
4.2	Study Setup and Data Collection.....	44
4.2.1	Why Makarpura Is Selected for Our Study Area. ....	44
4.3	Pollution & Temperature Ratio. ....	49
4.3.1	Pollutant Value at Industrial Area.....	53

4.3.1.1	Different Pollutant Value .....	54
4.4	Man Power And Health Effect of Pollutant in Air. ....	59
4.4.1	Health Effect & City History On Man Power.....	62
4.4.1.1	Particle Pollution Affects the Lungs. ....	62
4.4.1.2	Particle Pollution Affects the Heart .....	62
4.4.1.3	Certain Groups Are Most at Risk from Exposure to Particle Pollution...	62
4.4.1.4	Communicating Health Effects.....	63
4.4.1.5	Famous Particle Air Pollution incidence .....	63
4.4.1.6	Pyramid of Health Effects from Air Pollution .....	64
CHAPTER 5	DATA ANALYSIS .....	65
5.1	Background.....	65
5.2	Biochemical Characteristics Analysis .....	70
5.3	Air Pollution Tolerance Index .....	72
5.4	Estimation of API .....	74
CHAPTER 6	PLANNING AND DESIGNING PROPOSAL .....	77
6.1	Conceptual review .....	77
6.1.1	Background .....	77
6.1.2	Urbanization and green spaces in India .....	78
6.2	Green Space Planning.....	80
6.2.1	Site selection in green space planning .....	80
6.2.2	Landscape ecological approach. ....	81
6.2.3	Green spaces planning for climate change mitigation .....	82
6.2.4	Planning green spaces for meeting social needs .....	82
6.3	Study of Planning .....	83
6.4	Design of Study .....	88
6.4.1	Identifying the green patch .....	88
6.4.2	Connecting ecological scenes .....	89
6.4.3	Design setup at industrial area. ....	90
6.4.4	Irrigation System.....	92
CHAPTER 7	CONCLUSION & FUTURE SCOPE .....	97
7.1	Conclusion.....	97
7.2	Future Scope .....	98
References	.....	99

## LIST OF FIGURES

Figure 1.1 Performance of Gujarat in ESI (2008) .....	2
Figure 2.1 Critical polluted cities in Gujarat .....	13
Figure 3.1 India geographical location .....	28
Figure 3.2 Vadodara district .....	29
Figure 3.3 Makarpura GIDC.....	30
Figure 3.4 WRF metrological NCEP reanalysis data .....	30
Figure 3.5 WRF metrological NCEP reanalysis data .....	31
Figure 3.6 Infrastructure Development.....	35
Figure 3.7 Pollution slowly occurrence in city .....	38
Figure 3.8 lay out of the MAKAR PURA GIDC .....	39
Figure 3.9 Boundary Of Makarpura GIDC.....	39
Figure 3.10 Wind Direction Of Vadodara Dist.....	40
Figure 3.11 Study Distance And Study Road Network.....	41
Figure 3.12 Study Road Network .....	41
Figure 4.1 Makarpura GIDC.....	45
Figure 4.2 wind direction of Vadodara city .....	45
Figure 4.3 layout of the industry area .....	46
Figure 4.4 Unit Block Of GIDC .....	49
Figure 4.5 CO <sub>2</sub> Level in Industrial Area. ....	51
Figure 4.6 Temperature of Base On Month.....	51
Figure 4.7 Temperature of Base on Month.....	52
Figure 4.8 Temperature Of Base On hourly .....	52
Figure 4.9 Urban Traffic Speed .....	53
Figure 4.10 Hourly traffic in industrial area of Vadodara .....	54
Figure 4.11 Gridded PM <sub>2.5</sub> Emissions (2018 and 2030) .....	55
Figure 4.12 PM <sub>2.5</sub> Emissions by Sector 2018-2030. ....	56
Figure 4.13 PM <sub>2.5</sub> Emissions by Sector 2018-2030. ....	56
Figure 4.14 Ribbon Graph of Pollutant .....	57
Figure 4.15 PM <sub>10</sub> Emissions by Sector 2015.....	57
Figure 4.16 So <sub>2</sub> Emissions by Sector 2015. ....	58
Figure 4.17 No <sub>2</sub> Emissions by Sector 2015. ....	58

Figure 4.18 Number of Factories and Average Number of Workers in Vadodara District from 2008 to 2011.....	61
Figure 5.1 The linear regression plots of individual variables with APTI .....	74
Figure 6.1 Planning of green patch at vadsar to sussan circle. ....	85
Figure 6.2 Planning of green patch at sussan circle to manej circle. ....	85
Figure 6.3 Planning of green patch total industrial area. ....	86
Figure 6.4 Design the Intermediate Point .....	91
Figure 6.5 Design the Green Patch .....	92
Figure 6.6 Irrigation Channel Provided At Selection Area. ....	92

## LIST OF TABLES

Table 1.1 Standard Air Pollutant Ratio.....	4
Table 1.2 Value of The Air Pollutant Before Green Belt In Vadodara City .....	6
Table 2.1 literature review .....	18
Table 3.1 Population of Vadodara .....	31
Table 4.1 Net calorific values and CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O emission factors for different fuel .....	43
Table 4.2 Year Wise Maximum and Minimum Temperature .....	50
Table 4.3 Distribution of Important Industrial Establishments by Major Industrial Group	59
Table 5.1 Air pollution tolerance index of tree species studied in makarpura industrial area, Gujarat. ....	67
Table 5.2 Gradation of plant species based on air pollution tolerance index (APTI).....	68
Table 5.3 Anticipated performance index (API) of plant species.....	69
Table 5.4 Anticipated performance index of different plant species in selected area. ....	75
Table 6.1 Major Indian cities with per capita green source.....	79
Table 6.2 Planning of Intermediate Point .....	84
Table 6.3 Planning Data of Parking Area And Road Side.....	86
Table 6.4 Water Irrigation Line .....	93

## LIST OF CHARTS

Chart 1.1 PSIR FRAME WORK .....	3
Chart 1.2 Temperature of Vadodara city on behalf of year 1960 to 1990 .....	5
Chart 2.1 Carbon intensity by country (kg CO <sub>2</sub> /constant) .....	12
Chart 3.1 Economic Ratio Of Production Unit. ....	33
Chart 3.2 Investment in Industrialization. ....	34
Chart 4.1 Monthly Maximum and Minimum Temperature of the District for the Year 2011 .....	50
chart 7.1 Temperature of the industrial zone for the Year 2019 .....	97
chart 7.2 Temperature of the industrial zone for the Year 2020 .....	98

# **CHAPTER:- 1 INTRODUCTION**

- 1.1 BACKGROUND OF STUDY**
- 1.2 RESEARCH BACKGROUND**
- 1.3 PROBLEM STATEMENT**
- 1.4 JUSTIFICATION OF STUDY**
- 1.5 AIM & OBJECTIVES**
- 1.6 SCOPE OF WORK**
- 1.7 METHODOLOGY**
- 1.8 CHAPTERIZATION**



# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Air is an important life sustaining resource. Given the fact that a person breathes in more than six litres of air every minute, the quality of air becomes a prime concern. Air pollution as defined under Air (Prevention & Control of Pollution) Act 1981 is “presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentrations as may be injurious to human beings or other living creatures or plants or property or environment.”

The composition of air in natural environment is constant but is being changed due to release of large amount of emissions by industries, automobiles and other sources. This changed quality has become a great threat to survival of life and ecosystem as a whole.

Urbanization and industrialization are the twin necessary evils that accompany economic growth and development. They often produce such large amounts of pollutants that they have almost become synonyms for pollution. Hazardous gaseous emission, industrial effluent, and wastes adversely affect human health, vegetation, and property.

To abate the impact of pollutants, environmentalists/ decision-makers have long been emphasizing the need for a perennial green envelope requiring large-scale afforestation in and around industrial areas and alongside roadways.

During the past few decades, urban areas have experienced increasing environmental stress, notably in the form of poor air quality, excessive noise and traffic congestion.

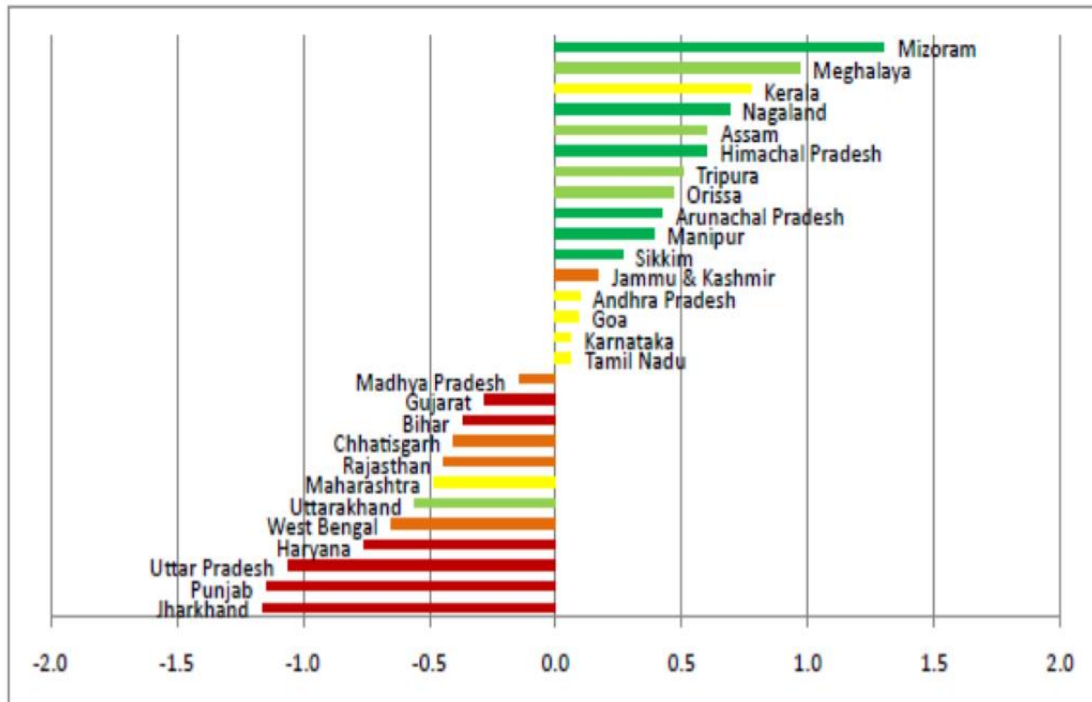
Road traffic is considered as one of the most important sources of air and noise pollution with adverse effects on human health (Aparicio-Ramon and Surez, 1993; Lercher, 1995; Williams and McCreae, 1995; Pathak et al., 2008).

The World Bank has predicted that India’s water, air, soil and forest resources will be under more human pressure than those of any other country by the year 2020. India is also ranked lowest (132) for

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

its air quality (effect on Human Health) in the recent Environmental Performance Index conducted by Environmental Research Centres at Yale and Columbia Universities in 2011.

Trees in parking lots can also affect evaporative emissions from vehicles, particularly through tree shade. Increasing parking lot tree cover from 8% to 50% could reduce Sacramento County, CA, light duty vehicle VOC evaporative emission rates by 2% and nitrogen oxide start emissions by less than 1%.



**Figure 1.1 Performance of Gujarat in ESI (2008)**

Source: - Centre for Development Finance, IFMR, Chennai

The current study analyses the state of Air Environment for Gujarat. The framework used is Pressure, State, Impact and Response (PSIR) which is the same as used in preparation of State of Environment Report at National level. State of Environment for Gujarat was last published in 2005.

The report has been arranged as follows. Section I discusses the pressures which alter the natural composition of atmosphere. These include natural as well as anthropogenic factors like meteorological and climatic conditions, population growth, urbanisation, industrialisation fuel consumption by domestic and industrial sectors.



**Chart 1.1 PSIR FRAME WORK**

## 1.2 Research Background

The present state of environment with respect to various pollution parameters for last five years. Trends in SO<sub>2</sub>, NO<sub>x</sub>, SPM, RSPM, PM<sub>2.5</sub> are established. VOCs and their influence in the industrial areas of Gujarat are also considered.

In the context of environmental pollution abatement, green belt has been defined as mass plantation of pollutant tolerant trees for mitigating the air pollution by filtering, intercepting and absorbing pollutants in a sustainable. It is well documented that plants remove air pollutants such as hydrogen fluoride, SO<sub>2</sub>, and some compounds of photochemical reactions, and collect heavy metals such as mercury (hg) and lead (pb) from the air.

Green belts in petroleum refining industries have been found to reduce air pollution (Rao Et Al., 2004). Plants remove air pollutants by three means: absorption by the leaves, deposition of particulates and aerosols over leaf surfaces, and fallout of particulates on the leeward side of the vegetation (Banerjee, 1996).

Several researchers have designed models for green belt development which include factors such as distance of the green belt from pollution source, and density, width and height of the green belt. The likely effectiveness of a green belt in attenuating pollutant levels is given by the attenuation factor, defined as the ratio of mass flux reaching a particular distance in the absence of the green belt to the mass flux reaching the same distance in the presence of the green belt (Kapoor and Gupta, 1984).

However, models for green belt development also need to consider the selection of tree species. Plants differ markedly in their responses to pollutants, some being highly sensitive and others hardy and tolerant.

Parameters used in defining sensitivity or resistance of plants towards different air pollutant concentrations are ascorbic acid content (Keller and Schwager, 1977), relative water content (RWC) (Sen and Bhandari, 1978), chlorophyll content (Bell and Mudd, 1976), leaf extract pH (Chaudhary and Rao, 1977) and peroxide activity (Eckert and Huston, 1982).

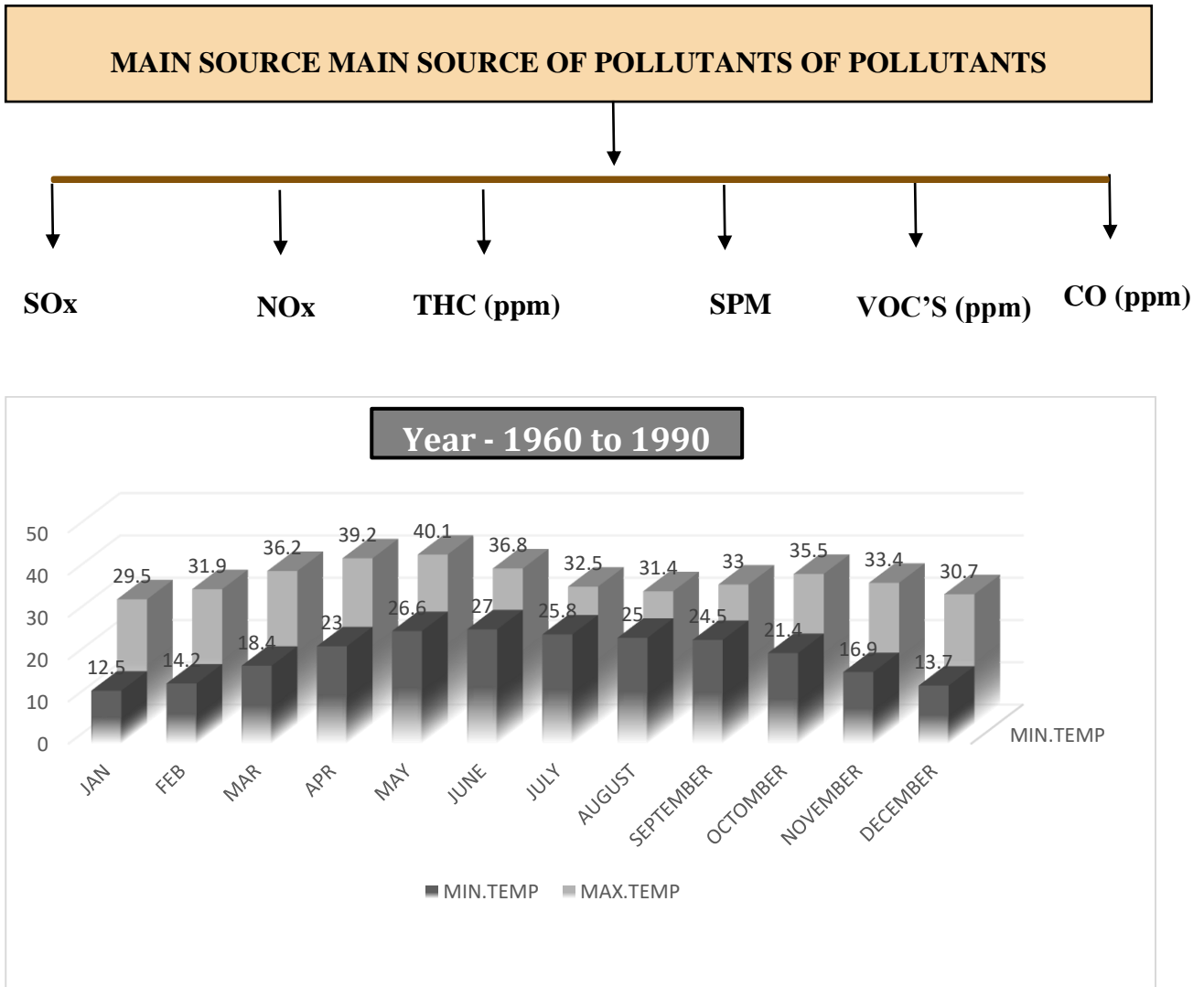
**Table 1.1 Standard Air Pollutant Ratio.**

Pollution Level	Industrial (I)		
	So <sub>2</sub> , NO <sub>x</sub>	RSPM	SPM
LOW(L)	0-40	0-60	0-180
MODERATE(M)	40-80	60-120	180-360
HIGH(H)	80-120	120-180	360-540
CRICAL(C)	>120	>180	>540

### 1.3 Problem Statement

Air pollutants can be natural or may be the result of various anthropogenic activities like industrial, vehicular or other emissions. Further the air pollutants can be primary or secondary depending upon their formation mechanism. Primary pollutants are directly emitted from the source and secondary pollutants are formed in the atmosphere. Air pollutants are classified into particulate matter and gaseous pollutants.

Gujarat has continued to witness impressive industrial development. Government of Gujarat while announcing Industrial Policy in 2003 and 2009 had given strong emphasis on making Gujarat based industries competitive enough to meet with challenges of urbanization.



**Chart 1.2 Temperature of Vadodara city on behalf of year 1960 to 1990**

The problem of declining air quality is mainly the result of anthropogenic emissions from traffic, industry and domestic heating, especially affecting the world's urban residents.

Industrial area exhibits major sources of particulate matter, Sox and NOx. Depending upon the type of raw material used emission of one or more of these pollutants is obvious.

**Table 1.2 Value of The Air Pollutant Before Green Belt In Vadodara City**

<b>Air pollutant (<math>\mu\text{g m}^{-3}</math>)</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>
<b>SO<sub>2</sub></b>	<b>18.6</b>	<b>18.67</b>	<b>22.8</b>
<b>NO<sub>x</sub></b>	<b>3.5</b>	<b>22.4</b>	<b>31.73</b>
<b>SPM</b>	<b>108.6</b>	<b>102.3</b>	<b>103.7</b>
<b>THC (ppm)</b>	<b>8.8</b>	<b>11.0</b>	<b>9.6</b>
<b>CO (ppm)</b>	<b>ND</b>	<b>1.39</b>	<b>1</b>
<b>VOC'S (ppm)</b>	<b>7.4</b>	<b>10</b>	<b>7.5</b>
<b>NOISE Generation (ppm)</b>	<b>61.4</b>	<b>66.6</b>	<b>35.8</b>

#### **1.4 Justification of Study**

Firstly, the industrial area of study should be rest in a central part of a city. The wind direction of the city is toward the southern and eastern side of the city.

Is to be the direction of wind passes to the industry and go out the residential area of the beside the GIDC area. That why presently the health problem should be arisen by air quality and atmospheric behaviour. Right now, the major problem of the residential area too unsafe the health problem by air quality and we provide the plant in industry to absorb the bad pollutant in the air as well as to pass the air not a pure but good quality as compare to the past scenario.

## 1.5 Aim & Objectives

**AIM**

**“To control air pollutant from amiable air by development of green patches”**

**OBJECTIVES**

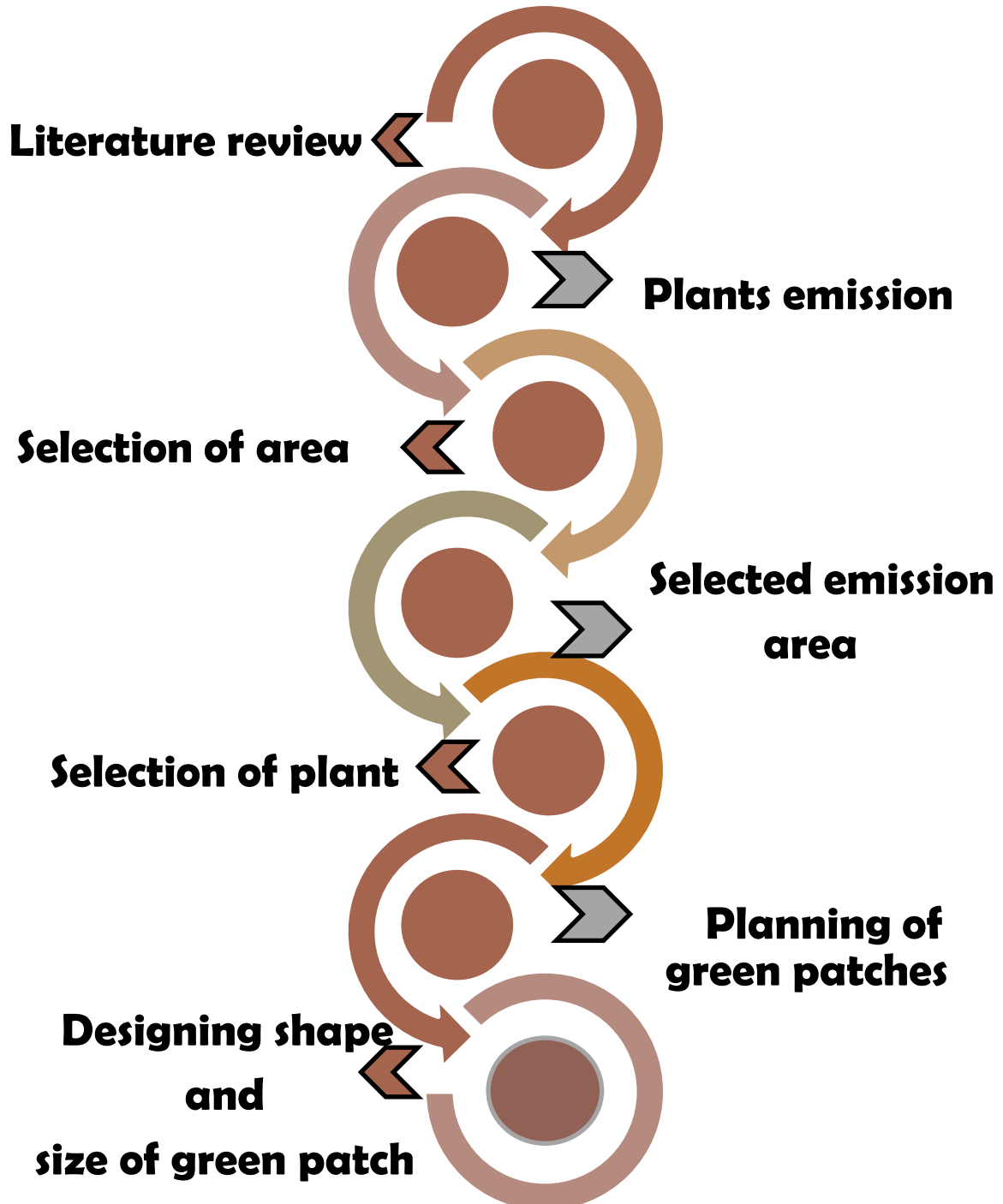
- ☉ To suggest parameters to maintain available air level.
- ☉ To identify different pollutants in atmosphere for related GIDC zone.
- ☉ To study different plans for green patch planning to control the pollutant.
- ☉ To analyse the effect of reduction of pollutants by, change in planning.
- ☉ To suggest parameters for maintaining air levels.

## 1.6 Scope of Work

**“To design and planning the green patches in industrial area to balanced industrial pollutant in environment for selected area of Vadodara city.**

## 1.7 Methodology

Methodology is based on the study area and how to move on the project to guide and to move systematic in the project path.



## 1.8 Chapters

### **Chapter.1: - Introduction**

This chapter gives the research background introduction, justification of the study problem and research Aim with research methodology to achieve objective.

### **Chapter.2: - Literature review**

This chapter formed with a detailed systematic literature review of research paper, Cost guide, government and private institution report on cost overrun, cost estimation methods with critical literature review and major finding.

### **Chapter.3: - Study Area**

Third chapter discusses detailed wind direction and air pollutant absorb methodology and reduce of in carbon

### **Chapter.4: - Data Collection**

This chapter consists Quality attributes selection, Data analysis and pre-processing normalization of data.

### **Chapter.5: - Data Analysis**

This chapter consists to analysis the data of the collecting the tree species.

### **Chapter.6: - Planning and Designing**

In this chapter based on data to planning the green patch and provided the different design of the zone of study area.

### **Chapter.7: - Conclusion**

Finally conclude this study to define n this chapter.

# **CHAPTER-2 LITERATURE REVIEW**

**2.1 INTRODUCTION**

**2.2 CARBON FOOT PRINT**

**2.3 CARBON FOOT PRINT IN CITIES**

**2.4 DEFINITIONS**

**2.5 METHOD FOR CALCULATING CURRENT CO<sub>2</sub> SEQUESTRATION IN TREE**

**2.6 CURRENT CARBON SEQUESTER IN TREE.**

**2.7 CRITICAL LITERATURE REVIEW**

**2.8 MAJOR FINDING**



# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Introduction

The literature review occupies searching, assembly and taking note from literature related to reducing carbon, balanced the air pollutant of area in industry projects. The firstly discover the source through searching with the keyword like carbon emission, tree plantation, green belt, sustainable development, healthy environment, air pollution under in search engine to identify significant important literature for research.

The literature review, clarify the base of this research and targeted to the reduced the carbon emission by design and plan plant (green patch) in industrial area in the projects. Estimating the pollutant level of the industry area to calculate the APIT value of the area which is very complex and costly, other method to determine but healthy and safety as well as economic base it is very better and good recommended for us. Presently the controlling of pollution which most effective point of our engineer because of day to day air pollution ration should be drastically increase it was most favourable point in people for health. Some time we plan some rule and regulation but increasing the urbanization and industrialization that`s why our controlling system should move very slow.

Today most of people aware to clean India and to less produce pollution in our area as well as to plantation the tree an green patches its nearest area to gave good environment and healthy air of inhaling. A systematic literature review done of to select different plant to absorb more carbon and other gases of industrial area. After that to done different design the and planning how to planting a green patch in study area in the different zone of study area. The primary objective is to find and list out various plant to absorb more carbon are used and design and planning the green patch.

### 2.2 Carbon Footprint

Many organizations and governments are looking for strategies to reduce emissions from greenhouse gases from anthropogenic origins, which are responsible for global warming (Kennedy et al. 2009,

2010). The increasing interest in carbon footprint assessment has resulted from the growing public awareness of global warming. The global community now recognizes the need to reduce greenhouse gas emissions to mitigate climate change (Jessica 2008). Many global metropolitan cities and organizations are estimating their greenhouse gas emissions and developing strategies to reduce their emissions. (Sector-Wise Assessment of Carbon Footprint).

The carbon footprint is defined as a measure of the impact of human activities on the environment in terms of the amount of greenhouse gases produced. The total greenhouse gas emissions from various anthropogenic activities from a particular region are expressed in terms of carbon dioxide equivalent, which indicate the carbon footprint of that region (Andrew 2008). Carbon dioxide equivalent (CO<sub>2</sub>e) is a unit for comparing the radiative forcing of a GHG (a measure of the influence of a climatic factor in changing the balance of energy radiation in the atmosphere) to that of carbon dioxide (ISO 14064-1, 2006a, b). It is the amount of carbon dioxide by weight that is emitted into the atmosphere and would produce the same estimated radiative forcing as a given weight of another radiatively active gas.

Carbon dioxide equivalents are calculated by multiplying the weight of the gas being measured by its respective global warming potential (GWP). It is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.

### **2.3 Carbon Footprint In Cities**

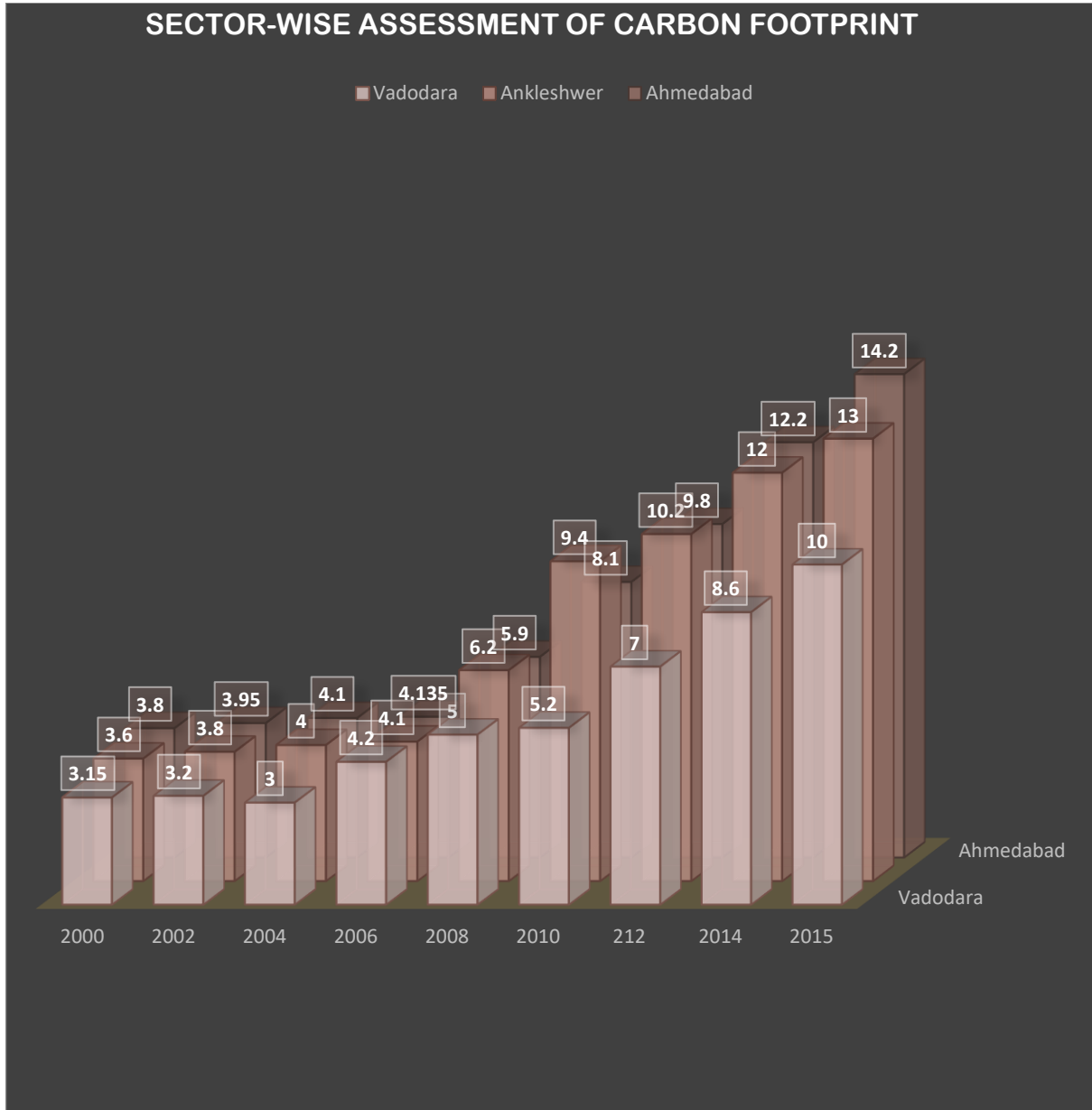
Emissions of GHG emissions at city levels with a detailed analysis of per capita GHG emissions for several large cities helps in evolving appropriate mitigation measures and resource efficiency (Hoorweg et al. 2011). Kennedy et al. (2009, 2010) developed a method for comparing emissions resulting from electricity consumption, heating and industrial fuel use, transportation, and waste sectors across 10 global cities.

Similar studies by Sova and Brown (2009) provided a comparative account of carbon footprints in metropolitan areas, with suggestions for policymakers and planners regarding policy implications. The assessment of carbon footprint is being used for the management of climate change and to mitigate changes in climate at local levels. Studies on the carbon footprint of Norwegian municipalities were calculated to be related to the factors of size and wealth (Hogne et al. 2010).

The World Health Organization (2002) estimates that approximately 5% of trachea, bronchus and lung cancer, 2% of cardiorespiratory mortality, and about 1% of respiratory infections are attributed to

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

urban outdoor air pollution. This amounts to about 800,000 deaths (1.4% of the total) and about 0.8% of the total global burden of disease. This burden falls predominantly on low and middle-income countries, with 42% occurring parts of the WHO Western Pacific region and 19% occurring in parts of the WHO Southeast Asian Region.



**Chart 2.1 Carbon intensity by country (kg CO<sub>2</sub>/constant)**

Source: - Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP)

Cities	Source of pollution (1)	Stations (2)	2003-2004 (2)				2003 (3)	2005 (4)
			SO <sub>x</sub>	NO <sub>x</sub>	SPM	RSPM	RSPM	RSPM
Ahmedabad	Vehicles, Industries	Ashram Road, Nehru Bridge	7	15	378	104	154	134
Baroda	NA	Mayur Park, Laxmipura, Gorwa	18	17	228	142	167	90
Surat	Vehicles, Industries	Hi-Choice Textile	32	36	272	NA	132	124
Vapi	Industries	GIDC, GEB Substation	30	45	226	175	131	134
Bharuch	Vehicle, Industries	GIDC, Ankleshwar	39	29	252	NA	126	126

Figure 2.1 Critical polluted cities in Gujarat

Source: - The Case study Of Baroda City

## 2.4 Definitions

### 2.4.1 Air Pollution

Pollution is now a commonplace term, that our ears are attuned to. We hear about the various forms of pollution and read about it through the mass media. Air pollution is one such form that refers to the contamination of the air, irrespective of indoors or outside. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals, and humans to survive as the air becomes dirty.

Air pollution can further be classified into two sections- visible air pollution and invisible air pollution. Another way of looking at air pollution could be any substance that holds the potential to hinder the atmosphere or the wellbeing of the living beings surviving in it. The sustainment of all things living is due to a combination of gases that collectively form the atmosphere; the imbalance caused by the increase or decrease in the percentage of these gases can be harmful to survival.

**2.4.2 Primarily air pollutants: -**

**Primarily air pollutants** can be caused by primary sources or secondary sources. The pollutants that are a direct result of the process can be called primary pollutants. A classic example of a primary pollutant would be the sulphur-dioxide emitted from factories.

**2.4.3 Secondary pollutants: -**

**Secondary pollutants** are the ones that are caused by the intermingling and reactions of primary pollutants. Smog created by the interactions of several primary pollutants is known to be as a secondary.

**2.4.4 Carbon monoxide: -**

**Carbon monoxide** is both odourless and colourless, and it's produced through combustion. Most carbon monoxide emissions come from vehicles, about 62%, but they also come from forest fires, lawn equipment and the burning of industrial waste. This pollutant is dangerous to human health because, even in very small concentrations, it can prevent oxygen from being delivered through your body to major organs. At higher levels, it can cause death.

**2.4.5 Nitrogen dioxide (NO<sub>2</sub>): -**

Nitrogen oxides (NO and NO<sub>2</sub>, referred together as NO<sub>x</sub>) are highly reactive gases formed when oxygen and nitrogen react at high temperatures during combustion or lightning strikes. Nitrogen present in fuel can also be emitted as NO<sub>x</sub> during combustion. Emissions are dominated by fossil fuel combustion at northern mid-latitudes and by biomass burning in the tropics.

**2.4.6 Sulphur dioxide (SO<sub>2</sub>): -**

Sulphur dioxide (SO<sub>2</sub>) is a gas formed when sulphur is exposed to oxygen at high temperatures during fossil fuel combustion, oil refining, or metal smelting. SO<sub>2</sub> is toxic at high concentrations, but its principal air pollution effects are associated with the formation of acid rain and aerosols. SO<sub>2</sub> dissolves in cloud droplets and oxidizes to form sulfuric acid (H<sub>2</sub>SO<sub>4</sub>), which can fall to Earth as acid rain or snow or form sulphate aerosol particles in the atmosphere.

**2.4.7 Carbon monoxide: -**

Carbon monoxide (CO) is an odourless, colourless gas formed by incomplete combustion of carbon in fuel. The main source is motor vehicle exhaust, along with industrial processes and biomass burning.

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

Carbon monoxide binds to haemoglobin in red blood cells, reducing their ability to transport and release oxygen throughout the body. Low exposures can aggravate cardiac ailments, while high exposures cause central nervous system impairment or death.

### 2.4.8 Volatile organic compounds: -

Volatile organic compounds (VOCs), including hydrocarbons (C<sub>x</sub>H<sub>y</sub>) but also other organic chemicals are emitted from a very wide range of sources, including fossil fuel combustion, industrial activities, and natural emissions from vegetation and fires. Some anthropogenic VOCs such as benzene are known carcinogens.

### 2.4.9 Aerosols or particulate matter (PM).

The atmosphere contains solid and liquid particles that are suspended in the air. These particles are referred to as aerosols or particulate matter (PM). Aerosols in the atmosphere typically measure between 0.01 and 10 micrometres in diameter, a fraction of the width of a human hair. Most aerosols are found in the lower troposphere, where they have a residence time of a few days. They are removed when rain or snow carries them out of the atmosphere or when larger particles settle out of suspension due to gravity.

## 2.5 Method of calculating current CO<sub>2</sub> sequestration in tree.

We use the method of carbon counting devised by Broward County (2012). The equation to estimate a tree's dry weight is based on the physical relationship between tree volume and wood density (Xu and Mitchell, 2011). As tree density figures can vary, even within the same species, using different formula for each tree species does not necessarily provide more accurate CO<sub>2</sub> estimations. Therefore, the method we used is based on average wood density figures across species.

- **There are five steps to measure the amount of CO<sub>2</sub> sequestered in a tree per annum, namely:**

- (1) estimate the total weight of the tree using the diameter of the trunk and an estimate of the height;
- (2) convert the weight of the tree to the dry weight of organic matter (on average 72.5 per cent of the total weight);
- (3) estimate the amount of carbon, being a proportion of the dry weight (on average 50 per cent of the dry weight);

(4) convert the amount of carbon to the amount of CO<sub>2</sub> sequestered (multiply by 3.6663, because two oxygen molecules are added to each carbon molecule); and

(5) convert the total CO<sub>2</sub> sequestered into an annual amount sequestered (by dividing by the age of the tree) (Broward County, 2012).

- Given differing wood densities, the measurement of CO<sub>2</sub> sequestered in a tree per year can be summarised in the following equations.

$$W = \frac{0.25 * D^2 * H * 120\% * 72.5\% * 50\% * 3.6663}{Tree\ age} \quad (\text{when } D < 11 \text{ inches})$$

$$W = \frac{0.15 * D^2 * H * 120\% * 72.5\% * 50\% * 3.6663}{Tree\ age} \quad (\text{when } D \geq 11 \text{ inches})$$

**Where:**

- W ¼ weight of CO<sub>2</sub> sequestered in the tree per year in pounds.
- D ¼ tree diameter in inches.
- H ¼ tree height in feet.

Therefore, in this method, each tree’s diameter has to be measured and its height and age estimated (Appendix 1 for more detailed information). Three measures were recorded for each tree estimated to be three meters or taller, namely the circumference (which was later converted to diameter), the estimated height, and the estimated age. Ages were estimated based on grounds staff’s detailed records and personal knowledge of tree plantings in specific areas over the years.

## 2.6 Current Carbon Sequester in Tree.

### 2.6.1 Tree in Separate Area.

We divided the campus into eight arbitrary areas to facilitate record keeping. Figure 3 shows the total weight of CO<sub>2</sub> sequestered in the trees by area. Note that the trees in area one has sequestered almost one third of CO<sub>2</sub> of the main campus. The major reason for the highest CO<sub>2</sub> sequestration in this area is that almost one quarter of the total number of trees is in this area. Moreover, the majority of trees in area one is large and high. The trees in the other areas have only stored about 500,000 kg of CO<sub>2</sub> per area. In these areas, most of the trees are around buildings or along roads.

### **2.6.2 Tree Classification.**

Evergreen plants have leaves in all seasons, while deciduous plants have leafless periods during the winter or dry season (Benavides et al., 2009). With the help of expert ground staff, the measured trees were divided into these two groups. According to Table I, 70 per cent of main campus trees are evergreen, whilst 30 per cent are deciduous.

There are profound differences in CO<sub>2</sub> sequestration between evergreen and deciduous plants (Buchmann et al., 1997). The differences in CO<sub>2</sub> storage between species are less marked (Kirby and Potvin, 2007). Therefore, the use of an average CO<sub>2</sub> sequestration for evergreen trees and for deciduous trees is regarded as fairly accurate. Evergreen trees sequester an average of 44.37 kg of CO<sub>2</sub> per year, while deciduous trees sequester an average of 40.87 kg of CO<sub>2</sub> per annum.

### **2.6.3 Tree at Different Age.**

We already mentioned that trees store different amounts of CO<sub>2</sub> depending on their age (Unwin and Kriedemann, 2000). In trees younger than 15 years old, the weight of CO<sub>2</sub> sequestered increases smoothly. Between the ages of 15 and 45, CO<sub>2</sub> sequestration increases dramatically (Unwin and Kriedemann, 2000). However, after 45 years of age, the weight of CO<sub>2</sub> sequestered declines slowly as trees start to release some CO<sub>2</sub> back into the atmosphere (Nowak et al., 2002).

### **2.6.4 Determine the dry weight of the tree**

This is based on an extension publication from the University of Nebraska.<sup>4</sup> This publication has a table with average weights for one cord of wood for different temperate tree species. Taking all species in the table into account, the average tree is 72.5% dry matter and 27.5% moisture.

Therefore, to determine the dry weight of the tree, multiply the weight of the tree by 72.5%.

### **2.6.5 Determine the weight of carbon in the tree**

The average carbon content is generally 50% of the tree's total volume.<sup>5</sup> Therefore, to determine the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

### **2.6.6 Determine the weight of CO<sub>2</sub> sequestered in the tree per year**

Divide the weight of carbon dioxide sequestered in the tree by the age of the tree.

**Table 2.1 literature review**

<b>SR. NO</b>	<b>TITLE</b>	<b>AUTHOR</b>	<b>YEAR</b>	<b>PUBLICATION</b>	<b>KEY OUTCOMES</b>
1.	<b>Carbon footprint: current methods of estimation</b>	Divya Pandey · Madhoolika Agrawal · Jai Shanker Pandey	2011	Environmental Monitoring and Assessment	Carbon footprint · Direct emissions · Embodied emissions · Greenhouse gases
2.	<b>A Review on Green ICT Solutions for CO<sub>2</sub> Emissions</b>	Neethu Lukose	2016	International Journal of Science and Research (IJSR)	UNEP, Green economy, Green solution, ICT.
3.	<b>Energy Retrofitting: The Technique to Reduce Carbon Emission</b>	Rohit V Ambapkar , Dr. K Ravi	2016	International Journal of Science and Research (IJSR)	Construction industry, carbon emission, traditional approaches, retrofitting,
4.	<b>Carbon storage and sequestration by urban trees in the USA</b>	David j. Nowek	2002	Elsevier	Global climate change, Carbon dioxide, Urban forestry, Carbon storage, Carbon sequestration
5.	<b>Estimation of carbon footprint from fuels (gasoline and diesel) as an instrument of attenuating</b>	Okparaku v. I. , Igbokwe e. E. , Igbokwe, k. K. , ndukwe p. U	2018	International research journal of engineering and technology	Carbon footprint, carbon emissions, CO <sub>2</sub> , attenuation, ASPA

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

	<b>climate change – a case study of abia state polytechnic, aba, abia state, nigeria.</b>				
<b>6.</b>	<b>Assessment and reduction of embodied carbon in buildings</b>	Jeffy george, jeevan jacob	2018	International research journal of engineering and technology	Embodied carbon emission, BIM, estimation, reduction strategy.
<b>7.</b>	<b>Vehicular exhaust emission estimation and control modelling</b>	Purnima kadam, dr. Sarita sharma, dr. Ashok sharma, dr. Sanjay verma	2018	International research journal of engineering and technology	Control emission, COPART (computer programmer to estimate emissions from road transport).
<b>8.</b>	<b>Impacts of urban greenspace on offsetting carbon emissions for middle korea.</b>	Hyun kill jo	2002	Elsevier	Climate change, fossil fuels, woody plants, soils, benefits, strategies
<b>9.</b>	<b>Carbon credit assessment on modal shift of goods from roadways to inland waterways.</b>	Devika L, er. P. Kalaiarasan , nittin johnson.	2019	International research journal of engineering and technology	Carbon credit, national waterways NO: 3, origin-destination (OD) matrix, perishable and non-perishable goods carbon foot-print, activity based approach

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

10.	<b>Survey of green computing</b>	Ms. Pooja verma, prof. Pooja kadam	2018	International research journal of engineering and technology	Green computing, carbon footprint, energy consumption, fossil carbon.
11.	<b>Performance evaluation of a green belt in a petroleum refinery: a case study</b>	Padma S. Rao*, A.G. Gavane, S.S. Ankam, M.F. Ansari, V.I. Pandit, P. Nema	2004	Elsevier	Plant filter; Pollution attenuation coefficient; Model; Attenuation factor
12.	<b>Air Pollution Tolerance Index of climber plant species to develop Vertical Greenery Systems in a polluted tropical city</b>	Ashutosh Kumar Pandeya, Mayank Pandeya, B.D. Tripathib,	2015	Elsevier	Air Pollution Tolerance Index (APTI),Green roof,Sky garden,Urban green space,Vertical garden,Vertical greenery systems (VGSs)
13.	<b>Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise</b>	Vinita Pathak, B.D. Tripathi, V.K. Mishra	2018	Elsevier	Peri-urban green,space,Pollution,Noi se reduction,Traffic noise

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

14.	<b>Anticipated Performance Index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city, India</b>	Santosh K. Prajapati, B.D. Tripathi	2007	Elsevier	Air Pollution Tolerance Index (APTI); Anticipated Performance Index (API); Green belt; Management
15.	<b>Valuing Environmental Quality: The Case study Of Baroda City</b>		2005		
16.	<b>Brief Industrial Profile Of Vadodara District</b>		2011	MSME-DEVELOPMENT INSTITUTE	
17.	<b>Carbon sequestered in the trees on a university campus</b>	Charl De Villiers, The University of Waikato, Hamilton, New Zealand and University of Pretoria, Pretoria, South Africa	2015	Sustainability Accounting, Management and Policy Journal	Reduce carbon footprint, tree plantation
18.	<b>Carbon Footprint of Tree Nuts</b>	Roberto Volpe, Simona Messineo, Maurizio Volpe	2015	Sustainability	transformed food; almond; hazelnut;

	<b>Based Consumer Products</b>	and Antonio Messineosustainability			pistachio; peanut
19.	<b>Atmospheric Carbon Reduction by Urban Trees</b>	David j.nowek	1993	Journal of environmental management	urban forestry, carbon storage, greenhouse effect, urban wildfire

## 2.7 Critical Literature Review

Paper name: - **An Evaluation of Air Pollution Tolerance Index and Anticipated Performance Index of Some Tree Species Considered for Green Belt Development: A Case Study of Nandesari Industrial Area, Vadodara, Gujarat, India**

**Author name:** Dhruti Patel, J. I. Nirmal Kumar

**Publish year:** 05 janury,2018

**Publishing:** - Scientific research publishing.

**Key word:** - Air Pollution, APTI, API, Nandesari, Green Belt

**Abstract:** -

- It is well renowned that trees have capacity to reduce the air pollution. It is mandatory to expand tree plantation in industrial area to minimize the threat of pollutants. For green belt development, it is necessary to use plants that are tolerant to air pollution. The present study includes Air pollution tolerance index (APTI) of selected plant species with the help of biochemical analysis.
- On the basis of APTI and some other socioeconomic and biological parameters of plants, Anticipated Performance Index (API) was calculated. Out of twelve species, Ficus Bengalese's showed to be the most efficient among others. As per classification of API, Ficus religiosa tree species is classified into the moderate category. Based on the APTI and API, appropriate plant species for green belt development in industrial area were identified and recommended for mitigating the pollution.

Paper name: **Biological Carbon Sequestration Through Fruit Crops (Perennial Crops -Natural “Sponges” For Absorbing Carbon Dioxide From Atmosphere)**

**Author name: -** Prabhugouda Patil, Dr. A. Kiran Kumar

**Publish year:** 15 January, 2017

**Publishing: -** Plant archive

**Key word: -** Atmosphere, Carbon sequestration, Biosphere and climate.

**Abstract: -**

- Rapid increase in carbon dioxide (CO<sub>2</sub>) concentration in the atmosphere associated with other greenhouse gases (GHGs) such as nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>), since the industrial revolution is a major concern with respect to its impact on climate change. Therefore, there is an urgency to adopt effective measures for mitigating the threat of global climate change. Carbon dioxide (CO<sub>2</sub>) is a major contributing gas to the greenhouse effect.
- So, Carbon sequestration is a natural method for the removal of carbon from the atmosphere by storing it in the biosphere. The atmospheric carbon dioxide is captured and stored in plants, soils, oceans, or atmosphere in the forms of biomass by photosynthesis process. The removal of atmospheric CO<sub>2</sub> by increasing the assimilation of CO<sub>2</sub> with terrestrial vegetation, retaining carbon and enhancing the transformation of atmospheric carbon to plant biomass and soil organic matter along with reducing GHG emission has become a worldwide strategy to mitigate climate change.

Paper name: - **Controls on hourly variations in urban background air pollutant concentrations**

**Author name:-** Teresa Moreno a, Javier Lavíñ b, Xavier Querol a, Andre' s Alastuey a, Mar Viana a, Wes Gibbons

**Publish year:-** 22 May 2009

**Publishing:-** Elsevier

**Key word:-** Urban air pollution, Transient concentration peaks ,Cardiorespiratory health effects

**Abstract: -**

- Average 21st century concentrations of urban air pollutants linked to cardiorespiratory disease are not declining, and commonly exceed legal limits. Even below such limits, health effects are being observed and may be related to transient daytime peaks in pollutant concentrations. With this in mind, we analyses >52,000 hourly urban background readings of PM10 and pollutant gases throughout 2007 at a European town with legal annual average concentrations of common pollutants, but with a documented air pollution-related cardiorespiratory health problem, and demonstrate the hourly variations in PM10, SO2, NOx, CO and O3.
- Back-trajectory analysis was applied to track the arrival of exotic PM10 intrusions, the main controls on air pollutants were identified, and the typical hourly pattern on ambient concentrations during 2007 was profiled. Emphasis was placed on “worst case” data (>90th percentile), when health effects are likely to be greatest.
- The data show marked daytime variations in pollutants result from rush-hour traffic-related pollution spikes, midday industrial SO2 maxima, and afternoon O3 peaks.

**Paper name:** Trends and Variability of Climatic Parameters in Vadodara District.

**Author name: -** Apurva. J. Patel ,Dr. T. M. V. Suryanarayana ,Dr. Falguni Parekh

**Publish year:** March 2016

-

**Publishing:** GRD JOURNAL

**Key word: -** Climate change, Mann-Kendal Test, Sen’s Slope Estimator, Trend Analysis

**Abstract: -**

- Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions. The impact of climate change on the various meteorological parameters has received a great deal of attention by scholars worldwide .

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

- The means for detecting climate trends and variability are time series analysis based on data sets e.g. Temperature, precipitation, wind speed and relative humidity. In this study the focus is on detecting trends in mean monthly maximum temperature, mean monthly minimum temperature, mean monthly precipitation, mean monthly wind speed and mean monthly relative humidity for the Vadodara district in the state of Gujarat.
- For this study, Mann-Kendall test was run at 5% significance level on time series data for Vadodara district for the period of thirty seven years starting from 1969 to 2005. Mann-Kendall test is carried out using software XLSTAT to analyze trend in given data. The resultant Mann-Kendall test statistic (Zs) indicates how strong the trend is and whether it is increasing or decreasing

Paper name: **Performance evaluation of a green belt in a petroleum refinery: a case study**

**Author name: -** Padma S. Rao\*, A.G. Gavane, S.S. Ankam, M.F. Ansari, V.I. Pandit, P. Nema

**Publish year:** 19 June 2004

-

**Publishing:** Elsevier

**Key word: -** Plant filter; Pollution attenuation coefficient; Model; Attenuation factor

**Abstract: -**

- Green belts (GB) or vegetation around factories and industrial premises mitigate air pollution (as the plants serve as a sink for pollutants and check the flow of dust, etc.) and reduce noise levels. Software developed by National Environmental Engineering Research Institute (NEERI) for the determination of optimal width of a GB in and around an industry is based on pollution attenuation coefficient of selected plant species of deciduous trees existing in the region.
- The performance of the green belt of 500m width of a 13.5 million tons/year refinery in the West coast of India is evaluated for reducing/managing various wastes generated. Its overall efficiency is above 60%.

Paper name:- **Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise**

**Author name:-** Vinita Pathak, B.D. Tripathi, V.K. Mishra

**Publish year:** June 2011

-

**Publishing:** Elsevier

**Key word: -** Peri-urban green space, Pollution, Noise reduction, Traffic noise

**Abstract: -**

- Green belts are effective tools for mitigation of traffic generated noise. For green belt development it is necessary that plants used for green belts must be tolerant to air pollution. In this study, the Air Pollution Tolerance Index (APTI) of plants commonly used for green belt establishment in Varanasi city, Uttar Pradesh, India was evaluated with the help of analysis of some biochemical parameters.
- On the basis of APTI and some biological and socioeconomic parameters of plants, the Anticipated Performance Index (API) of these plants was calculated. Among all the plants taken under consideration *Ficus infectoria* L. ranks first and is a keystone species. *Mangifera indica* L. and *Ficus religiosa* L. were classified into the 'excellent' category. The most suitable plant species for green belt development in urban areas were identified and recommended.

**Paper name:** **Anticipated Performance Index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city, India**

**Author** Santosh K. Prajapati, B.D. Tripathi

**Publish year:** 20 August 2007

-

**Publishing:** Elsevier

**Key word: -** Air Pollution Tolerance Index (APTI); Anticipated Performance Index (API); Green belt; Management

**Abstract: -**

- It is well established that trees help to reduce air pollution, and there is a growing impetus for green belt expansion in urban areas. Identification of suitable plant species for green belts is very important. In the present study, the Air Pollution Tolerance Index (APTI) of many plant species has been evaluated by analyzing important biochemical parameters.
- The Anticipated Performance Index (API) of these plant species was also calculated by considering their APTI values together with other socio-economic and biological parameters.

## **2.8 Major Finding**

- We find out that the most economical and best method of the to reduce the carbon we planning the green belt.
- Which is good for environment as well as safest way to reduced the human dieses.
- At that present duration no. of city which had cover in heavy pollutant city, we have no any other method to reduce the carbon as compare that.
- Yes, it is very careful and praises because of to take care about good environment and safe place to grow up and to rapidly growth up after that they automatically done this work.

# **CHAPTER-3 STUDY PROFILE AREA**

**3.1 GEOGRAPHICAL LOCATION**

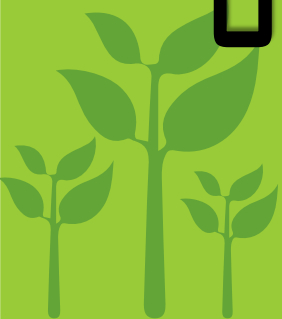
**3.2 METROLOGY PROFILE**

**3.3 DEMOGRAPHICAL PROFILE**

**3.4 ECONOMICAL PROFILE**

**3.5 INFRASTRUCTURE PROFILE**

**3.6 ABOUT STUDY AREA  
PROFILE**



# CHAPTER 3

## STUDY PROFILE AREA

### 3.1 Geographical location

Vadodara district with 7548.50 Sq km area, is located central part of mainland Gujarat, lies between 21°49“19” and 22°48“37” north latitude and 72°51“05”and 74°16“55” east longitude. It falls in the Survey of India, degree sheets numbered 46B, 46F, 46J & 46G. The district is bounded in north & northeast by Anand, Panchmahals & Dahod districts, in east & in south east by Madhya Pradesh & Maharashtra State, in south east by Narmada district & in south & in west by Bharuch district. Vadodara city, the district headquarter is about 100 km south of Ahmedabad, is well connected to other parts of the State & Country by network of highways and railway network.



**Figure 3.1 India geographical location**

Source: - <https://www.google.co.in/>

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

Vadodara district is divided into 12 talukas. Details of the Talukas, their urban & rural areas and numbers of revenue villages & towns etc., are given in Table – 1. Map showing its administrative units as Taluka & their headquarter is given as.



**Figure 3.2 Vadodara district**

Vadodara or Baroda as it was formerly called, is the 3<sup>rd</sup> largest city in the state of Gujarat. It is located on the banks of the Vishwa Mitri river. An important industrial, cultural and educational hub of western India, the city houses several institutions of national and regional importance while its major industries include petrochemicals, engineering, chemicals, pharmaceuticals, plastics, and information technology. Agriculture is also an important sector in the city, which is a leading producer of pulses, fruits and flowers in the state of Gujarat.

We compiled an emissions inventory for the Vadodara region for the following pollutants – sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), carbon dioxide (CO<sub>2</sub>); and particulate matter (PM) in four bins (a) coarse PM with size fraction between 2.5 and 10 µm (b) fine PM with size fraction less than 2.5 µm (c) black carbon (BC) and (d) organic carbon (OC), for year 2015 and projected to 2030. In Phase 1, base year for all the calculations was 2015. In Phase 2, all the calculations are updated for year 2018.

# PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

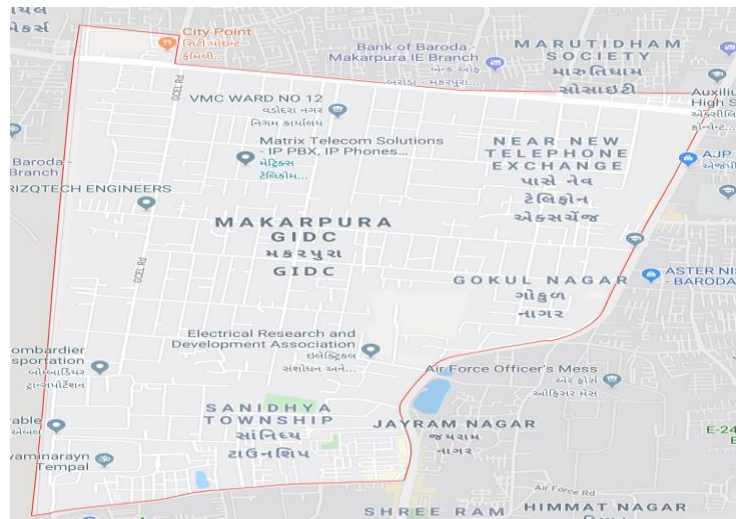


Figure 3.3 Makarpura GIDC

## 3.2 Metrology Profile

Meteorology fields are important as they have a direct impact on air pollution concentrations. During periods of high precipitation or high-speed winds, emissions from a city are swept away and do not have an impact on concentrations. On the other hand, during the winter months when temperatures and inversion heights are low, there is a greater impact of emissions on pollution concentrations. Low temperatures also affect behavior through the need for space and water heating which in turn has increases emissions.

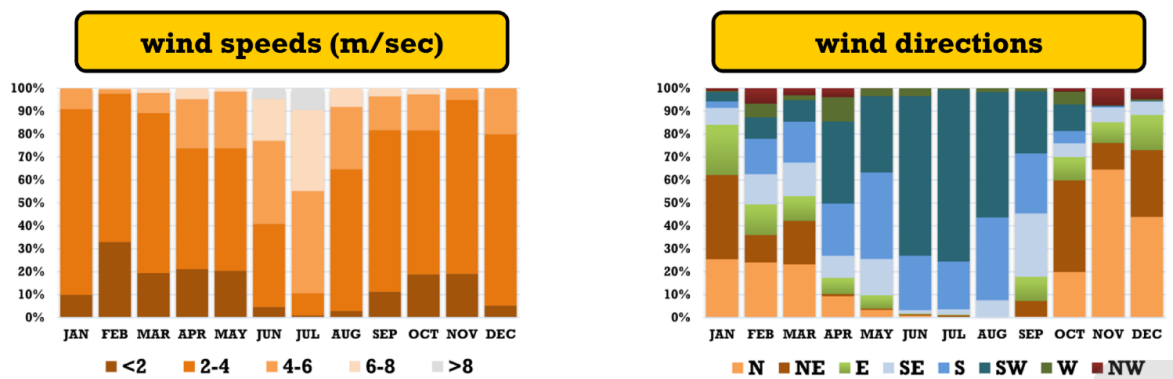


Figure 3.4 WRF metrological NCEP reanalysis data

• Source: - <http://www.urbanemissions.info/>

We processed the NCEP Reanalysis global meteorological fields from 2010 to 2018 through the 3D-WRF meteorological model. A summary of the data for one year, averaged for the city’s airshed is presented below by month. Download the processed data which includes information on year, month,

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

day, hour, precipitation (mm/hour), mixing height (m), temperature (C), wind speed (m/sec), and wind direction (degrees) – key parameters which determine the intensity of dispersion of emissions.

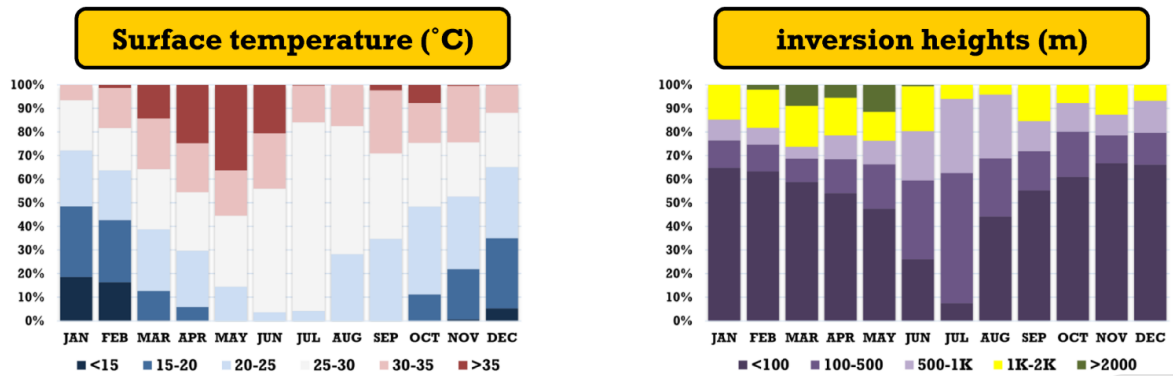


Figure 3.5 WRF meteorological NCEP reanalysis data

Source: - <http://www.urbanemissions.info/>

3.3 Demographical Profile.

The city has witnessed high growth (40%) from 1981 to 1991. However, it could not maintain the momentum of growth; the growth rate slowed down to 26% in the last decade, 1991--2001. The population registered in 2001 was 13.06 lakhs as against 10.31 lakhs 1991. The compounded annual growth rate (CAGR) has been steadily declining from 4.64% in 1971-81 to 3.45% in 1981-1991, and further to 2.39 % in 1991-2001.

The population in 2005 has been estimated at around 14.69 lakhs. The population projection for 2011 is estimated around 17.54 lakhs and is based on the hypothesis that the city would grow at a constant rate due to the increasing urbanisation in the state. The trend also shows that the population would increase at a stabilised average annual growth rate of 2.99% from 2005 to 2011.

Table 3.1 Population of Vadodara

Year	Population (Lakhs)	Average Annual Growth Rate(%)
1981	7.34	4.64%
1991	10.31	3.45%

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

<b>2001</b>	13.06	2.39%
<b>2005</b>	14.69	2.99%
<b>2011(projected)</b>	17.45	2.99%

Source: - Census.2011

The population density of the city has increased from 9527 per sq.km in 1991 to 12064 per sq.km in 2001. However, this density reduced to 9925 per sq.km due to the addition of new areas (148 sq. kms) in 2002. The jurisdiction of Vadodara city has further increased in February 2006 and covers urbanised areas of around 15-20 sq. kms, on the northern side of the city.

### 3.4 Economical Profile.

The industrial clusters include Chemicals and Fertilizers, Pharmaceuticals, Biotechnology, Cotton textiles, Machine tools, Glass, Engineering, Tobacco, Fisheries and Dairy.

Major crops cultivated are Rice, Wheat, Sorghum (Jowar), Yellow Peas, Grams, Oilseeds, Groundnut, Tobacco, Cotton and Sugarcane.

The district has huge reserves of Dolomite and Fluorspar.

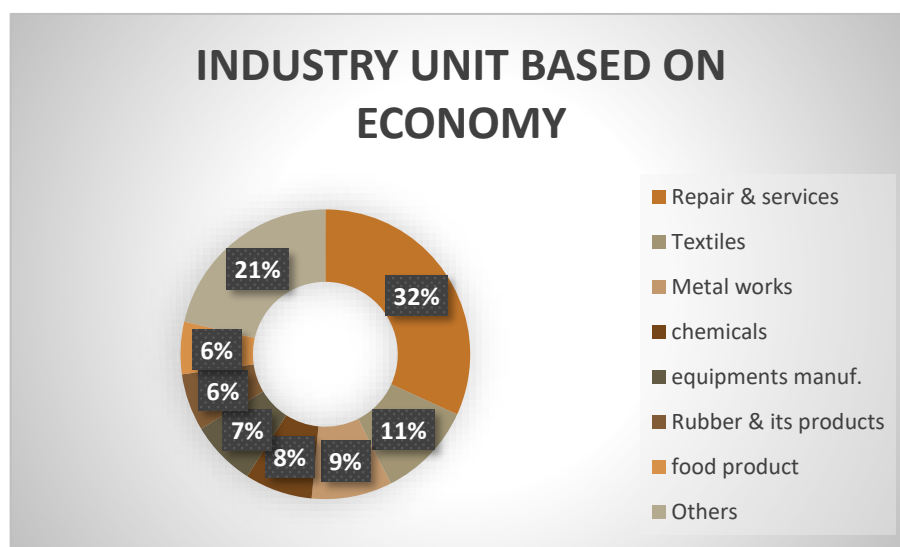
Manufacturing plants of several private industry players, as well as Public Sector Units (PSUs) such as Gujarat Alkalis and Chemicals Limited (GACL) and Gujarat State Fertilizers & Chemicals Ltd. (GSFC) are located here.

Retail sector is booming with seven malls under construction and another six at the planning stage.

We “**City Industries**” founded in the year **2000** are a prominent company that is betrothed in **manufacturing and supplying** a wide range of **Aluminium Component, Copper Profile, Copper Busbar, Plug In Base Assembly, Copper Alloy Component, Aluminium Profile and Copper Nickel Alloy**. We have enjoyed continuous growth over the last few years through its highly effective team. The objective of the company is to continue its development over the coming years and to place itself in a position to increasingly benefit from the growth of the Indian economy.

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

The industrial clusters include Chemicals & fertilizers, Pharmaceuticals, Biotechnology, Cotton Textiles, Machine Tools, Glass, Engineering, Tobacco, Fisheries and Dairy. There are over 18,000 small scale industrial units in Vadodara, in which repairs & services units are maximum in numbers accounting nearly 5,713 units, 1,923 textiles, 1,615 metal works, 1,357 chemicals, 1,316 equipment's\machinery, 1,145 rubber & its products, 1,047 food products and 3,840 are misc. units . Other key small scale industries include textiles, metal works, chemicals, equipment's, rubber products and food products etc.885 glass, ceramics & cement, 829 equipment's related to electricity, 753 papers & its products, 601 non ferrous metals, 543 leather, 173 tobacco and 56 are misc. units.



**Chart 3.1 Economic Ratio Of Production Unit.**

Source: Vadodara District Profile

### 3.4.1 Economic Drivers of Industry.

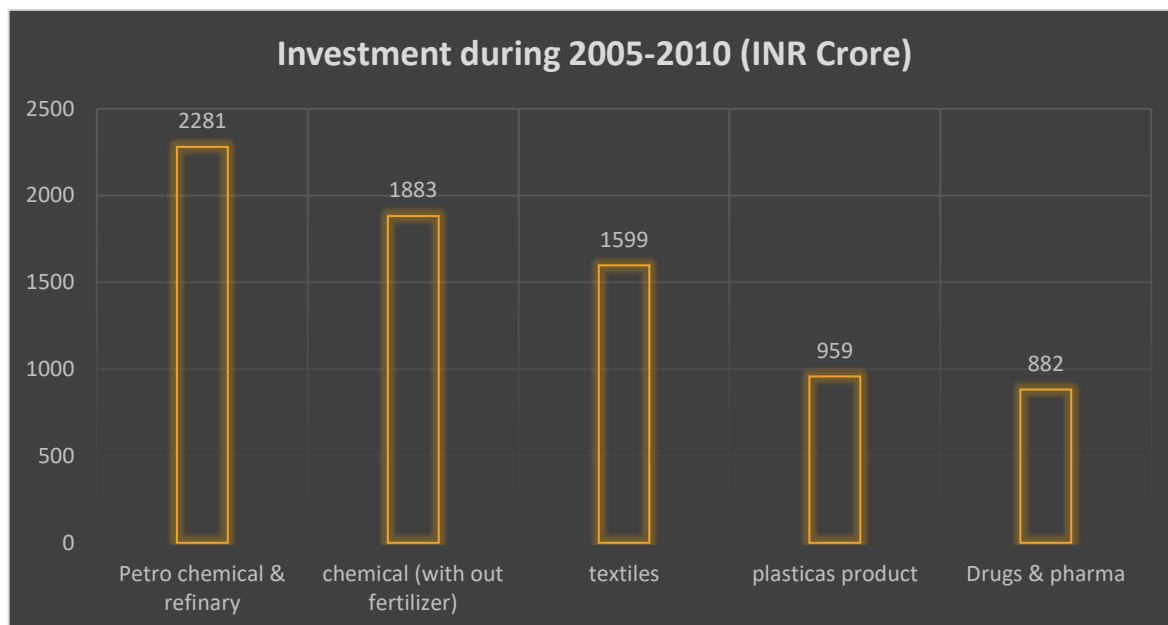
The Delhi-Mumbai Industrial Corridor passes through Vadodara, making it a key destination for attracting industrial investments.

Vadodara is the exclusive producer of Dolomite and Fluorspar in Gujarat, offering scope for tremendous growth in the processing industries.

Several Government companies such as GSFC and GACL have their manufacturing plants in the district.

Gujarat's leading educational institutions are located in Vadodara, offering skilled and intellectual manpower in abundance for various industries and R&D activities.

Proximity of Vadodara to key industrial centers of Gujarat such as Ahmedabad (via India's first Expressway), Bharuch and Surat, along NH8 could be considered a major driver for growth of the economy.



**Chart 3.2 Investment in Industrialization.**

Source: - Industries Commissionerate, Government of Gujarat.

### 3.5 Infrastructure Profile.

Vadodara is well connected to all major locations such as Delhi (1,028 km), and Mumbai (448 km) through Delhi-Mumbai Industrial Corridor ( DMIC) and on National Highway No.8. NH 8 also connects Vadodara with Ahmedabad (111 km), Rajkot (294 km), Ankleshwar (84 km),and Surat (167 km), the major industrial centres of Gujarat. State Highway No. 6 also connects the district with Ahmedabad, Surat and Rajkot among other districts. India's first National Expressway is passes through Vadodara connects it with Ahmedabad (93 km).

Vadodara is also well connected to all major locations such as Delhi, Mumbai and Ahmedabad as well as with other districts of the State from where Broad-gauge railway line passes through.

Vadodara has its own domestic airport at Harni, which is well connected with four metro cities in India such as Delhi, Mumbai, Chennai, Bangalore and Ahmedabad.

Water supply for industrial purposes in the district can be obtained from three main sources, viz. Gujarat Water Supply and Sewerage Board (GWSSB), Irrigation canals and Sardar Sarovar Project.

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

Sardar Sarovar envisages supply of water for drinking purposes, irrigation and industrial uses through branch canals.

**Figure 3.6 Infrastructure Development**

COMPONENTS	DESCRIPTION
<b>Export oriented industrial activity</b>	Engineering, Ceramics, Chemicals, Pharmaceuticals, Textiles
<b>IT/ITeS/Biotech hubs</b>	✓
<b>Integrated Township</b>	Residential, Commercial, Institutional/ Health, Transportation land use
<b>Augmentation of Existing Industrial Park/ Estate/ Cluster</b>	Ankleshwar, Jhagadia
<b>Development of Vadodara Airport</b>	✓
<b>Road-Rail based Warehousing and Packaging Facilities</b>	✓
<b>Knowledge Hub (Skill Development Centre)</b>	✓
<b>Feeder Road Links</b>	Augmentation of Vadodara-Rajpipla, Rajpipla-Ankleshwar-Dahej links
<b>Feeder Rail Links</b>	Served by Dedicated Freight Corridor (DFC) at Vadodara

Source: - Industries Commissionerate, Government of Gujarat.

### 3.5.1 Road

Vadodara is well connected to all major locations such as Delhi (1,028 km) and Mumbai (448 km) through DMIC and National Highway (NH) No. 8 .

NH 8 also connects Vadodara with Ahmedabad (111km), Rajkot (294 km ), Ankleshwar ( 84 km) Surat (167 km) – the major industrial centres of Gujarat .

State Highway 6 connects the district with Ahmedabad, Surat and Rajkot among other districts.

India's first National Expressway is located in Gujarat connecting Vadodara to Ahmedabad (93 km)

### 3.5.2 Rail

Vadodara is well connected to all major locations such as Delhi and Mumbai, as well as other districts of the State through a Broad-Gauge railway line.

### 3.5.3 Air

Vadodara has a domestic airport at Harni, which is well connected with four metro cities in India such as Delhi, Mumbai, Chennai and Bangalore.

### 3.5.4 Present Development.

The decision was taken at a high-level meeting between officials of the GIDC, the Vadodara Municipal Corporation (VMC) and the Vadodara Chambers of Commerce and Industries (VCCI) on Wednesday.

This comes after one Makarpura Infrastructure Industrial Development Board (MIIDB) failed to make headways in the parleys, even after a Memorandum of Understanding (MoU) was signed between MIIDB and GIDC two years ago.

GIDC will look after the repairing of storm water drains and roads.

Jayesh Rao, GIDC Divisional Manager, Vadodara, said: "An advisory committee will be formed comprising VCCI, MIIDB and VMC officials to suggest the GIDC authorities about the repair work."

GIDC Managing Director M Sahu was present in the meeting, said an official seeking anonymity. The official added that the project is estimated at Rs 20 crore.

"Fifty per cent of the funds will be contributed by Gujarat industrial development, 35 per cent by the GIDC and the rest 15 per cent will be contributed by the plot holders," the official said.

Confirming the meeting, Das said that the GIDC still needs to consult the higher authorities regarding the decisions taken today.

On the MoU with the MIIDB, Das said: "MIIDB also wanted to sign an MoU with the VMC for tax waiver, claiming that it was moving forward with the infrastructure development. However, there was no progress."

Comprising over hundreds of industrial units, Makarpura GIDC estate has concentration of mechanical industries. Every year, the units suffer huge losses due to flooding as the stormwater drain service remained in a bad shape.

### 3.6 About Study Area Profile.

We compiled an emissions inventory for the Vadodara region for the following pollutants – sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), carbon dioxide (CO<sub>2</sub>); and particulate matter (PM) in four bins (a) coarse PM with size fraction between 2.5 and 10 µm (b) fine PM with size fraction less than 2.5 µm (c) black carbon (BC) and (d) organic carbon (OC), for year 2015 and projected to 2030. In Phase 1, base year for all the calculations was 2015. In Phase 2, all the calculations are updated for year 2018.

We customized the SIM-air family of tools to fit the base information collated from disparate sources. Apart from the official reports, resource material ranges from GIS databases of land use, land cover, roads and rail lines, water bodies, built up area (represented in the adjacent figure), commercial activities (such as hotels, hospitals, kiosks, restaurants, malls, cinema complexes, traffic intersections, worship points, industrial hubs, and telecom towers), to population density and meteorology at the finest spatial resolution possible (1-km). A detailed description of these resources is published as a [journal article](#) in 2019, which also includes a summary of baselines and pollution analysis for 20 Indian cities.

This emissions inventory is based on available local activity and fuel consumption estimates for the selected urban airshed (represented in the grid above). This information is collated from multiple agencies ranging from the central pollution control board, state pollution control board, census bureau, national sample survey office, ministry of road transport and highways, annual survey of industries, central electrical authority, ministry of heavy industries, and municipal waste management, and publications from academic and non-governmental institutions.

For the road transport emissions inventory, besides the total number of vehicles and their usage information, we also utilized vehicle speed information to spatially and temporally allocate the estimated emissions to the respective grids. This is a product of google maps services. For the city of Vadodara, we extracted the speed information for representative routes across the city for multiple days. This data is summarized below for a quick look.

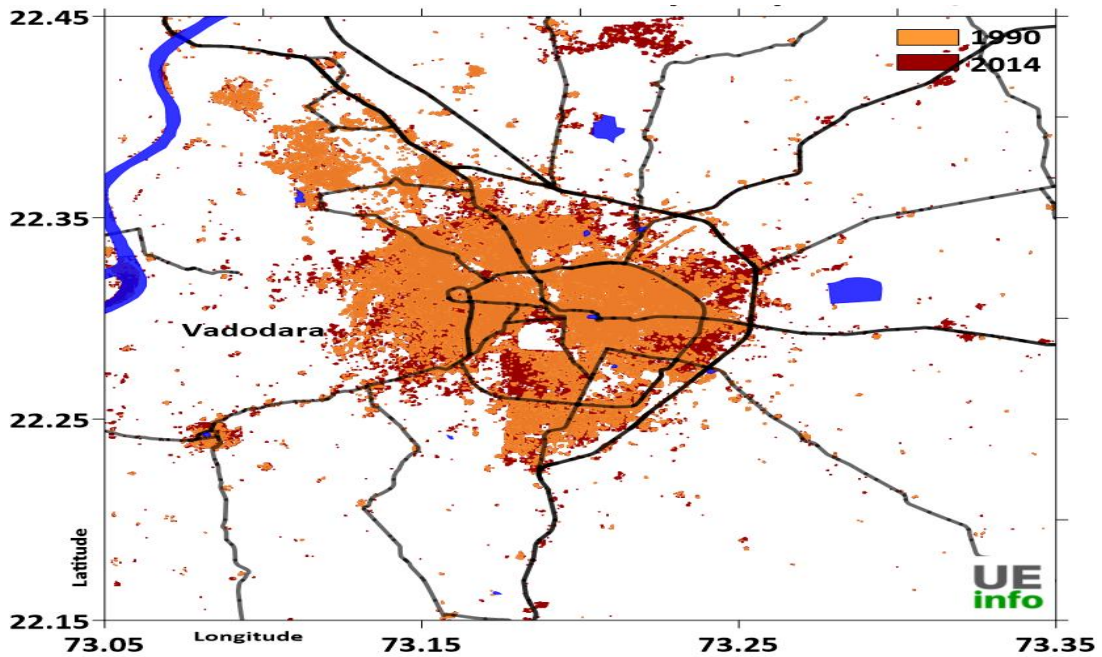


Figure 3.7 Pollution slowly occurrence in city

Source: - <http://www.urbanemissions.info/>

### 3.6.1 Study Area Description

**Makarpura** is a major area in Vadodara city of the Gujarat state in India.

It is an important industrial area of Vadodara city having Gujarat Industrial and Development corporation (G.I.D.C), which comprises many important and large Multinational corporations like Siemens, ALSTOM, ABB Group, TBEA, Philips, Panasonic, FAG, Sterling Biotech, Sun Pharmaceuticals, L&T, General Electric (Earlier known as Alstom), Bombardier, and GAGL (Gujarat Automotive Gears Limited). There are also a number of glass manufacturing companies in and around Vadodara, including Haldyn Glass, HNG Float Glass and Piramal Glass. the corporate of Makarpura is Pathak Ravindra. Vadodara Chamber of Commerce and Industry is also situated in Makarpura.

The Makarpura Palace is a former Gaekwad royal palace in this locality. It was built by Maharaja Khande Rao in 1870, designed in the Italian style. It was extended and renovated by Maharaja Sayajirao Gaekwad III. The palace is now used as a training school called No.17 Tetra School by the Indian Air Force.

Makarpura area is also an important area of Vadodara city in terms of transportation as it has a railway station and a bus station. Makarpura area also has the best concept school, phoenix high school with best quality of education.

- Makarpura GIDC between **72.51° to 74.17° southern Longitude and 20.49° to 22.49° western Latitude** on the World Map.

## PLANNING AND DESINING OF GREEN PATCHES FOR CARBON EMMISION

- Land acquire:-**3550.08 hac.**
- Development land :- **248.55 hac.**
- Total No. of plot:-**2370**
- No of. Unit in production :- **2346**



**Figure 3.8 lay out of the MAKAR PURA GIDC**

Source: - Makarpura GIDC Vadodara city.



**Figure 3.9 Boundary Of Makarpura GIDC**

Source: - Satellite Image Vadodara City.

3.6.2 Selection of Site.

The **wind direction** of the Vadodara city should be based on **Climatological Data of IMD Station** prove that the direction of the wind is the **south-west direction**.

We decided that **the Makarpura GIDC** should be placed in the middle part of the city.

Around the GIDC area, all areas should be a plan as a **residential or commercial** based as well the **wind direction** it should be affected by **people of Vadodara city**.



Figure 3.10 Wind Direction Of Vadodara Dist.

Source: - metoblue.weather.com

# PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

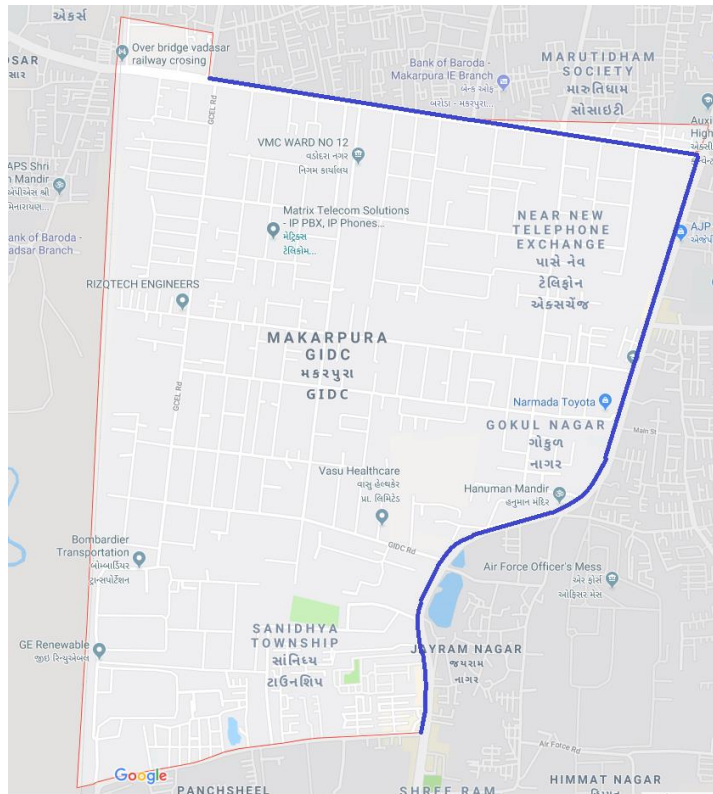


Figure 3.11 Study Distance And Study Road Network.

Source:- Makarpura GIDC Vadodara city.

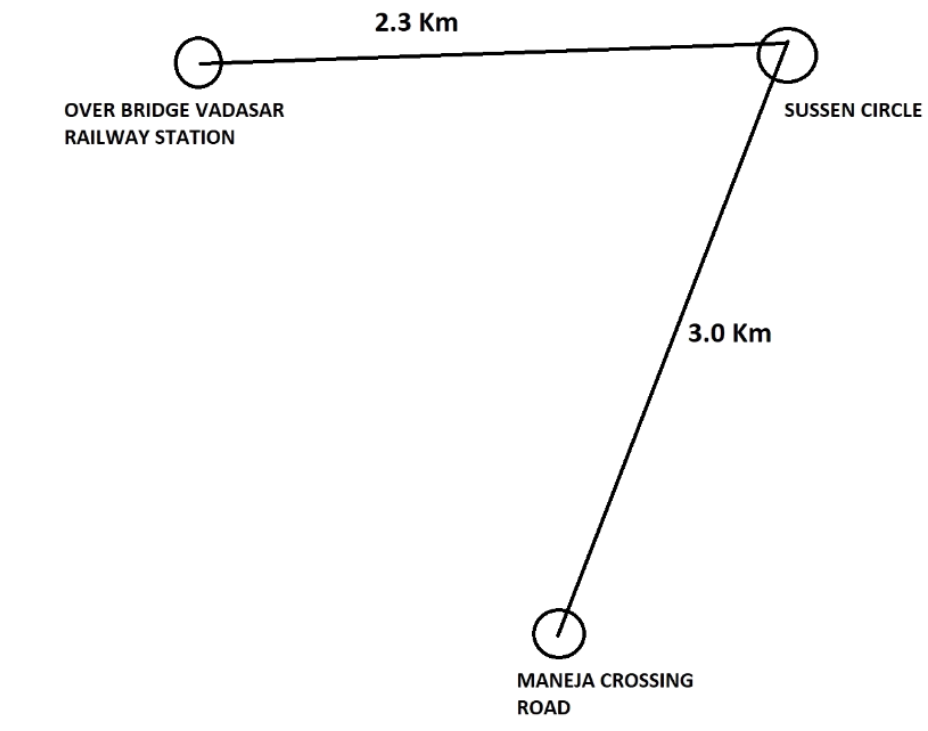


Figure 3.12 Study Road Network

# **CHAPTER-4 DATA COLLECTION**

**4.1 TOOLS & TECHNIQUE (FOR STUDY AREA)**

**4.2 STUDY SETUP & DATA COLLECTION**

**4.3 POLLUTION & TEMPERATURE RATIO**

**4.4 MAN POWER & HEALTH EFFECT OF POLLUTION IN AIR**

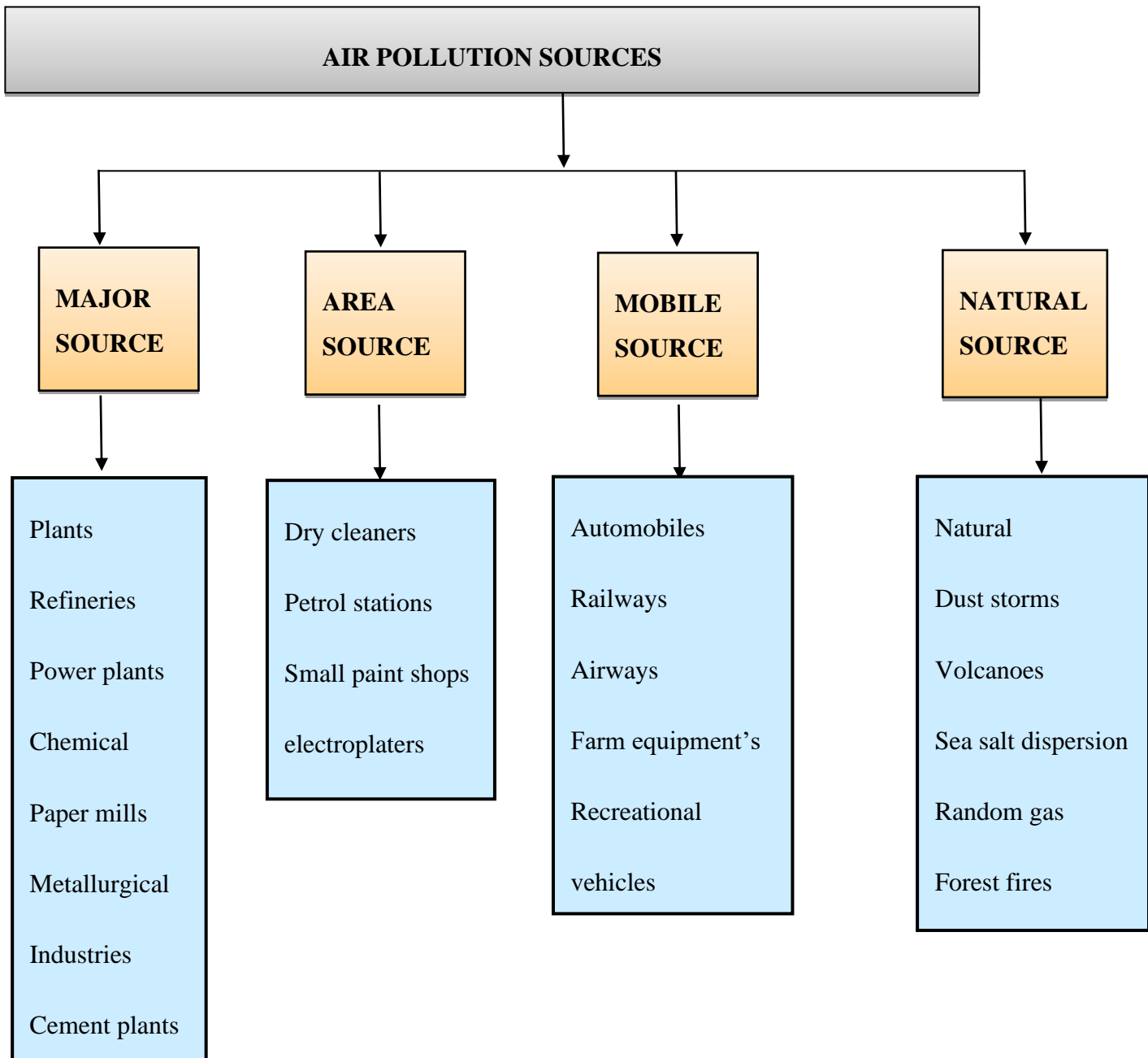
**4.5 FUTURE ACTION PLAN**



## CHAPTER 4

### DATA COLLECTION

#### 4.1 Tools and Technique (for study area)



#### 4.1.1 Ratio of Pollutant

The quantity of respective fuel is computed with the knowledge of the relative share of fuel and the quantity of fuel required for generating one unit of electricity (e.g., 0.7 kg coal is required for the generation of 1 unit [KWh] of electricity).

**Table 4.1 Net calorific values and CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emission factors for different fuel**

FUEL	NVC(TJ/KT)	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>Coal</b>	<b>19.63</b>	<b>95.81</b>	<b>0.001</b>	<b>0.0015</b>
<b>Natural Gas</b>	<b>48</b>	<b>56.1</b>	<b>0.001</b>	<b>0.0001</b>
<b>Naphtha</b>	<b>44.5</b>	<b>73.3</b>	<b>0.003</b>	<b>0.0006</b>
<b>Diesel Oil</b>	<b>43.33</b>	<b>74.1</b>	<b>0.003</b>	<b>0.0006</b>
<b>Natural Gas</b>	<b>48.632</b>	<b>64.2</b>	<b>0.003</b>	<b>0.0006</b>
<b>Low-Sulphur Heavy Stock</b>	<b>40.19</b>	<b>73.4</b>	<b>0.003</b>	<b>0.0006</b>
<b>Residual Fuel Oil</b>	<b>40.4</b>	<b>77.4</b>	<b>0.003</b>	<b>0.0006</b>
<b>Low-Sulphur Fuel Oil</b>	<b>41</b>	<b>73.3</b>	<b>0.003</b>	<b>0.0006</b>
<b>Heavy Fuel Oil</b>	<b>40.2</b>	<b>73.3</b>	<b>0.003</b>	<b>0.0006</b>

Sources: - Indian Network for Climate Change Assessment (INCCA 2010)

## 4.2 Study Setup and Data Collection

- Total 14 to 15 industry in Vadodara city

Sl. No.	Name of Indl. Area	Land acquired (Hec.)	Land Developed (Hec.)	Prevailing Rate per Sq. Mtr. (Rs.)	No. of Plots	No. Of Allotted Plots	No. of Vacant Plots	No. of Units in Production
1	Makarpura	355.08	248.55	3740	2370	2370	24	2346
2	Nandesari	271.68	190.18	1955	515	510	5	504
3	P. C. C.	666.16	466.31	540	370	370	0	370
4	Vaghodiya	314.91	220.43	525	925	924	1	872
5	Limda	53.10	37.17	--	--	--	--	--
6	Ranoli	41.22	28.85	1125	256	255	1	251
7	Por Raman-Gamdi	134.44	94.11	1000	564	562	2	537
8	Dabhoi	10.92	7.64	135	77	77	0	73
9	Sankheda	00.81	00.57	100	14	14	0	11
10	Pavi Jetpur	00.95	00.67	55	13	13	0	10
11	Savli	544.29	--	1050	971	814	157	492
12	Manjusar-Alindra & Jhumkal	536.69	377.07	--	--	--	--	--
13	Alindra(Expansion)	208.90	146.23	1050	--	--	--	--
14	Pilol Expansion	73.52	51.46	--	--	--	--	--
15	Pilol (Bombadier) EWxpansion	2.48	1.73	--	--	--	--	--
	TOTAL	3215.15	1870.97	-----	6075	5885	190	5466

**Source: GIDC, Vadodara.**

### 4.2.1 Why Makarpura Is Selected for Our Study Area.

- The **wind direction** of the Vadodara city should be based on **Climatological Data of IMD Station** prove that the direction of the wind is the **south-west direction**.
- We decided that **the Makarpura GIDC** should be placed in the middle part of the city.
- Around the GIDC area, all areas should be a plan as a **residential or commercial** based as well as the **wind direction** it should be affected by **people of Vadodara city**.

# PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

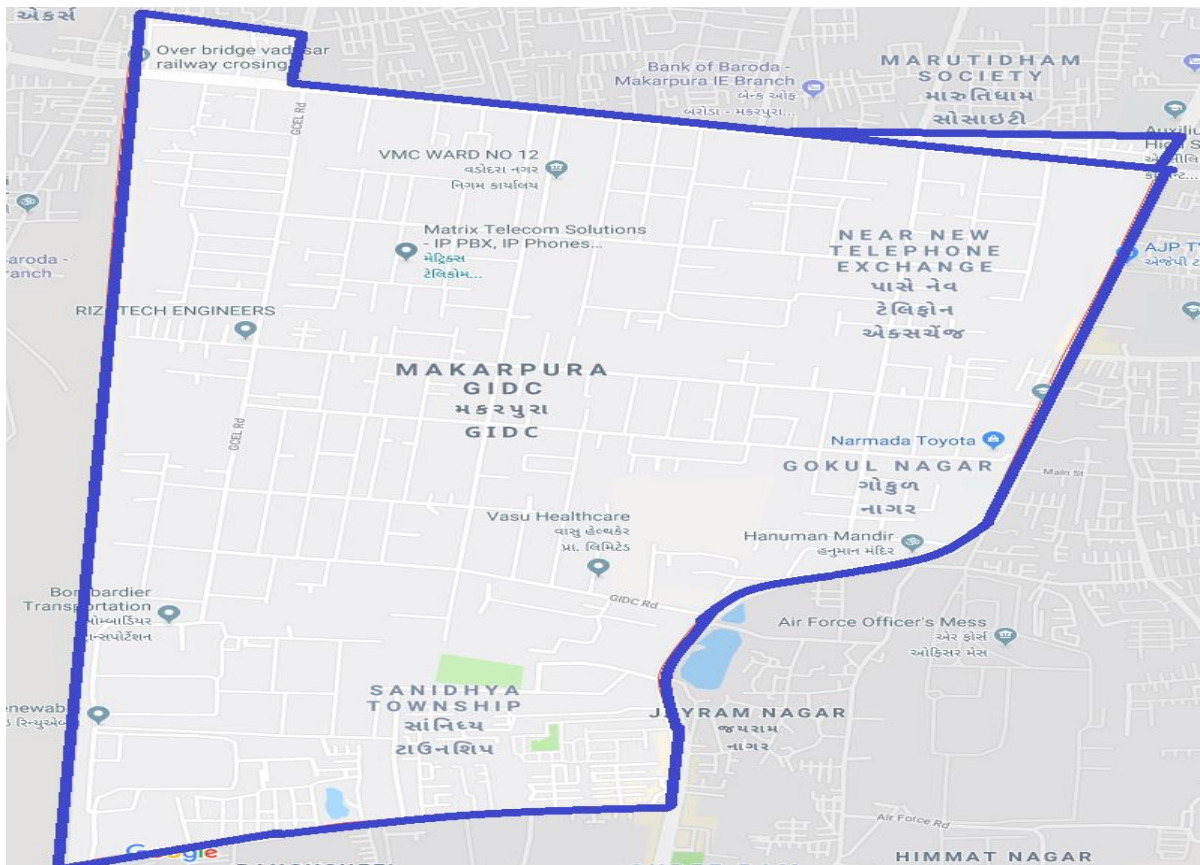


Figure 4.1 Makarpura GIDC

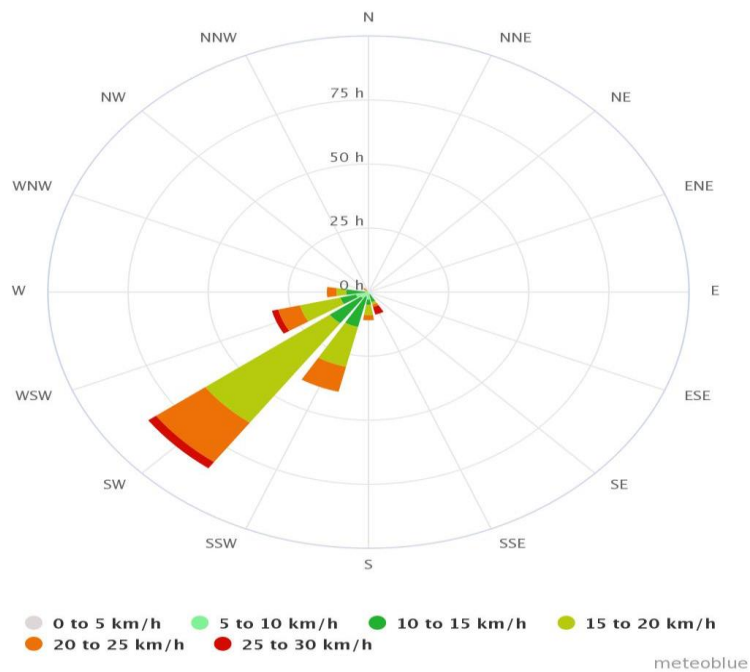


Figure 4.2 wind direction of Vadodra city

Source: - [Meteoblue](#)

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

- Makarpura GIDC between 72.51` to 74.17` southern Longitude and 20.49` to 22.49` western Latitude on the World Map.
  - **Land acquire:-3550.08 hac.**
  - **Development land :- 248.55 hac.**
  - **Total No.of plot:-2370**
  - **No of. Unit in production 2346**



**Figure 4.3 layout of the industry area**

Source: - Vadodara industrial layout profile

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

1. [A-2/510 - Patel Furnace & Forging Pvt. Ltd.](#)
2. [73/74 - VCCI Complex](#)
3. [74 - State Bank of India](#)
4. [75 - Makarpura Industrial Bank](#)
5. [76/77-1 - Umakant Party Plot](#)
6. [81/20 - S K D Enterprise](#)
7. [82 - Gujarat Aluminium Extrusion Private Limited](#)
8. [87/4 - Dhananjay Poly Processors](#)
9. [88 - Perfect Hydraulic Engineering Co](#)
10. [89/1 - Surendra Industries](#)
11. [89/2 - Narmada Enterprise](#)
12. [90/96 - Ushail Sales & Services](#)
13. [91 - Fusion Ceramic Tiles](#)
14. [92 - Star Plastic Industries](#)
15. [94 - Rangoli Plastic Industries](#)
16. [95 - B V K Enterprises](#)
17. [97 - Hasan Industrial Corporation](#)
18. [101/2 - Patel Printers & Stationers](#)
19. [101/1 - Demla Enterprise](#)
20. [102/2 - Paragon Synthetics](#)
21. [102/3 - Paragon Plastic Industries](#)
22. [102/1 - Atul Trading Corporation](#)
23. [103/2 - Dinesh Engineering Co](#)
24. [104 - H B Engineering Private Limited](#)
25. [105 - Shree Ram Foundry Corporation](#)
26. [106/13 - Yogi Enterprises](#)
27. [106/1-2-3-4 - Gurupal Industries](#)
28. [106/5 - Lord's Enterprises](#)
29. [106/11 - S M Engineering Works](#)
30. [106/10 - Xcon Controls](#)
31. [106/6 - M V Panchal](#)
32. [107 - Unifab Engineers](#)
33. [108/2 - B S A Enterprises](#)
34. [108/1 - Aditi Industries](#)
35. [148 - Taj Industries](#)
36. [149 - Jay Associates](#)
37. [150/A - Ambitious Engineers](#)
38. [150/B - Primax Engineers](#)
39. [151/1 - Lalit Engineers](#)
40. [151/2 - Kusumit Electro Works](#)
41. [152 - Green Electricals Private Limited](#)
42. [186 - Dipak Engineering Works](#)
43. [190/191/192 - Matrix Comsec Pvt Ltd-R & D Center](#)
44. [195 - Twin Antennas](#)
45. [303 - INDIAN ENGINEERING WORKS.](#)
46. [323/B/Basement 1 to 5 - HARIOM ELECTRONICS, The Load Cell Manufacturing Company](#)
47. [382 - 382 Dyna Mech](#)
48. [383 - Gautam Electricals & Contractors](#)
49. [383 - Gautam Engineers](#)
50. [421/422 - Wearresist Technologies Pvt Ltd](#)
51. [484 - Halol Jal Sagar-Makarpura](#)
52. [485/B-1 - Sayaji Tempo \(Force\)](#)
53. [485/486-A - Mahavir Engineering Company](#)
54. [485/B-2 - Polycraft Puff Unit - I](#)
55. [486/B-1 - Allied Electronics Corporation](#)
56. [486/B-2 - Chamunda Technical Services](#)
57. [749/9 - Krison Engineering Works](#)
58. [757/C - PRAVIN STEEL INDIA](#)
59. [858/2B - Mech-Tech Engineers](#)
60. [858/3C - Shivam Engineers](#)
61. [859/2A - Ankur Industries](#)
62. [859/2D - Wearresist Technologies Pvt Ltd](#)
63. [859/1D - Reliable Equipment Company](#)
64. [859/1E - Avadh Industries](#)
65. [859/3B - Aatmiya Polymers Industries](#)
66. [859/1B - Shaimil Laboratories](#)
67. [859/2C - Shilpa Engineering Works](#)
68. [859/1A - J K Fabricators & Engineers](#)
69. [859/4/A - R G Industries](#)
70. [859/4D - Balco Chemicals](#)

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

71. [859/4/B - Shree Gayatri Wood Works](#)
72. [860/1B - Dharmaj Enterprises](#)
73. [860/6 - GETCO Electrical Sub-Station](#)
74. [860/5 - Hydro Forge Industries](#)
75. [860/4A - Sarju Engineering](#)
76. [860/1A - Ambica Enterprises](#)
77. [860/2A - Stanfab Engineering Private Limited](#)
78. [860/3 - Sunrise Industrial Equipments Co](#)
79. [860/4B - Kuldev Engineering Works](#)
80. [861/5/1 - Bvm Engineers](#)
81. [861/1 - Royal Steel](#)
82. [861/5/2 - Jay Mahakali Shot Blasting](#)
83. [861/4 - Wearresist Technologies Pvt Ltd](#)
84. [861/5/3 - Maruti Engineering](#)
85. [862/6D - Baroda Sand Blasting](#)
86. [862/6A - Aditya Engineering Works](#)
87. [862/1 - Relax Pharmaceuticals](#)
88. [862/7/A - Canon Metal Industries](#)
89. [863/3 - C K Associates](#)
90. [863/6 - Doshi Technologies Pvt Ltd](#)
91. [863/1 - Mahavir Corporation](#)
92. [864/A - Newton Engineers & Chemicals Ltd](#)
93. [864/B4 - Newton Engineering & Chemicals Ltd](#)
94. [865/6B - Pentagon Engineering Industries](#)
95. [865/6A - Advance Engineering Fab Industry](#)
96. [865/8 - Supreme Technoplast](#)
97. [865/1 - Shree Umiya Industries](#)
98. [866/1 - Kaizen Switchgear Products](#)
99. [868 - Aatman Electro Magnetic Pvt Ltd](#)
100. [870/18 - Roy Enterprise](#)
101. [870/2 - Sima Engineering Works](#)
102. [870/13 - Moon Light Electricals](#)
103. [870/14 - Baroda Valves & Solenoids](#)
104. [870/6 - Shantiprakash Engineering Works](#)
105. [870/20 - Paragon Synthetics & Polymers Industries Ltd](#)
106. [870/15 - Matchless Engineers](#)
107. [870/10 - Polycraft Puff Machine Pvt Ltd](#)
108. [870/5B - Angstrom Biotech Pvt Ltd](#)
109. [870/16 - Sai International](#)
110. [870/4 - Shree Gayatri Die Works](#)
111. [870/17 - Hydromech Engineers](#)
112. [870/7 - Kaushik Industries](#)
113. [870/5/A - Lucky Traders](#)
114. [870/3 - Suchi Wires Industries](#)
115. [870/8 - Shubham Automation](#)
116. [870/19 - Atmiya Engineering & Plastics](#)
117. [870/12 - Ashish Engineers Company](#)
118. [870/1 - Riya Enterprise](#)
119. [870/11 - Paras Engineers](#)
120. [870/9 - S K Industries](#)
121. [871/A - Ishwar Engineering](#)
122. [871/B/3 - Kadam Environmental Consultants](#)
123. [871/B/1-B/2 - Techno Concepts Systems](#)
124. [872/1C - Aanjaney Micro-Engineering Pvt Ltd](#)
125. [905/3 - APS Pvt Ltd](#)
126. [924/B - Shree Chamunda Industries](#)
127. [986/32 - Aster Datsun](#)
128. [987/10-B - JALARAM PLY DECOR](#)
129. [GIDC Green Space](#)
130. [ROYAL INDUSTRIES](#)

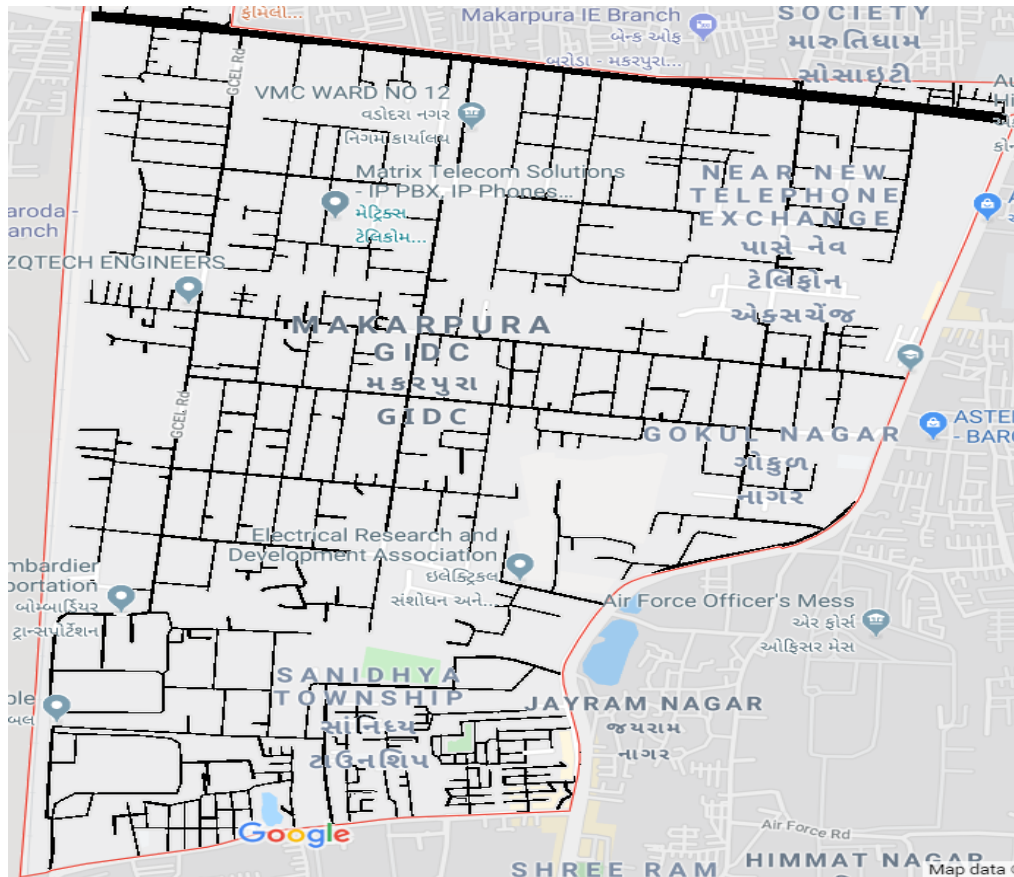


Figure 4.4 Unit Block Of GIDC

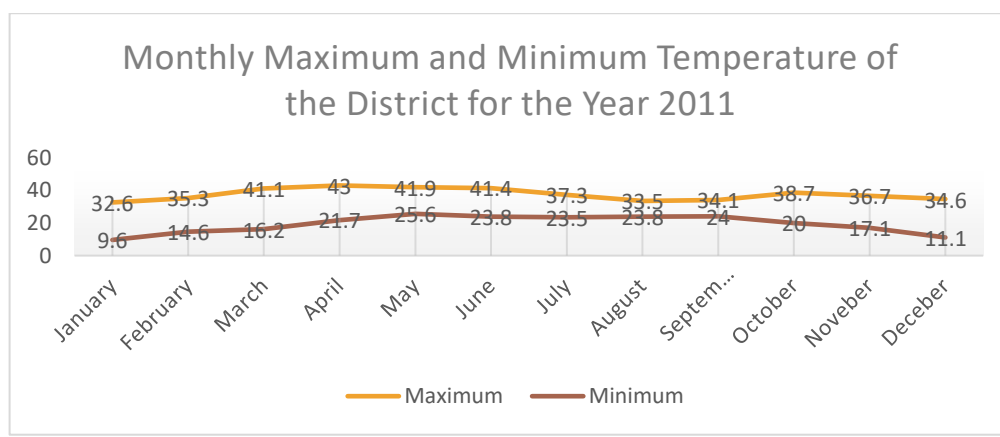
### 4.3 Pollution & Temperature Ratio.

Vadodara has its own meteorological observatory in the district. The records of this observatory may be taken as representative of the meteorological conditions in the district in general. The period from March to May is generally one of continuous increase in temperature. Generally May is the hottest month. Nights during June are warmer than in May. From the beginning of November both day and night temperature gradually drops and January becomes the coldest month as the daily maximum and minimum temperature for January found to be lower than that of other months. Cold waves sometimes affect the district in association with western disturbances which move across north India during the cold season.

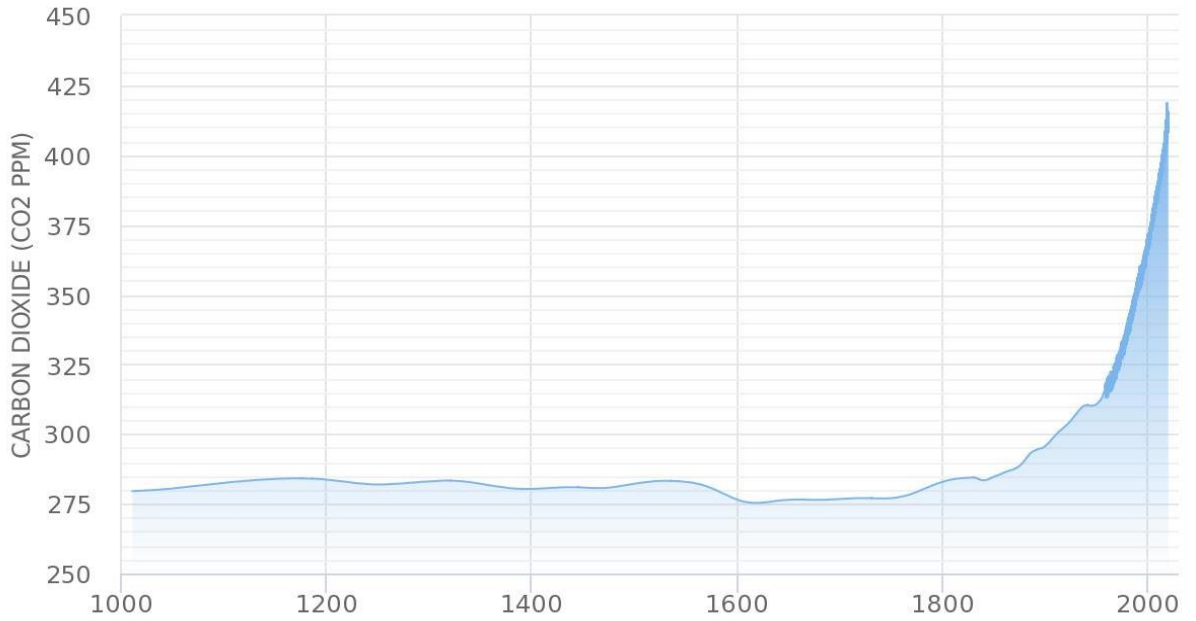
**Table 4.2 Year Wise Maximum and Minimum Temperature**

Sr.No	Year	Temperature	
		Maximum	Minimum
1	2010	40.3	12.7
2	2011	40.4	13.2
3	2012	42.1	14.1
4	2013	46.2	9.4
5	2014	44.5	8.5
6	2015	42.3	9.4
7	2016	43.5	10.4
8	2017	42.5	6.3
9	2018	44.2	12.0
10	2019	45.2	10.9

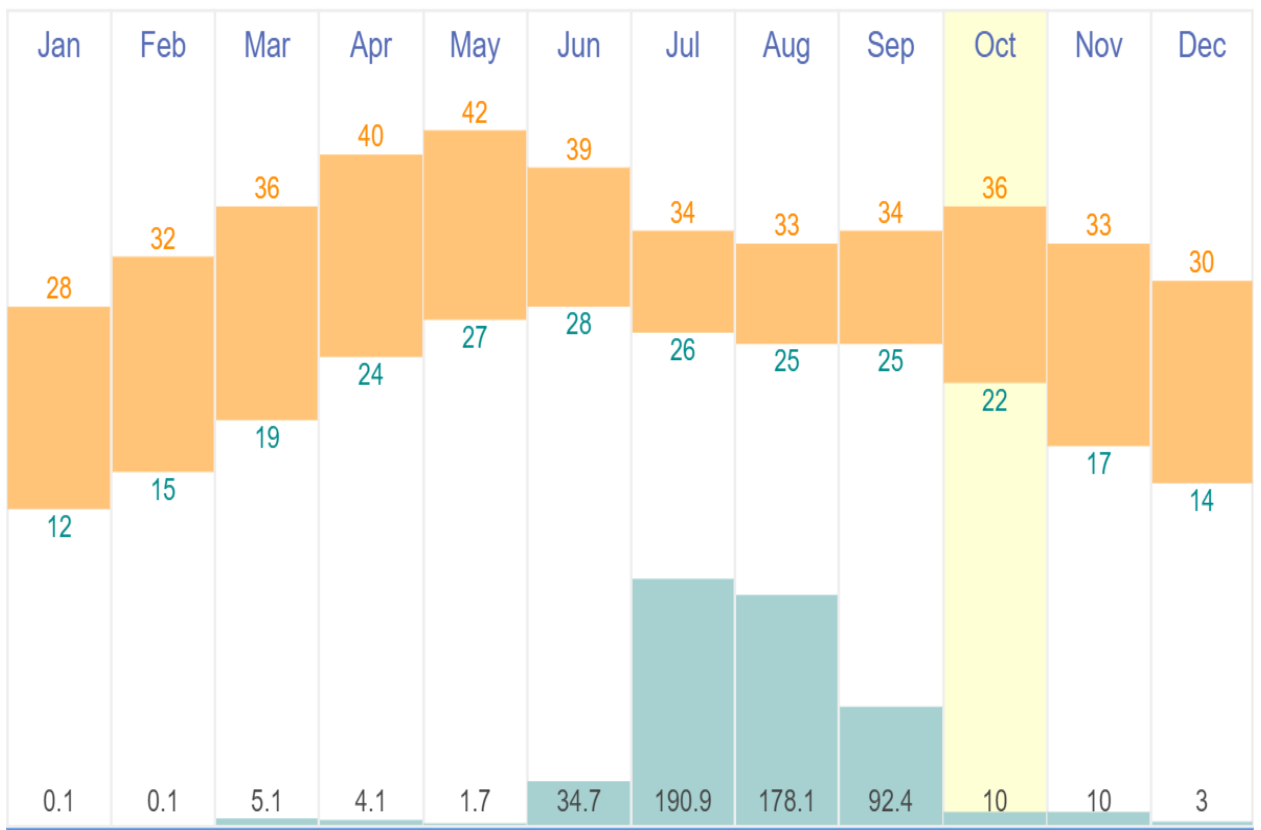
Statistical Abstract- 2012, Directorate of Economics and Statistics



**Chart 4.1 Monthly Maximum and Minimum Temperature of the District for the Year 2011**



**Figure 4.5 CO2 Level in Industrial Area.**



**Figure 4.6 Temperature of Base On Month**

Source: -weather costume of Vadodara

➤ **Monthly temp. on year 2010**

Month	Max Temp (Deg.C )	Mini Temp (Deg.C)	Humidity (%)	Wind Spd. Kmpd	Sun shine (Hours)	Solar Rad. (MJ/m2/ d)	Eto (mm/d)	Rainfall (mm)
January	30.30	12.00	50.00	65.80	9.10	17.23	3.02	1.20
February	33.00	13.80	43.00	67.50	9.70	20.07	3.81	0.60
March	37.10	18.40	36.50	69.10	10.20	23.16	4.88	2.20
April	40.20	22.90	36.50	79.00	10.80	25.75	6.03	0.90
May	40.90	26.50	44.50	143.20	10.90	26.38	7.46	4.40
June	37.10	27.00	63.50	169.50	7.10	20.62	5.97	146.80
July	32.70	25.70	80.00	138.20	4.40	16.51	4.11	297.60
August	31.50	25.00	82.00	116.80	4.50	16.32	3.82	284.70
September	33.20	24.30	74.50	83.90	6.90	18.87	4.28	141.70
October	36.00	21.30	58.00	49.40	9.30	20.24	4.12	22.00
November	34.30	16.70	52.50	49.40	9.40	18.02	3.24	16.20
December	31.20	13.40	55.00	59.20	9.10	16.50	2.83	4.40
<b>Total</b>	-	-	-	-	-	-	-	<b>922.70</b>
<b>Average</b>	<b>34.79</b>	<b>20.58</b>	<b>56.33</b>	<b>90.92</b>	<b>8.45</b>	<b>19.97</b>	<b>4.46</b>	-

Figure 4.7 Temperature of Base on Month

Source: -weather costume of Vadodara

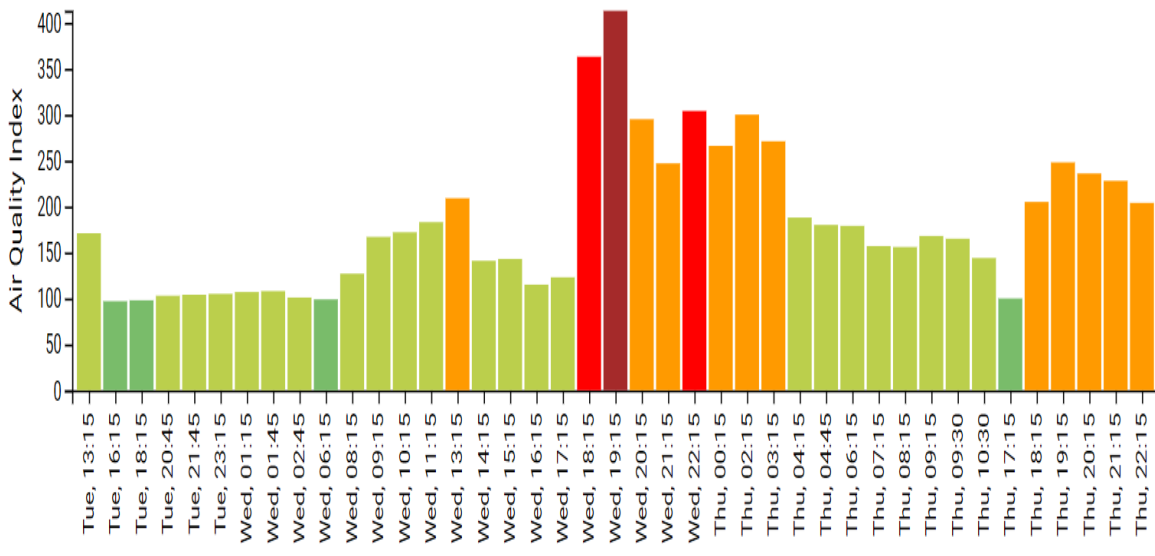


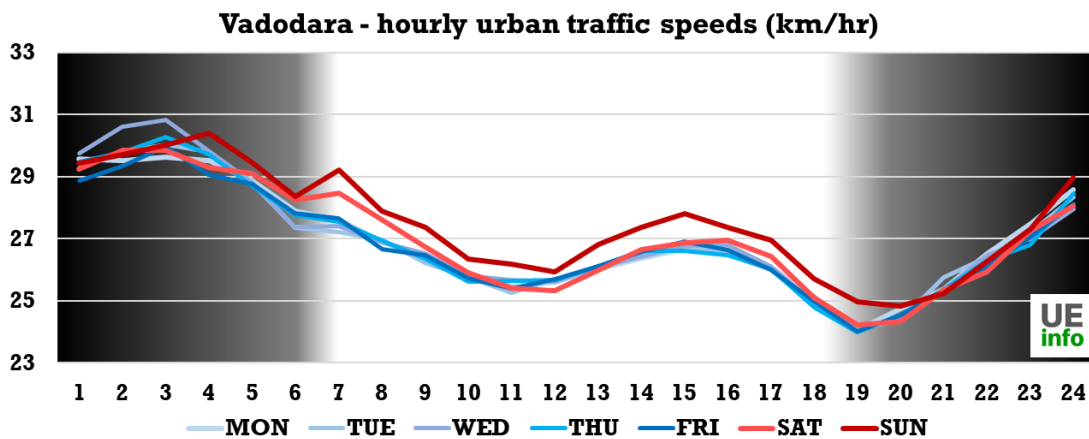
Figure 4.8 Temperature Of Base On hourly

Source: -weather costume of Vadodara

**4.3.1 Pollutant Value at Industrial Area.**

We compiled an emissions inventory for the Vadodara region for the following pollutants – sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), carbon dioxide (CO<sub>2</sub>); and particulate matter (PM) in four bins (a) coarse PM with size fraction between 2.5 and 10 µm (b) fine PM with size fraction less than 2.5 µm (c) black carbon (BC) and (d) organic carbon (OC), for year 2015 and projected to 2030. In Phase 1, base year for all the calculations was 2015. In Phase 2, all the calculations are updated for year 2018.

We customized the SIM-air family of tools to fit the base information collated from disparate sources. Apart from the official reports, resource material ranges from GIS databases of land use, land cover, roads and rail lines, water bodies, built up area (represented in the adjacent figure), commercial activities (such as hotels, hospitals, kiosks, restaurants, malls, cinema complexes, traffic intersections, worship points, industrial hubs, and telecom towers), to population density and meteorology at the finest spatial resolution possible (1-km). A detailed description of these resources is published as a [journal article](#) in 2019, which also includes a summary of baselines and pollution analysis for 20 Indian cities.



**Figure 4.9 Urban Traffic Speed**

Source: - <http://www.urbanemissions.info/>

This emissions inventory is based on available local activity and fuel consumption estimates for the selected urban airshed (represented in the grid above). This

information is collated from multiple agencies ranging from the central pollution control board, state pollution control board, census bureau, national sample survey office, ministry of road transport and highways, annual survey of industries, central electrical authority, ministry of heavy industries, and municipal waste management, and publications from academic and non-governmental institutions.

For the road transport emissions inventory, besides the total number of vehicles and their usage information, we also utilized vehicle speed information to spatially and temporally allocate the estimated emissions to the respective grids. This is a product of google maps services. For the city of Vadodara, we extracted the speed information for representative routes across the city for multiple days. This data is summarized below for a quick look.

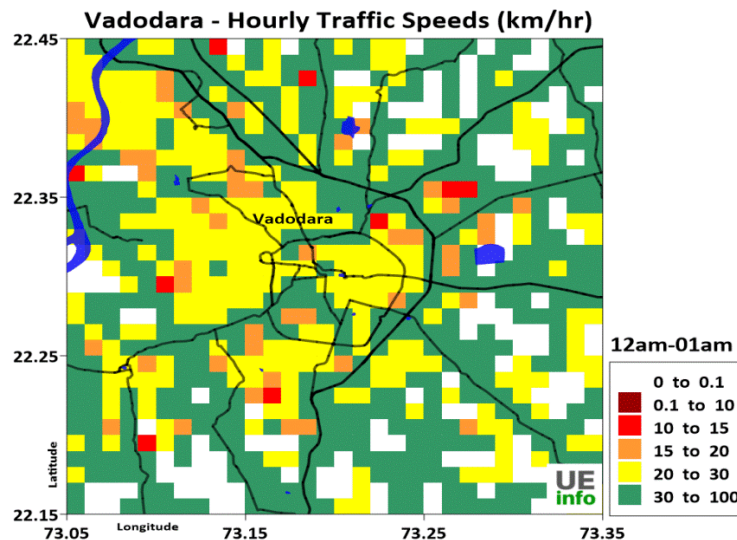


Figure 4.10 Hourly traffic in industrial area of Vadodara

Source: - <http://www.urbanemissions.info/>

#### 4.3.1.1 Different Pollutant Value

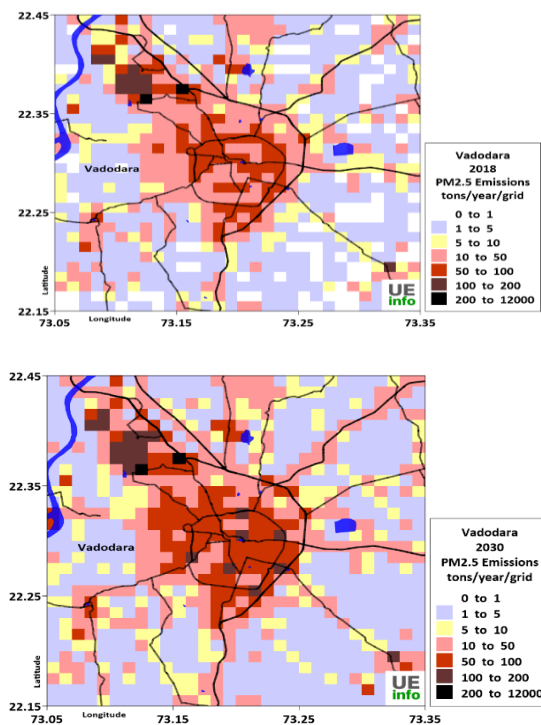
The summary for a city’s emissions inventory does not include natural emission sources (like dust storms, lightning, and sea salt) and seasonal open (agricultural and forest) fires. However, these are included in the overall chemical transport modelling in the national scale simulations. These emission sources are accounted in the

concentration calculation as an external (also known as boundary or long-range) contribution to the city’s air quality.

**PM<sub>2.5</sub>:-**

Projections to 2030 under the business as usual scenario are influenced by the city’s social, economic, land use, urban, and industrial layout and hence the projected (increasing and decreasing) rates that we assume are an estimate only. We based the vehicle growth rate on the sales projection numbers; industrial growth on the gross domestic product of the state; domestic sector, construction activities, brick demand, diesel usage in the generator sets, and open waste burning on population growth rates and notes from the municipalities on plans to implement waste management programs. We used these estimates to evaluate the trend in the total emissions and their likely impact on ambient PM<sub>2.5</sub> concentrations through 2030.

The emissions inventory was then spatially segregated at a 0.01° grid resolution in longitude and latitude (equivalent of 1 km) to create a spatial map of emissions for each pollutant (PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, CO and VOCs). The gridded PM<sub>2.5</sub> emissions and the total (shares by sector) emissions are presented below.



**Figure 4.11 Gridded PM<sub>2.5</sub> Emissions (2018 and 2030)**

**Total PM<sub>2.5</sub> Emissions by Sector 2018-2030.**

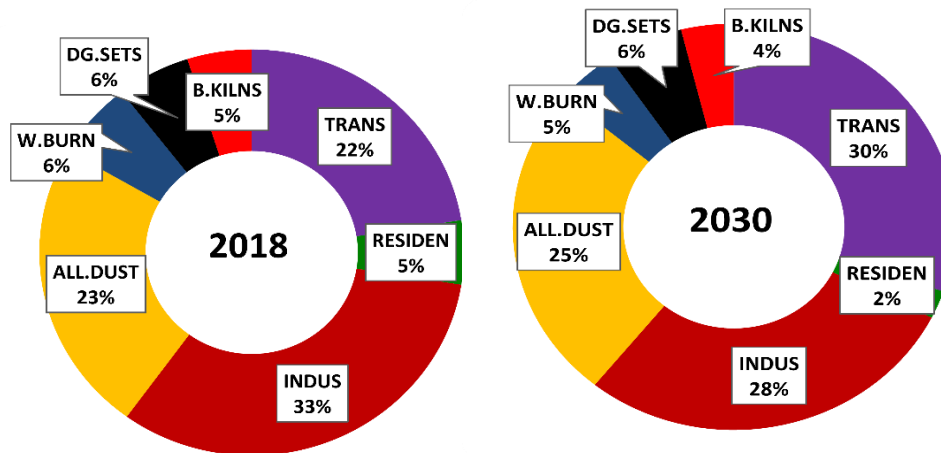


Figure 4.12 PM<sub>2.5</sub> Emissions by Sector 2018-2030.

Source: - <http://www.urbanemissions.info/>

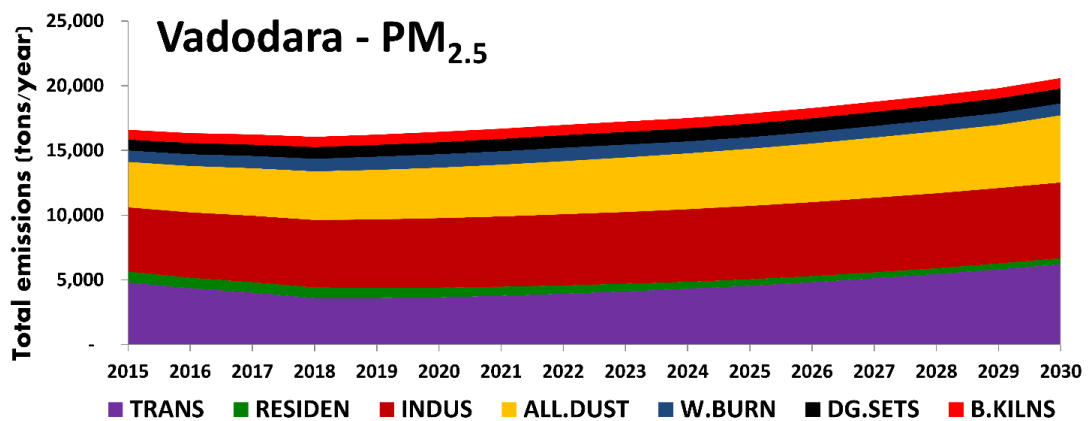


Figure 4.13 PM<sub>2.5</sub> Emissions by Sector 2018-2030.

Source: - <http://www.urbanemissions.info/>

We calculated the ambient PM<sub>2.5</sub> concentrations and the source contributions, using gridded emissions inventory, 3D meteorological data (from WRF), and the CAMx regional chemical transport model. The model simulates concentrations at 0.01° grid resolution and sector contributions for the urban area, which include contributions from primary emissions, secondary sources via chemical reactions, and long range transport via boundary conditions (represented as “boundary” in the pie graph below).

The ribbon graph shows the variation for average PM<sub>2.5</sub> pollution by month. Due to precipitation during the monsoon, usually pollution levels dip and may fall within national air pollution standards, however most cities are unable to attain these standards at other times of the year.

The following is a map of annual average PM<sub>2.5</sub> pollution for the city of Vadodara. The main sources contributing towards PM<sub>2.5</sub> in 2018 are in the pie-chart on the left. The change in contributions in 2030 from different sources are shown on the right.

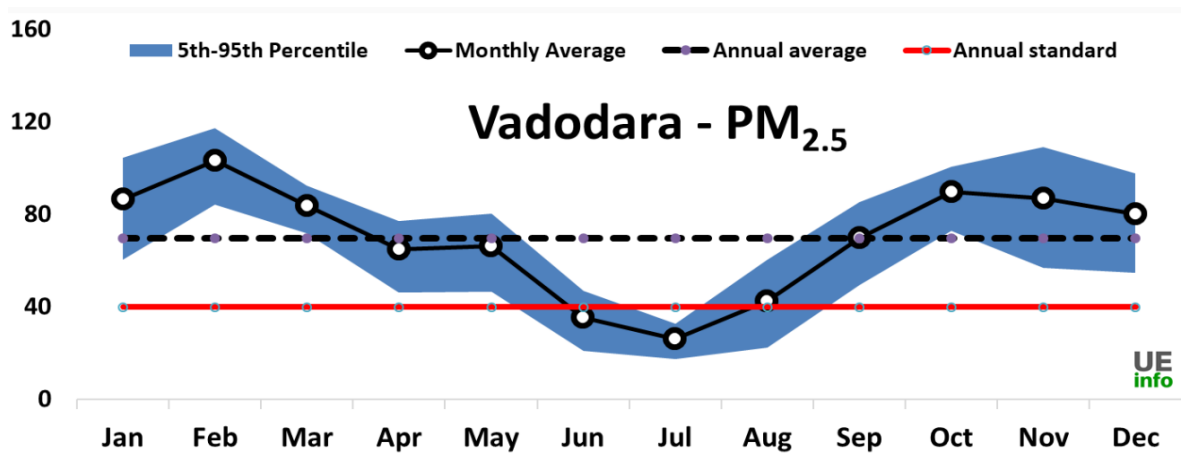


Figure 4.14 Ribbon Graph of Pollutant

Source: - <http://www.urbanemissions.info/>

**PM<sub>10</sub>: -**

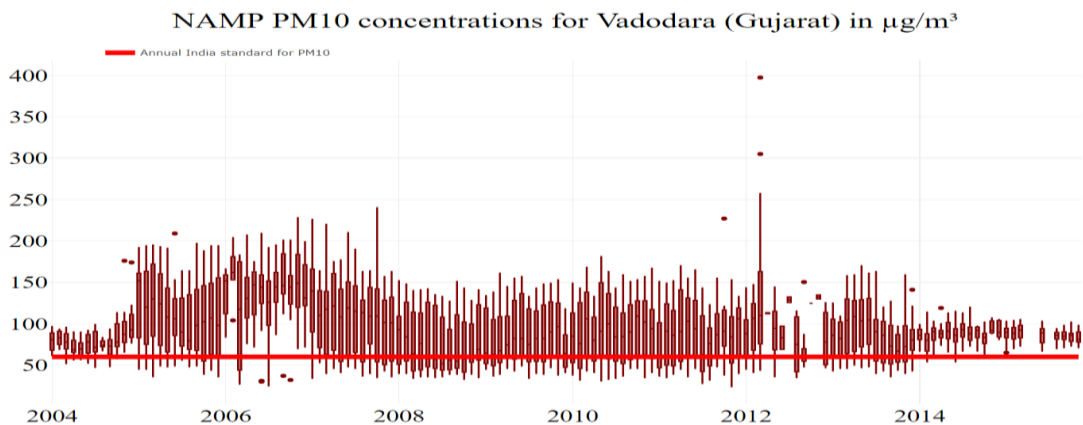


Figure 4.15 PM10 Emissions by Sector 2015.

Source: - <http://www.urbanemissions.info/>

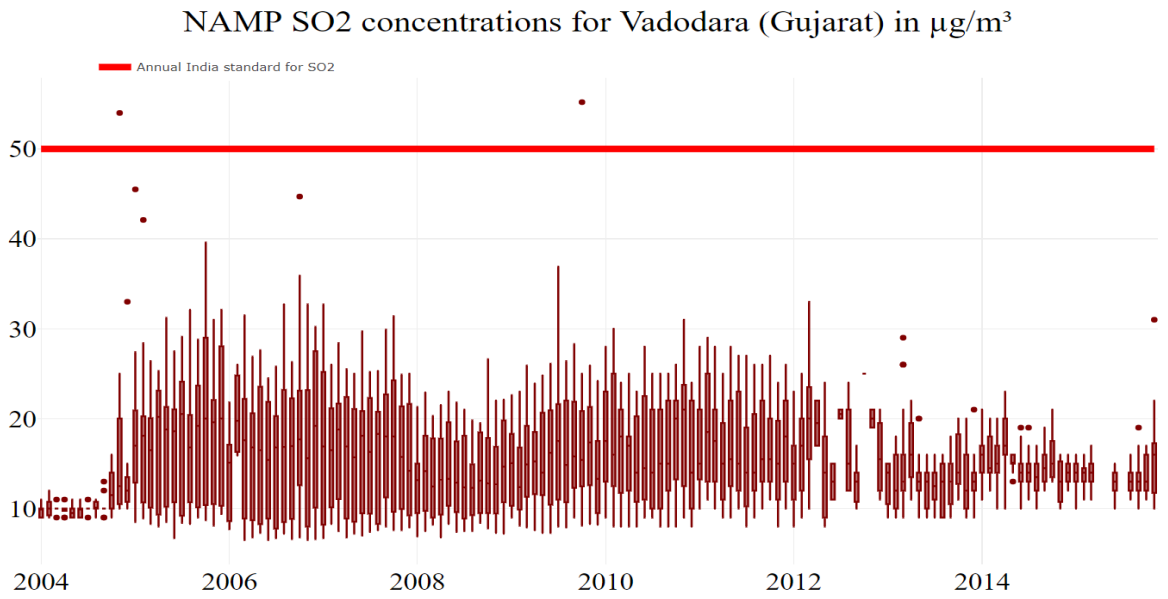


Figure 4.16 So<sub>2</sub> Emissions by Sector 2015.

Source: - <http://www.urbanemissions.info/>

**No<sub>2</sub>:** -

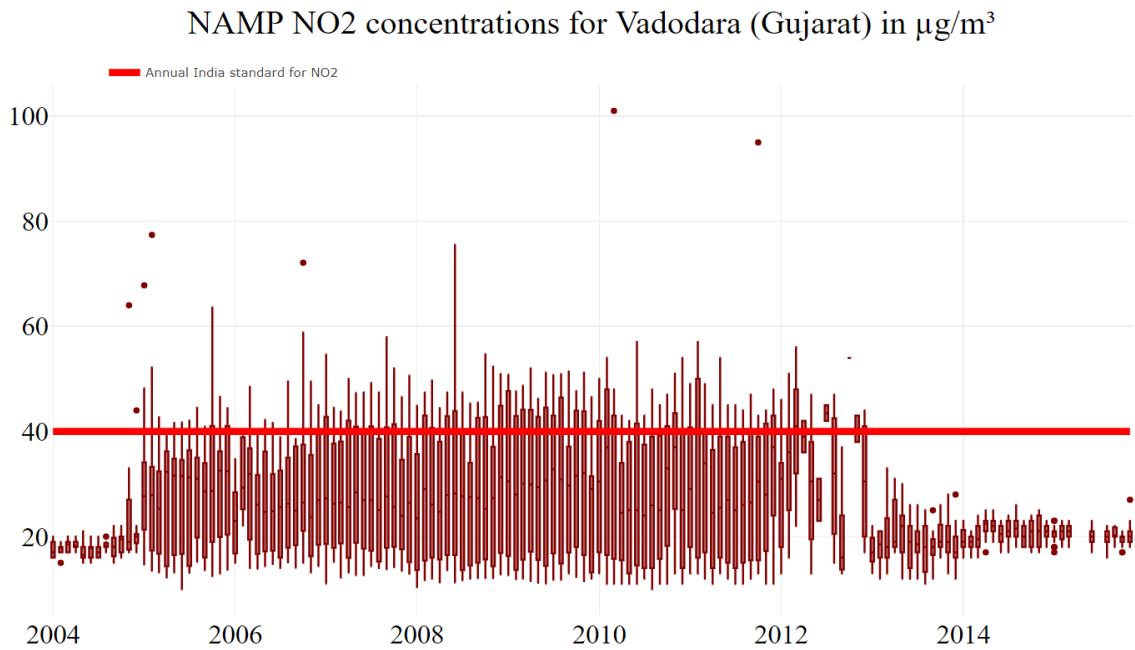


Figure 4.17 No<sub>2</sub> Emissions by Sector 2015.

Source: - <http://www.urbanemissions.info/>

4.4 Man Power And Health Effect of Pollutant in Air.

When Gujarat became a separate State after the bifurcation of the bilingual Bombay State, it was realized that one of the most important inputs required for agriculture was fertilizer. To meet the enormous needs of food for the ever-increasing population of the country, it was necessary inter alia to produce more fertilizers in the country itself rather than depend on imports. Accordingly, in 1960 the Government of Gujarat, then under the able leadership of Dr. Jivraj Mehta, conceived of this project. A new company called Gujarat State Fertilizers Company Limited (GSFC) was established in 1962 near Vadodara.

The total numbers of registered factories and average number of daily workers employed by major groups of industries for the year 2009-10 and 2010-11 are shown in the following statement.

**Table 4.3 Distribution of Important Industrial Establishments by Major Industrial Group**

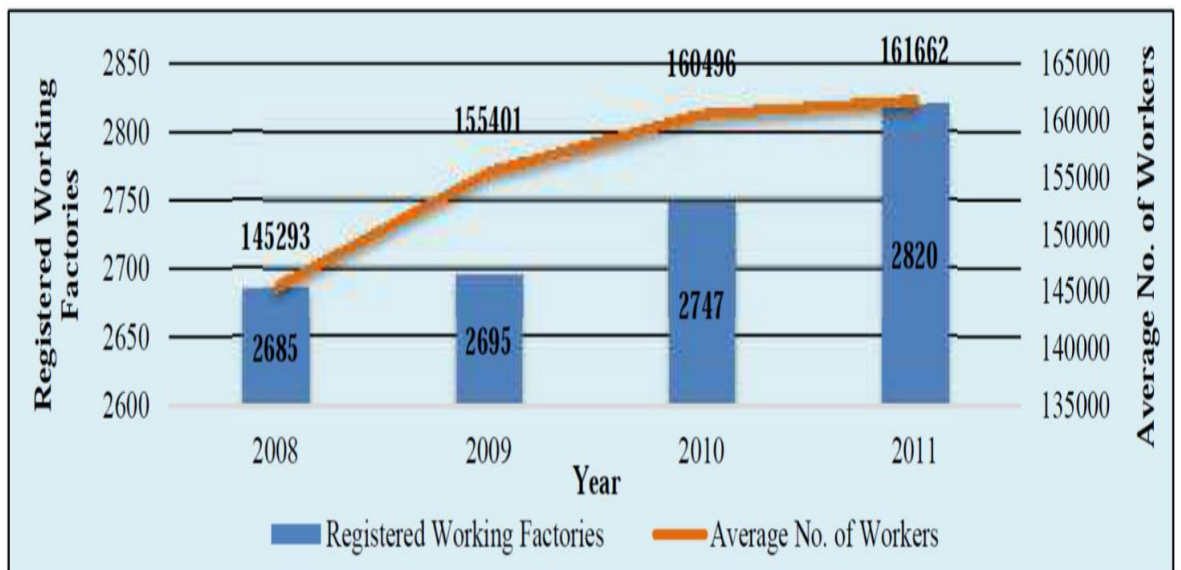
SR.NO	GROUP NAME	2009-10		2010-11	
		NO.OF ESTABL.	AVR. NO.OF PERSONS WORKING/DAY	NO.OF ESTABL.	AVR.NO.OF PERSONE WORKING/DAY
1	Textiles	17	486	71	143
2	Machinery and parts except electrical	118	1544	150	1858
3	Mining and Quarrying	16	282	34	393
4	Food Products	36	666	26	508
5	Chemical & chemical	117	2175	97	1666

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

	<b>Products</b>				
<b>6</b>	<b>Wood Products</b>	16	134	8	61
<b>7</b>	<b>Rubber &amp; Plastic Products</b>	42	612	32	388
<b>8</b>	<b>Non-metallic mineral Products</b>	54	922	41	1806
<b>9</b>	<b>Basic Metal Industries</b>	166	3613	122	1241
<b>10</b>	<b>Paper Product &amp; Printing</b>	44	397	27	267
<b>11</b>	<b>Electrical Machinery and Apparatus</b>	112	1490	49	1186
<b>12</b>	<b>Transports equipment and parts</b>	4	28	1	5
<b>13</b>	<b>Leather Products</b>	1	7	2	14
<b>14</b>	<b>Beverages, Tobacco &amp; Tobacco Products</b>	3	79	3	17
<b>15</b>	<b>Service Activities</b>	188	3083	174	2245
<b>16</b>	<b>Trading Activities</b>	21	322	21	180

<b>17</b>	<b>Other</b>	21	1178	29	272
<b>TOTAL</b>		<b>906</b>	<b>17018</b>	<b>887</b>	<b>122250</b>

Among the registered establishments in the year of 2010-11 the four most important establishments are related to manufacture of (1) Service Activities (2) Machinery and parts except electrical (3) Basic Metal Industries (4) Chemical & chemical Products. In the year 2009-10 the four most important establishments are related to manufacture of (1) Service Activities (2) Machinery and parts except electrical (3) Basic Metal Industries (4) Chemical & Chemical Products. That are same as year 2010-11. It can be observed that total number of establishment and total average number of persons employed per day has decreased in 2010-11 as compared to the year 2009-10.



**Figure 4.18 Number of Factories and Average Number of Workers in Vadodara District from 2008 to 2011.**

#### **4.4.1 Health Effect & City History On Man Power.**

##### **4.4.1.1 Particle Pollution Affects the Lungs.**

- **People are exposed to particle pollution when they breathe.**
- **Effects of short-term (acute) exposure:**
  - Coughing.
  - Shortness of breath.
  - Tightness of the chest.
  - Irritation of the eyes.
- **Effects of long-term (chronic) exposure:**
  - Reduced lung function.
  - Development of respiratory diseases in children.
  - Aggravation of existing lung diseases.
  - Premature death of people with lung disease.

##### **4.4.1.2 Particle Pollution Affects the Heart**

- **Inhaled particles can pass from the lungs into the bloodstream and affect the cardiovascular system.**
- **Effects of short-term (acute) exposure:**
  - Irregular heartbeat.
  - Nonfatal heart attacks.
- **Effects of long-term (chronic) exposure:**
  - Aggravation of existing heart diseases.
  - Premature death of people with heart disease.

##### **4.4.1.3 Certain Groups Are Most at Risk from Exposure to Particle Pollution**

- **Children**
  - Lungs are still developing.
  - Spend more time at high activity levels.
- **Senior citizens**
  - May have undiagnosed heart or lung diseases.

- **People with existing heart or lung diseases.**
  - Particle pollution aggravates these diseases.
- **People who exercise or work outdoors.**
  - Breathe faster and deeper than sedentary adults.

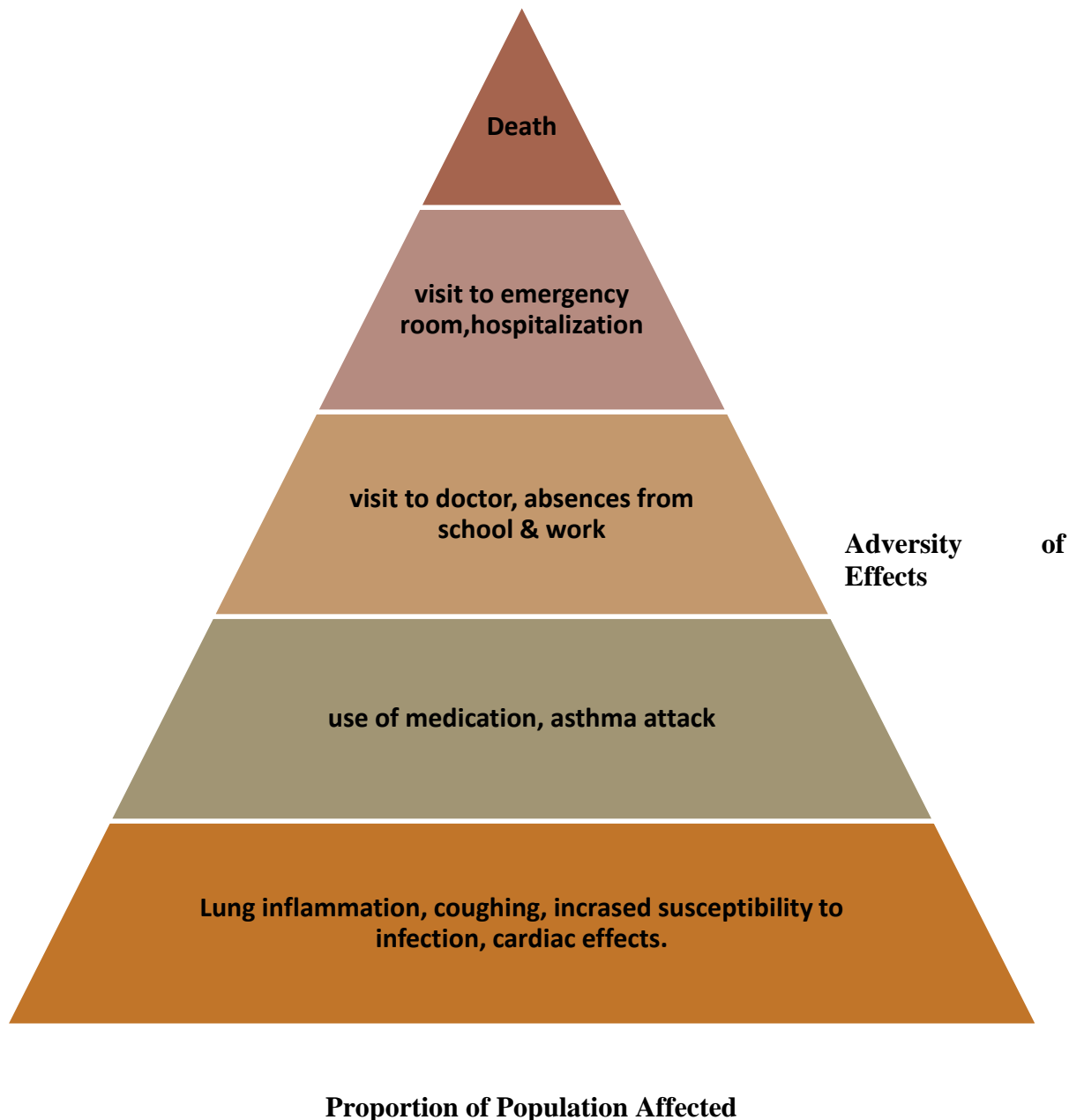
#### 4.4.1.4 **Communicating Health Effects.**

- **Morbidity**
  - Increased frequency of chronic bronchitis, respiratory hospital admissions, restricted activity days, etc.
- **Disability-Adjusted Life Year (DALY)**
  - Indicates how a disease can alter the ability of people to live a normal life compared to those with no disease
  - Expresses years of lost life.
- **Mortality (number of deaths)**
  - Number of deaths.

#### 4.4.1.5 **Famous Particle Air Pollution incidence**

- Donora, Pennsylvania, USA October 26-31, 1948 air pollution kills 20 people.
- London, England December 4-9, 1952 air pollution kills 4000 people.

**4.4.1.6 Pyramid of Health Effects from Air Pollution**



# **CHAPTER-5 DATA ANALYSIS**

**5.1 BACKGROUND**

**5.2 BIOCHEMICAL**

**CHARACTERISTICS ANALYSIS**

**5.3 AIR POLLUTION TOLERANCE**

**INDEX**

**5.4 ESTIMATION OF API**



# CHAPTER 5

## DATA ANALYSIS

### 5.1 Background

The status of air quality in every part of the world always parallels the changes in development of surrounding area [1]. Industrial area exhibits major sources of Particulate Matter, Sox and NO<sub>x</sub>. Depending upon the type of raw material used emission of one or more of these pollutants is obvious. The problem of declining air quality is mainly the result of anthropogenic emissions from traffic, industry and domestic heating, especially affecting the world's urban residents [2] [3]. Air pollution can have profound effects on the health of the entire planet. Increasing human population with decreasing green environment has produced ambient air polluted. Mainly increasing number of industries, vehicular exhaust, and fossil fuels to nuclear energy produces air heavily polluted day by day [4].

The air pollution causes health problems in the workers and residents in places near the industrial area, therefore it is essential to study the air quality in the surroundings of the industries [5] [6]. To terminate the impact of air pollutants, environmentalists and decision makers have long been emphasizing the need for a “perennial green envelop” in and around industrial areas as well as along roadsides [7] [8]. The plant has capacity to provide one of the natural ways of cleaning the atmosphere by absorption, reflection, diffusion of gaseous through their leaves. Heumann (2002); Psaras and Christodoulakis (1987) have shown the interactions between plant and different types of pollutants with the influence of environmental pollution on physiological and ultrastructural aspects [9] [10].

Based on responses of plants towards a particular stress as well as gaseous stress, they can be categorized into “sensitive” and “tolerant”. Sensitive species are early indicators of pollution, and the tolerant species help in reducing the overall pollution load [11].

Moreover, the present investigation is based on identification of stress tolerant plant species (noise and air pollution) from the study area to develop green belt. By the help of the Natural processes, air pollution level can be reduced by precipitation, Chemical reaction and sedimentation [12].

In present study emphasis is given on evaluation of tolerance level in plant species against air pollution and calculation of air pollution tolerance index (APTI) [11]. Air Pollution Tolerance Index (APTI), an index developed by Singh and Rao (1983), is used for the evaluation of the tolerance level of plant species from leaf [13]. The parameters used in defining sensitivity or resistance of plants towards different air pollutant concentration includes, Total Chlorophyll, Ascorbic acid, leaf pH, relative water content.

Plant sensitivity and tolerance to air pollutants vary with these above parameters. Chlorophyll content decreases due to production of reactive oxygen species (ROS) in the chloroplast underwater stress condition. (ROS is very small reactive molecules that can affect to cell structure during the stress condition). It also imparts leaf injury and causes change in stomatal movements, Changes in Chlorophyll content causes change in the rate of photo-synthesis. In the plant, higher ascorbic acid concentration of leaves might be an effective strategy to protect thylakoid membranes from oxidative damage under such water stress [14].

Alkaline particles such as limestone and dust particle may damage plant surfaces [15], and high pH improves tolerance against air pollution [1]. Based on APTI (Table 1) and somerelevant biological and socio- economic characters (Table 2), the Anticipated Performance Index (API) (Table 3), of various plant species was determined. By measuring these parameters, we can predict the effectiveness of plant as possibly being suitable in terms of pollution abatement.

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

**Table 5.1 Air pollution tolerance index of tree species studied in makarpura industrial area, Gujarat.**

Sr.no	Name of species	A	P	T	R	APTI
1	Michelina champak L	7.31	5.68	6.2	56	13.26
2	Polyantha long folia Son.	6.42	6.89	5.78	60.25	15.68
3	Azedarach Indica A. Juss	6.79	6.2	3.87	54.21	12.98
4	Ficus religiosa	6.98	6.98	9.87	60.54	14.42
5	Ficus benghalensis	6.65	5.93	6.54	55.65	18.65
6	Cassia fistula L.	6.07	5.43	4.44	54.24	13.65
7	Spathodea campanulata P. Beauv.	5.54	6.65	4.65	55.24	11.46
8	Adina cordifolia Hook. f.	5.05	6.87	3.98	51.35	12.05
9	Cassia siamea Lamk.	6.19	5.68	4.55	52.18	12.05
10	Nerium odorum Sonnad.	4.08	6.54	3.52	53.54	8.65
11	Alstonia scholaris (L.) R.Br.	5.26	6.05	3.81	50.42	9.01
12	Cascabela thevetia L.	5.90	5.98	4.73	50.15	9.54

Source: - Open Journal of Air Pollution

**Table 5.2 Gradation of plant species based on air pollution tolerance index (APTI)**

<b>GRADING CHARACTER</b>		<b>PATTERN ASSESSMENT</b>	<b>GRADE ALLOTTED</b>
<b>(a) Tolerance</b>	<b>APTI</b>	9.0-12.0	+
		12.1-15.0	++
		15.1-18.0	+++
		18.1-20.0	++++
		20.1-24.0	+++++
<b>(b) Biological &amp; socioeconomic</b>	<b>Plant habit</b>	Small	-
		Medium	+
		Large	++
	<b>Canopy structure</b>	Sparse/irregular/globular	-
		Spreading crown/open/semi-dense	+
	<b>Types of plant</b>	Spreading dense	++
		Deciduous	-

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

		Evergreen	+
<b>(c)Laminar structure</b>	<b>size</b>	Small	-
		Medium	+
		Large	++
	<b>texture</b>	Smooth	-
		Coriaceous	+
	<b>Hardiness</b>	Delineate	-
		Hardy	+
	<b>Economic value</b>	Less than three uses	-
		Three or four uses	+
		Five or more uses	++

Source: - Open Journal of Air Pollution

**Table 5.3 Anticipated performance index (API) of plant species.**

Grade	Score (%)	Assessment Category
0	Up to 30	Not recommended

1	31-40	Very poor
2	41-50	Poor
3	51-60	Moderate
4	61-70	Good
5	71-80	Very good
6	81-90	Excellent

Source: - Open Journal of Air Pollution

## 5.2 Biochemical Characteristics Analysis

In order to collect the plant leaf samples, a plant survey was made at the three selected sites on that basis twelve common plants of same age were elected for the foliar biochemical studies.

The matured leaves from each plant species were plucked from individual sites. These leaves were placed into the polythene bags and brought to the laboratory to preserve at  $25 \pm 0.5^{\circ}\text{C}$  until analysis.

The plant samples were analyzed for different parameters within 24 hours of their harvesting. The leaf samples were analyzed for pH (P) of leaf extract, Chlorophyll (T), Ascorbic acid (A), and Relative Water Content (R). The APTI, an empirical value representing tolerance level of a Plant to air pollution, was used to interpret the impact of pollution on the plants. The APTI was calculated by using the following formula for a given plant species.

Results from biochemical analysis of plants revealed that higher ascorbic acid contents were recorded in *Michelia champaca* (7.31), followed by *Ficus religiosa* (6.98),

*Azadirachta indica* (6.79), *Polyalthia longifolia* (6.42), *Cassia siamea* (6.19), *Cassia fistula* (6.09) [19] Table 1 Ascorbic acid is concentrated mostly in chloroplasts that act as an antioxidant. It is mostly found in growing parts of the plant and enhances resistance to adverse environmental conditions, including air pollution [23] [24]. Earlier Air pollution and soil contamination results have showed a decrease in leaf ascorbic acid content in exposed *Tibouchina pulchra* samplings [25].

In this study, *Ficus religiosa* has the maximum relative water content of 64% and followed by *Polyalthia longifolia* 60%, *Spathodea campanulata* 55%, *Ficus benghalensis* 55%. High water content within a plant body helps to maintain its physiological balance under stressful conditions, such as exposure to air pollution [26] (Table 1). The highest Relative Water Content (RWC) was found in response to the high availability of soil, water content and lower evaporation and transpiration rate. RWC of a leaf is the water present in response to its full turgidity. Under air polluted conditions, transpiration rates are frequently high, which leads to dryness. Therefore, the maintenance of RWC by the plant may determine its relative tolerance to pollution. Therefore, the high RWCs of plants in an industrial area sample may be responsible for the normal function of plant biological processes [27].

The plant samples of the study exhibited an acidic pH. This might be due to presence of certain air pollution in the atmosphere. As leaf pH values increased in the polluted area compared with that of control. Similarly, rise in pH values in polluted site was observed [27]. The lowest pH concentration was found in case of *Michelia champaca* (5.68) followed by *Cassia fistula* (5.43), *Cassia siamea* (5.68), *Cascabela thevetia* (5.98). The plants were observed to have lower pH as washing of leaves lowers dust accumulation. On unalike, where dust accumulation is more, dust particle dissolution in cell sap is higher which results in rise in the pH [28]. It has been reported that the lower leaf pH is due to presence of acidic pollutants [29]. Swami et al., (2004) also observed similar results. The changes in leaf-extract pH might influence the stomata sensitivity in presence of air pollutants. Consequently, sensitive plants had higher leaf-extract pH than tolerant plants. Low leaf pH extract showed good correlation with sensitivity to air pollution and also reduces photosynthetic process in plants [30].

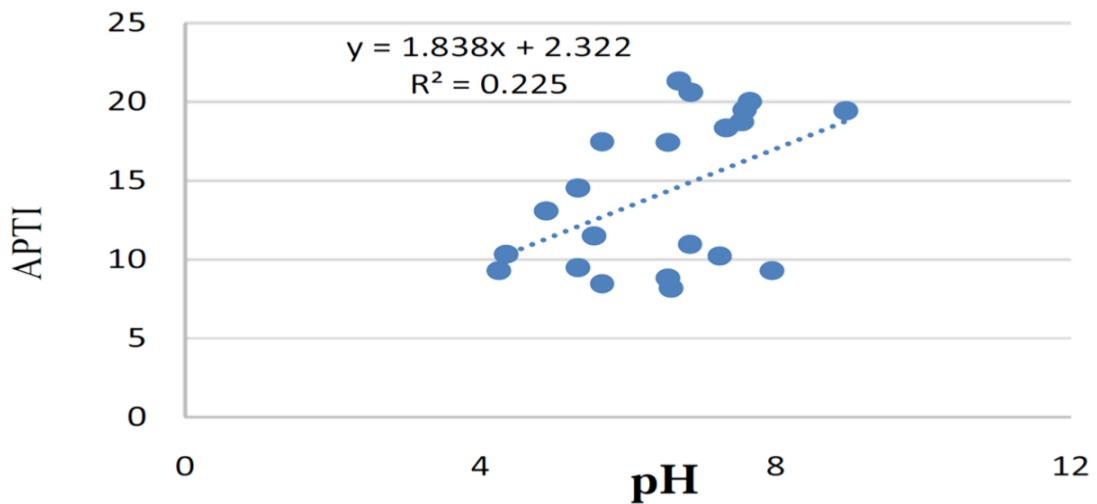
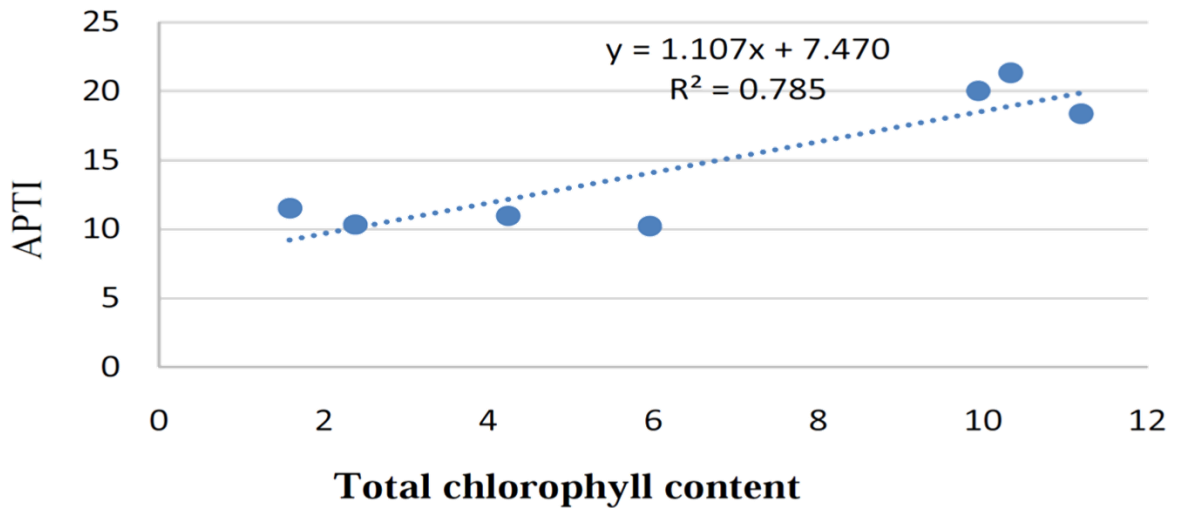
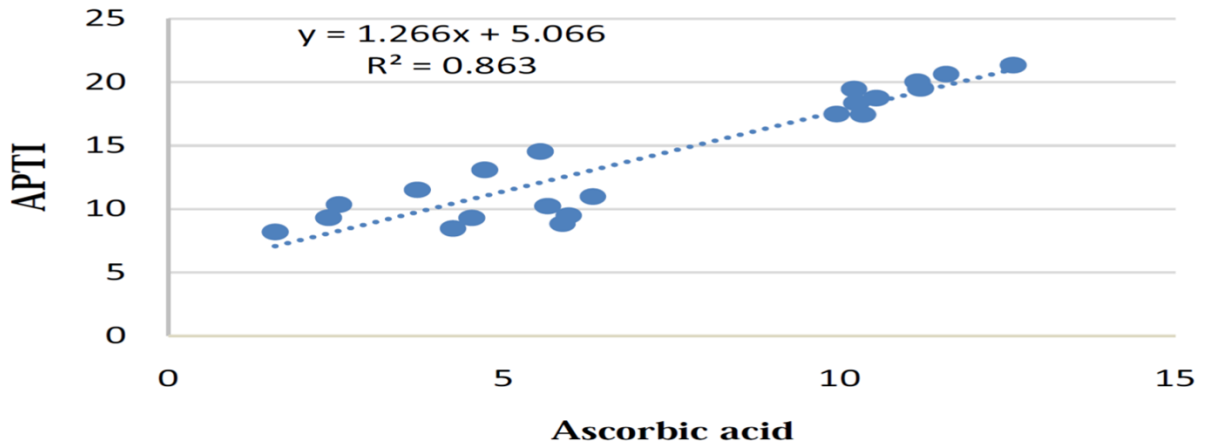
The NO<sub>x</sub>, SO<sub>2</sub> and PM<sub>2.5</sub> content estimated in the ambient air of the study stations were within the NAAQS limits for residential area and industrial areas [31]. The main air pollutants in Makarpura industrial area are SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>2.5</sub>. The concentrations of all of these pollutants were within the limits prescribed by CPCB. The average concentrations of three study area were SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>2.5</sub> in the Makarpura industrial area are 52, 46, and 35 µg/m<sup>3</sup>, correspondingly. Higher concentrations in winter season may be credited to the atmospheric inversion [32].

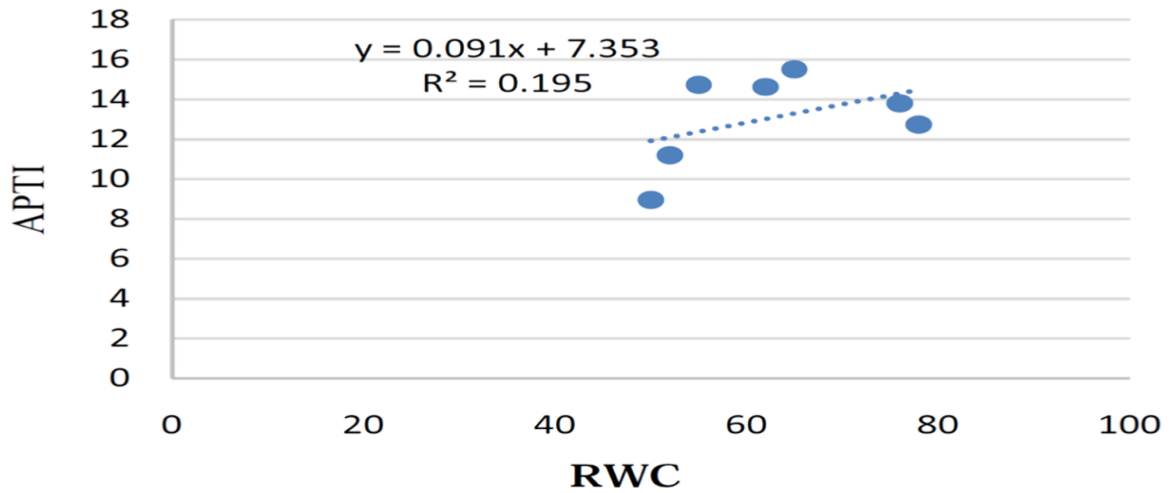
During inversion the normal atmospheric conditions i.e. cool air above and warm air below gets inverted. This condition leads to trap an intense layer of cold air under a layer of warm air. This dormant condition of atmosphere traps the pollutants close to the surface of the earth. Dust interception ability of plants depends on their surface geometry, phyllotaxy, leaf external characteristics (such as hairs, cuticle, etc.), and height and canopy of trees [6] [13]. The methodology of APTI and API can be used globally as they are based on parameters and universally significant biological and socio-economic characters. The planting of larger tree has been avoided because of their thick canopy structures and too close with each other, as this may lead to chances of obstructing the scattering of pollutants, thus provoking the pollution problem. Leaf petioles have more capacity to eliminate particulate than either twigs (stem) or leaf lamina [33]. Green belts offer one of the natural ways of cleaning the atmosphere by absorption of gaseous pollutants, particulates and noise through their leaves. Plants with bulky leaves can act as efficient pollutant trapping device.

### **5.3 Air Pollution Tolerance Index**

Presence of plants and trees in the industrial area can improve air quality through uptake of pollutant gases and particles. Air pollution tolerance index (APTI) was calculated for each plant. Species studied at different sites is mentioned in the above Table 1. The highest APTI value is found in the winter season. On the basis of calculated APTI with respect to season, the plants were found to follow this order; *Ficus benghalensis* showed the highest APTI value at all the sites followed by *Polyalthia longifolia* > *Ficus religiosa* > *Cassia fistula* > *Michelia champaca* > *Azadirachta indica* > *Adina cordifolia* > *Cassia siamea* > *Cascabela thevetia* > *Alstonia scholaris* > *Nerium odorum*. Different plant species show

substantial variation in their susceptibility towards air pollution. The plants with high and low APTI can serve as tolerant and sensitive species respectively. All other plants were found to be sensitive and accommodating as air pollution indicator [34].





**Figure 5.1 The linear regression plots of individual variables with APTI**

Source: - Open Journal of Air Pollution

Linear regression plots of APTI with individual variables like ascorbic acid, chlorophyll content, PH and relative water contents. that a significant correlation exists between APTI and ascorbic acid content ( $R^2 = 0.86387$ ) while a positive correlation was found between APTI and total chlorophyll content ( $R^2 = 0.7853$ ). On the contrary, a non-significant & low correlation with leaf extract pH ( $R^2 = 0.2254$ ) and relative water content ( $R^2 = 0.1952$ ) were observed. It brings to knowledge that ascorbic acid and chlorophyll content of the leaf are responsible factors on which the APTI relies [35].

#### 5.4 Estimation of API

Out of above mentioned *Ficus benghalensis* rank first among all plants studied and is a keystone species [24]. Keystone species can be expressed as species which play a key role in the sustenance of ecosystems; it has a consistent effect on its environment relative to its abundance. An ecosystem may experience a remarkable shift if a keystone species is removed, even if that species is a minute part of the ecosystem on account of productivity. Henceforth, it will be highly appropriate for planting this in industrial area to assist improvement in pollution. *F. religiosa* was judged to be in the “Very Good” category and was recommended for plantation (Table 4).

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

These species have an intense canopy of evergreen foliage and is well known for its economic and aesthetic value [16] [36]. Apart from this investigation, 4 of the 13 tree species drops in the moderately suitable category, but can be recommended for plantation due to their aesthetic value (Table 4). The rest of the naturally growing species in the study area was not recommended for planting due to their particularly poor pollution tolerance indices or their very low API values (Table 5).

**Table 5.4 Anticipated performance index of different plant species in selected area.**

PLANT SPECIES	GRADE		API VALUE	ASSESSMENT
	TOTAL PLUS	PER. %		
<i>Michelia champa</i> L.	9	52.94	3	Moderate
<i>Polyalthia longifolia</i> sonn	10	58.82	3	Moderate
<i>Azadirachta indica</i> A. Juss.	8	47.06	2	Poor
<i>Ficus religiosa</i>	12	70.59	5	VERY Poor
<i>Ficus benghalensis</i>	14	82.35	6	Excellent
<i>Cassia fistula</i> L.	7	41.18	2	Poor
<i>Spathodea campanulata</i> P. Beauv.	4	23.53	0	Not Recommended
<i>Adina cordifolia</i> hook. F.	10	58.82	3	Moderate

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

Cassia siamea lamk	<b>9</b>	<b>52.94</b>	<b>3</b>	Moderate
Nerium odorum sonnad.	<b>5</b>	<b>29.41</b>	<b>0</b>	Not Recommended
Alstonia scholaris (L.) R.Br.	<b>6</b>	<b>35.29</b>	<b>1</b>	VERY Poor
Cascabela thevetia L.	<b>7</b>	<b>41.17</b>	<b>2</b>	Poor

Source: - Open Journal of Air Pollution

# **CHAPTER-6 PLANNING & DESIGN PRPOSAL**

**6.1 BACKGROUND**

**6.2 GREEN SPACE**

**PLANNING**

**6.3 PLANNING OF STUDY**

**AREA**

**6.4 DESIGN OF STUDY**



## CHAPTER 6

### PLANNING AND DESIGNING PROPOSAL

#### 6.1 Conceptual review

##### 6.1.1 Background

Urban green space planning in the 21st century requires greater insights in social, ecological and economical aspects that provide a sustainable urban form (Thompson, 2002). Urban Centres are a key driver of climate change; and while being the prime emitter of Green House Gases (GHGs), they are also vulnerable to the impacts of climate changes. The major effects of urbanization on the environment are an increase in temperature (urban heat island effect) (Wilby and Perry, 2006), increase on the runoff due to impervious surfaces and a surge in the emission of carbon dioxide (Whitford et al., 2001). Urban and suburban expansion deteriorates native ecosystems, and affects air and water quality (McKinney, 2002). Changes in the precipitation pattern and sea level rise, on the other hand, are increasing the vulnerability of urban centres lying in low coastal areas, often leading to extreme events such as floods (De Sherbinin et al., 2007) that are likely to cause economic losses and damages in billions of dollars (Hallegatte et al., 2013).

Rapid population growth and urban development have transformed natural environments into areas of highly engineered infrastructure. Heat generation from cars, industry and commerce, coupled with the retention of the solar energy by buildings and paved surfaces, creates unnaturally warm city environments (known as urban heat islands). This can have negative effects on human health and wellbeing. The transition from the natural landscape to the built environment has also created large areas of impervious paved surfaces, creating problems such as loss of vegetation and habitat, increased surface run-

off and flash flooding. Each of these issues is being exacerbated by an increasingly variable climate.

### **6.1.2 Urbanization and green spaces in India**

India has been experiencing rapid urbanization since 1970, with its urban population rising from 109 million in 1971 to 377 million in 2011, a percentage increase from 19.9 to 31.6 over four decades. The number of million-plus cities in the country, meanwhile, has steadily increased from 23 in 1991, and 35 in 2001, to 53 in 2011 (Census of India, 2011). The vehicular traffic in Indian cities has also risen from 5.4 million in 1981 to 141 million in 2011, which is a phenomenal growth. The transport sector of Indian cities contributes to over 7% of total GHG emissions in India. High vehicular emissions in many cities have raised air pollution to unbearable levels (Ghose et al., 2004). By 2030 India is projected to have six cities with a population over 10 million, and more than a 100 million-plus cities (IIHS, 2012). Environmental degradation and loss of green spaces are likely to increase too; and combined with climate change challenges, the environmental sustainability of Indian cities will face serious threats, going forward.

Green spaces across many cities in India have decreased significantly and are further decreasing with growing urbanization and population increase. To take the case of Bangalore city, it has lost much of its open spaces and urban wetlands due to urban sprawl, which has affected its drainage network, local hydrology and ground water table levels (Sudhira et al., 2004). With rise in urban population the per capita availability in many urban areas has reduced drastically and can be expected to decrease further.

It can be noted from Table 1 that many cities in India already fall short of green space available per capita, which is much below the WHO recommended norms of 9 sq m/capita. Gandhinagar and Chandigarh being post-independence planned cities of India, their City Master Plans offer better integration of urban greenery. Chandigarh city, in fact, is one of the greenest cities of India.

**Table 6.1 Major Indian cities with per capita green source**

<b>City</b>	<b>Geographical area (sq.m)</b>	<b>Population in million (census,2011)</b>	<b>Forest and tree cover (sq.km)</b>	<b>Per capita green space (sq.m/inhab)</b>
<b>Delhi</b>	435	16.31	90.74	5.5
<b>Bangalore</b>	226	8.43	150	17.79
<b>Mumbai</b>	735	18.48	122	2.01
<b>Hyderabad</b>	172	7.74	3.87	0.5
<b>Ahmedabad</b>	469	6.35	21.8	3.9
<b>Chennai</b>	174	8.69	9	1.03
<b>Kolkata</b>	186.23	14.11	0	0
<b>Surat</b>	395	4.58	11.84	2.7
<b>Jaipur</b>	484.64	3.07	61.4	20
<b>Gandhinagar</b>	75	0.20	30.75	147.6
<b>Chandigarh</b>	114	1.05	16.78	54.45

## 6.2 Green Space Planning

Urban green spaces enrich aesthetic and recreational avenues for urban communities and facilitates the general well-being of city dwellers (Attwell, 2000; Maas et al., 2006). Green spaces also reinforce the process of carbon sequestration, and mitigate the effects of climate change (Nowak and Crane, 2002; Escobedo et al., 2010). Gill et al. (2007) show that green spaces help in reducing urban heat island effect, and improve the hydrology by preventing surface runoff, while providing ground water recharge too.

Green spaces can act also as buffers in case of extreme events such as floods, and act as natural storm water drains, thus reducing climate-related disaster risks for cities and providing climate adaptation. Urban green landscapes can act as “soft engineering” strategy for climate adaptation (Kitha and Lyth, 2011), which is ideal for low income countries like India. Green spaces provide ecosystem services, which are highly linked to help in climate change adaptation and disaster risk reduction (Munang et al., 2013), and such Ecosystem Based Approach (EBA) in climate adaptation has been widely reported as a cost-effective tool in climate adaptation (IUCN, 2011).

- The important aspects of green space in urban form are:
  1. **Quantity:** what percentage of the urban area is filled with green space?
  2. **Quality:** can the green space improve urban biodiversity and provide better ecosystem services?
  3. **Connectivity:** how much of the green space is connected? 4) **Accessibility:** how much of the population has access to the green space?

Based on such successful green space planning projects, the following key approaches are discussed, which can be helpful in guiding urban planners plan environmentally and socially sustainable urban green spaces for Indian cities for climate adaptation.

### 6.2.1 Site selection in green space planning

Urban planners are often confused with selecting the right areas for green space planning. McCargo (1969) was probably the first person to propose the concept of design with a nature and site suitability analysis framework. The initial site suitability analysis can help identify areas suitable for development, and those that can be maintained as open spaces.

The technique involves a comprehensive Geographical Information System (GIS) analysis of several layers. This approach uses overlaying layers of land use, slope, water features (which include floodplains, wetlands, steep slopes, etc.) as well as agricultural, visual, and historical resources. Based on a suitability analysis of physiographic and hydrological features, areas suitable for development of buildings and infrastructure, as well as areas with a potential for green space development, can be identified. Planning for conservation involves a clear investigation into which natural values should be protected from development, and how they should be managed. Setting priorities for conservation will rely on parameters such as integrity, rarity, diversity, vulnerability or uniqueness of landscapes and ecosystem components. Location decisions will be determined by their existing spatial distribution and dynamics (McHarg, 1969).

GIS-based land suitability analysis is fast becoming a strong, efficient and effective application for green space planning (Miller et al., 1998). Kong et al. (2010) developed green space network for Jinan City, China, based on graph theory and the gravity model. It simplified and systematized the complex landscape, helping to identify the significance of each green space, and guiding urban planning for biodiversity conservation. Such models can also be used in the Indian context, especially in planning green spaces, with an objective for conserving the rich biodiversity of urban India, while avoiding the incompatibility of environment and development.

### **6.2.2 Landscape ecological approach.**

Landscape-ecology principles are useful tools for planning ecologically sound urban green spaces. Landscape ecology focuses on three fundamental structural elements— Patches, Corridors and Matrix. The function also includes ecological flow of animals, energy, minerals, water and other elements across the landscape. Taken in its entirety, this is widely known as “patch corridor-matrix”. The framework includes the identification of spatial elements (large patch areas, major corridors, special sites, etc.) and landscape functions (water protection, wildlife and human movement). It is important to connect the patches (parks, gardens and green spaces) using corridors (riverine buffers, streetscapes, green ways, etc.) to maintain ecological connectivity.

Corridors are important elements in green space planning and design; and ecological corridors can be used to reduce the negative impact of landscape fragmentation. Landscape-level habitat connectivity plays an important role in population viability by maintaining gene flow and facilitating migration, dispersal, and recolonization that on the whole enhances urban biodiversity. developed a GIS-based tool “Corridor design” that helps in creating habitat and corridor models. It is important to connect patches using corridors to maintain ecological connectivity and models. For example, using the least cost method can help planners to develop green space networks from potential corridors, identify relatively high-quality habitats, and choose the best opportunities to maintain and restore connectivity.

### **6.2.3 Green spaces planning for climate change mitigation**

Using models such as the Urban Forest Effects Model (UFORE) can help in quantifying key values of urban green spaces such as carbon storage and sequestration, as well the selection of appropriate trees that help in air pollution mitigation. The GIS-based UFORE model can help to understand and quantify urban forest structure, function and value. The model helps to quantify the structure of urban forests (e.g., species composition, number of trees, tree sizes, tree locations, etc.). The model also helps planners in evaluating existing green spaces, and making informed decisions on tree planting requirements and urban forestry improvement.

### **6.2.4 Planning green spaces for meeting social needs**

The social aspect of open spaces in urban sustainability deals with access to open spaces and availability of open space per capita or per 1000 population. Improving the quality of life in the cities is a major objective in green space planning. As we aim towards planning more liveable cities in the 21st century, it is important to provide our residential areas with accessible and attractive green spaces. Global standards recommend 33% green cover for urban areas, and that the maximum green spaces.

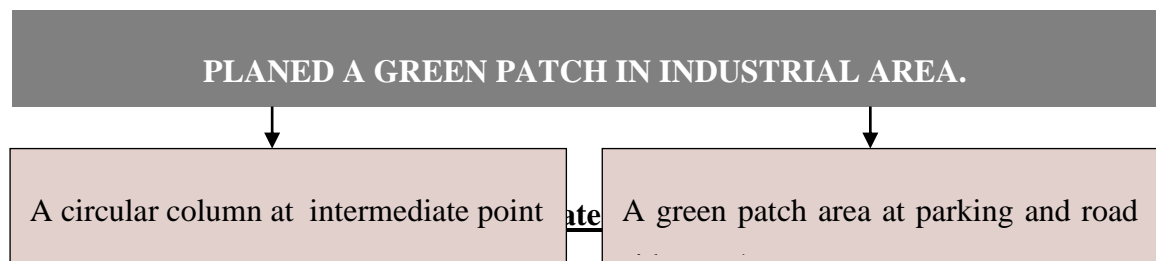
be connected. The LEED ND (Leadership in Energy and Environment Design Neighbourhood development) recommends that the green area per capita be >20 sq m or maintain a minimum of 1.25 ha of open space per 1000 residents, and that the access to

open space be within 250 m of residential areas for smaller parks. The type of open space required at each level may vary, such as children's parks near schools and residential areas, small parks for daily activities, and large parks that can serve as weekend destinations.

### 6.3 Study of Planning

In India planning urban green spaces requires an integrated approach that balances ecological and social aspects of green spaces with urban development needs. It is important to preserve the existing green spaces that are biodiversity-rich from unplanned urban development, while simultaneously developing green spaces with higher connectivity to ensure ecological sustainability. Models that combine ecological, aesthetic and social needs are critical in planning green spaces. With the advancement in tools such GIS, planning has become much easier by incorporating social and ecological needs.

- **We are planned two types of green patch in our selected industrial area.**



- Planning should be done by **GOOGLE EARTH PRO.**
- Based on this software to identify **the road junction and to point out** for the designing purpose.
- Total **23 intermediate point** in our path.

**Table 6.2 Planning of Intermediate Point**

<b>Intermediate Point</b>	<b>Diameter (ft)</b>	<b>Intermediate Point</b>	<b>Diameter (ft)</b>
Vadsar point	<b>8.92</b>	12	<b>44.10</b>
1	<b>12.55</b>	13	<b>13.0</b>
2	<b>45.0</b>	14	<b>17.05</b>
3	<b>45.8</b>	15	<b>32.75</b>
4	<b>38.1</b>	16	<b>32.07</b>
5	<b>25.8</b>	17	<b>60.0 with patch green</b>
6	<b>26.15</b>	18	<b>42.0</b>
7	<b>33.5</b>	19	<b>35.01</b>
8	<b>90.0 with patch green</b>	20	<b>34.0 with patch green</b>
9	<b>42.50</b>	21	<b>100.0 with patch green</b>
10	<b>12.0</b>	22	<b>15.0</b>
11	<b>7.0</b>	23	<b>12.75</b>



Figure 6.1 Planning of green patch at vadsar to sussan circle.

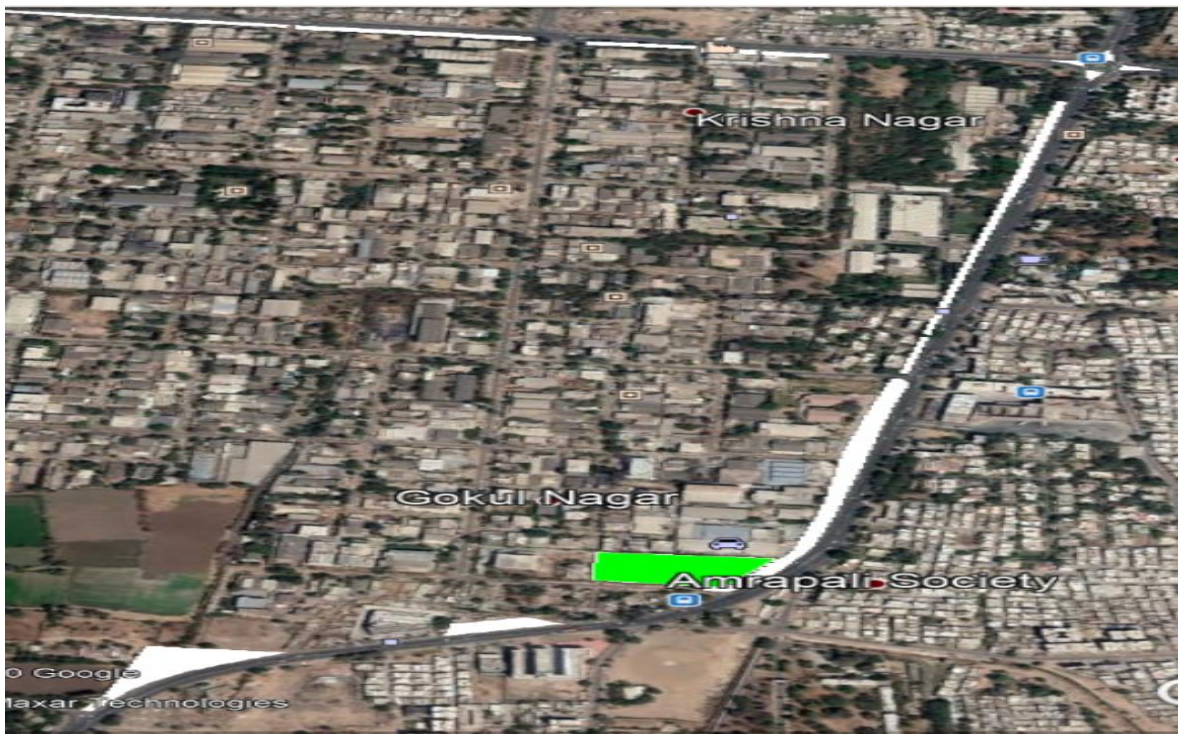


Figure 6.2 Planning of green patch at sussan circle to manej circle.



Figure 6.3 Planning of green patch total industrial area.

2) A Green Patch Area At Parking And Road

- The green patches planning done by **GOOGLE EARTH PRO**.
- The green patches are select to base on a space of industry and parking area of the zone.
- Total **21 green patches** are plan under this project.
- In this planning process we get the **parameter, area and width** of the patch.
- In this planning we design **green patch area and parking congested zone** we **provide parking area** as well as green patch between parking area.

Table 6.3 Planning Data of Parking Area And Road Side.

Patch	Parameter (m)	Area (sq.m)	Width (m)	Remark
1	557	718	2.72	To plan at divider side
2	225	376	3.656	Grass land

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

3	159	321	4.84	Periphery of the parking
4	284	1396	11.2	Grass land
5	703	2734	8.21	G.Patch between parking
6	251	1072	8.10	G.Patch between parking
7	183	840	14.3	G.Patch between parking
8	606	2440	7.53	G.Patch between parking
9	491	2668	10.3	G.Patch between parking
10	231	1057	10.4	G.Patch between parking
11	133	743	13.9	Periphery and mid span
12	150	758	11.4	G.Land small parking
13	90.4	283	12	Rotary part to provide column design and green patch.
14	90.4	283	12	
15	90.4	283	12	
16	90.4	283	12	
17	1292	5149	10.3	very long Length to green patch

18	194	556	6.87	Fully green grass land
19	1056	8307	21.7	Well plan parking and plant design
20	399	8258	---	Open plot
21	224	1754	20.9	Open space & well plan
22	465	5652	13.0 & 35.0	Green land existed but not well plan

## 6.4 Design of Study

As a community that aims for eco-tourism destination, they realized the landscape arrangement needs to be improved, especially to respond to the government’s program to build an inspection road along the river as well as concrete revetment.

### 6.4.1 Identifying the green patch

A map is developed based on the participatory-design mapping, interviews, and discussion. It shows the landforms water bodies, vegetation, and traces of human activities. The documented everyday occurrences on Clawing Condit landscape serves as basis for further development.

Based on the maps’ development, important points are revealed. Vegetation, which has a crucial role in the ecosystem and from the sociocultural perspective, grows in the landscape on certain pattern. The strength of the landscape is on the large area of land surface, its steep contour, and presence of native vegetation, and its areas to improve includes its limited access for maintenance of the riverbank and unprotected riverbank.

The high plain has direct access to the street and acts as the main area and base camp. There are two units of structure: a gazebo-like structure, which can be used for recreational activities, and a glass-house structure, which can be used for meetings or a library or a prayer room. There is also a toilet and a pantry. Due to the challenging

landscape and minimal developments at the site, it is experiencing difficulties in supporting community activities due to concerns regarding accessibility, convenience, and safety.

The plain is located in an elevated area and arranged to be an outdoor seating area, mainly a place for viewing the scenery and witnessing the plucking of salak (*Salacca zalacca*) or snake fruit, the native fruit of Condet. Vegetation in this area includes shrubs, trees with a height of more than six meters, and large canopies, such as picung tree (*Pangium edule*) and gandaria tree (*Bouea macrophylla* Griffith). The large trees and the structures at the site serve as the shade for the visitors.

### 6.4.2 Connecting ecological scenes

It is important to integrate the landscape with a holistic program that aims to create environmental improvement that can be enjoyed by all (Public Utilities Board Singapore, 2018). Particularly for Ciliwung river, it is possible to develop the landscape that encourages sustainable lifestyle and activities by and with the waters. A connection is generated through suitable landscape treatment. Developing programs that complement a masterplan is required, especially one in relation to the ecology where the community can learn more about the issues on water and land pollution and how to address them.

Based on observation, there are at least two goals for environmental improvement and landscape development in Ciliwung Condet as a green patch, which are necessary to be elaborated in planning the green patch. One is increasing the ecosystem function of the Ciliwung Condet landscape and restoring its native vegetation.

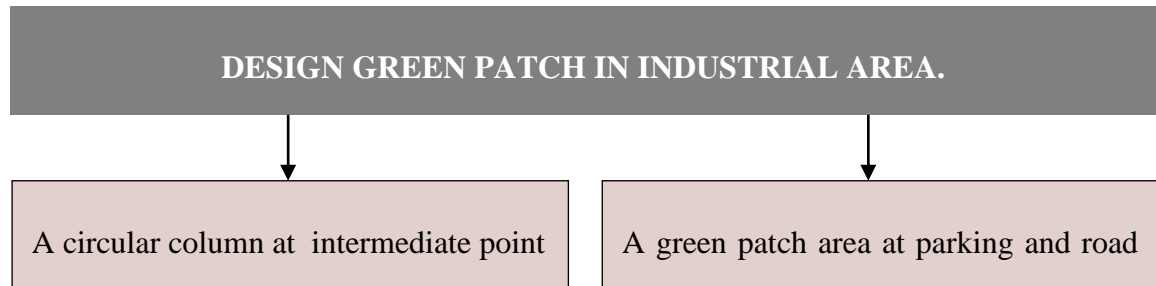
As a watershed area, the masterplan needs to prevent a disconnection between the land and water in term of natural water flow, and to adapt suitable approaches, such as enhancing floodplain as a wetland, capturing stormwater runoff, grading the riverbank with levee breaching and widening, as well as using riparian vegetation along the river to establish river-flow and improvement of river water quality.

Activities with specific purposes (ecological purpose, economical purpose, conservation purpose, and recreative purpose) are identified and zones created

conceptually based on the native vegetation present, such as kapuk randu and bamboos. Once again, native vegetation plays an important role in this concept. And they will be equipped with a technological technique based on the hydrogeomorphic feature.

### 6.4.3 Design setup at industrial area.

We are design two major part in this study, and we conclude that we provided systematic parking facility in this industrial area.



#### 1) A Circular Column At Intermediate Point.

To design the circular column for the intermediate point because of this intermediate which situated at the road junction that's why do not design green patch so we would design a circular column at that junction point.

#### ❖ Parameter of circular column

- Column diameter = 2.0 ft
- External plate diameter = 5.0 ft
- Total No.of plate = 3 No. at 3 ft. distance
- Column height is 10 ft.
- Total no.of green pots in column =  $(1*8)*3= 24$  No.
- On each plate to provide grass base to provide moisture to the plant.
- The plant selection based on temp. occurrences.



**Figure 6.4 Design the Intermediate Point**

**2) A Circular Column At Intermediate Point.**

To design the green patch for an open space with the parking facilities because of some of the land which is use as a parking of the industries vehicles but which was very hazardous for that area. Finally to design well parking area with green patch periphery, mid span and its intermediate point which situated at the road junction and walk way sides.

❖ **Parameter of green patch:**

- The length based on planning area.
- Width should selected on parking or non-parking bases
- The intermediate porch size is 2 ft \* 3 ft.
- The height of the patch is 2.5 ft.

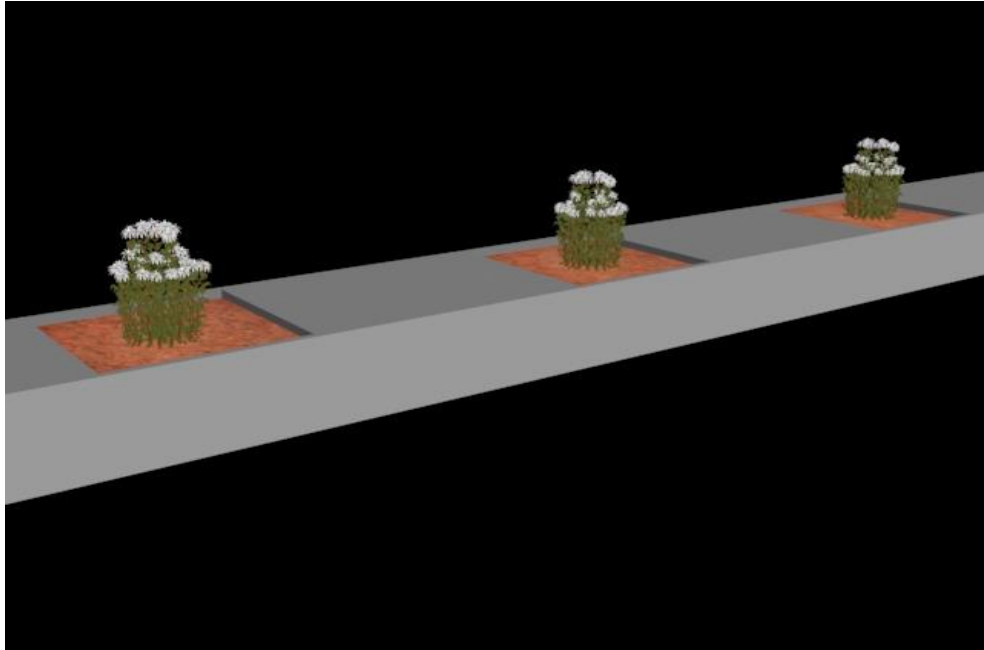


Figure 6.5 Design the Green Patch

#### 6.4.4 Irrigation System.

- Water line provided at the selection site for irrigation purposes.
- We set out nearest point with respect to patch and intermediate points.
- Without water line do not maintain our plants.



Figure 6.6 Irrigation Channel Provided At Selection Area.

**Table 6.4 Water Irrigation Line**

<b>Patch</b>	<b>Irrigation Water Line Point</b>	<b>Water Line Distance (m)</b>
<b>Patch-1</b>	Canton laboratory	<b>18.0</b>
	Sukkan industry	<b>7.10</b>
<b>Patch-2</b>	ICIC bank	<b>11</b>
<b>Patch-3</b>	ICIC bank	<b>11</b>
<b>Patch-4</b>	Gujarat aluminium	<b>10.2</b>
	Ultratech builders	<b>4.49</b>
<b>Patch-5</b>	Gopinath Honda show room	<b>4.30</b>
	Somnath enterprise	<b>2.96</b>
	Amit electronics	<b>5.60</b>
	Emtect sales	<b>3.87</b>
	VMC public toilet	<b>3.58</b>
<b>Patch-6</b>	Eagle plastics	<b>21.9</b>
	Food court	<b>7.43</b>

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

<b>Patch-7</b>	Bombay styles	<b>3.39</b>
	Shri Ambika sales	<b>6.1</b>
<b>Patch-8</b>	Allip chemicals	<b>14.70</b>
	Aadha engineering	<b>4.98</b>
	Divine industry	<b>8.48</b>
	Syndicate bank	<b>4.81</b>
	Shri umiya glass industry	<b>5.90</b>
	Ghanshaym electronics	<b>11.70</b>
	Vikash sales	<b>4.17</b>
<b>Patch-9</b>	Bank of Baroda	<b>9.73</b>
	Casting & casting industries	<b>10.20</b>
	IndusInd bank	<b>5.85</b>
	ICIC bank	<b>8.10</b>
	VMC pubic toilet	<b>0.0</b>
<b>Patch-10</b>	Yamuna jal	<b>8.32</b>

PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

	Yamuna jal	8.30
<b>Patch-11</b>	Ceragem centre	0.0
<b>Patch-12</b>	Maruti courier	0.0
<b>Patch-13,14,15,16</b>	Circle part	0.0
<b>Patch-17</b>	Gilgal Pentecostal	0.0
	Kamal transport	12.0
	Durga lubricant	1.60
	Vimal pipe	7.11
	Panasonic energy india	31.0
	Convert high school	8.53
<b>Patch-18</b>	Hotel Krishna	5.52
	Safe services	4.12
<b>Patch-19</b>	Rotex automation	16.0
	Ashok lay land	12.0

## PLANNING AND DESIGNING OF GREEN PATCHES FOR CARBON EMISSION

	LIC od India office	12.4
	Hyundai motors	8.42
<b>Patch-20</b>	Indian oil	0.0
<b>Patch-21</b>	Prathama trading	16.8

# **CHAPTER-7 CONCLUSION AND**

## **FUTURE SCOPE**

**7.1 CONCLUSION OF STUDY**

**7.2 FUTURE SCOPE**



## CHAPTER 7

### CONCLUSION & FUTURE SCOPE

#### 7.1 Conclusion

- ❑ It is concluded study that include like Baroda city in many high pollution zone to make green patch thus such small patches will be helpful in reduction of air of industrial pollution and vehicular pollution.
- ❑ This green patch will be helpful in control the temperature 0.5° to 1°degree.
- ❑ Economic study indicates that initially beet high due to development of infrastructure but is negligible as compare to air pollution and temperature.
- ❑ The maintaining the green patch they would work better and after the 3 to 5 yr. They become more effective to reduced the carbon emission.
- ❑ To reduce the carbon emission as to directly effect on tempareture and reduce the tempareture.

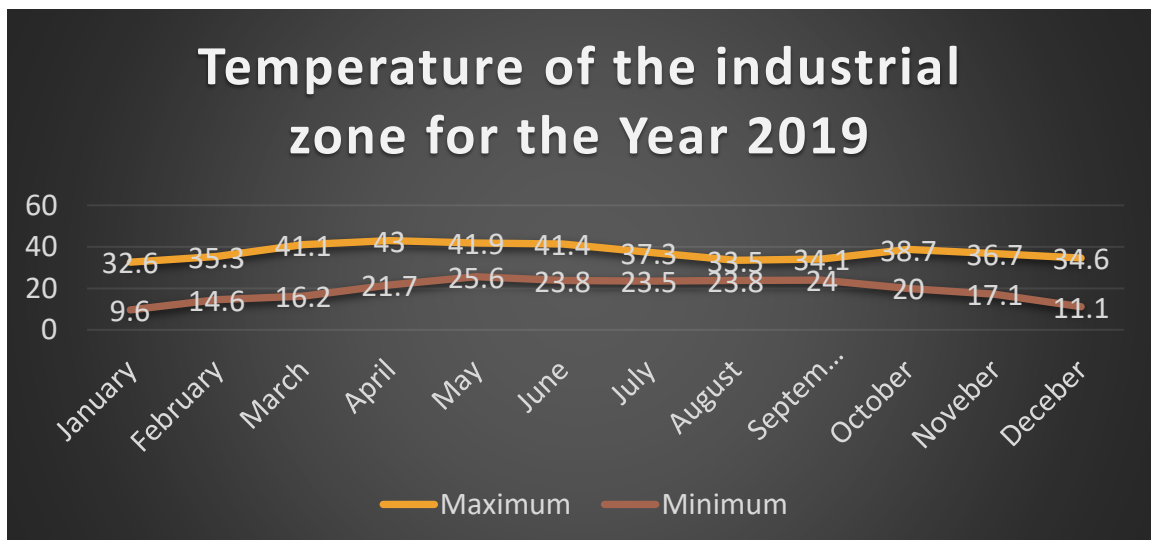


chart 7.1 Temperature of the industrial zone for the Year 2019

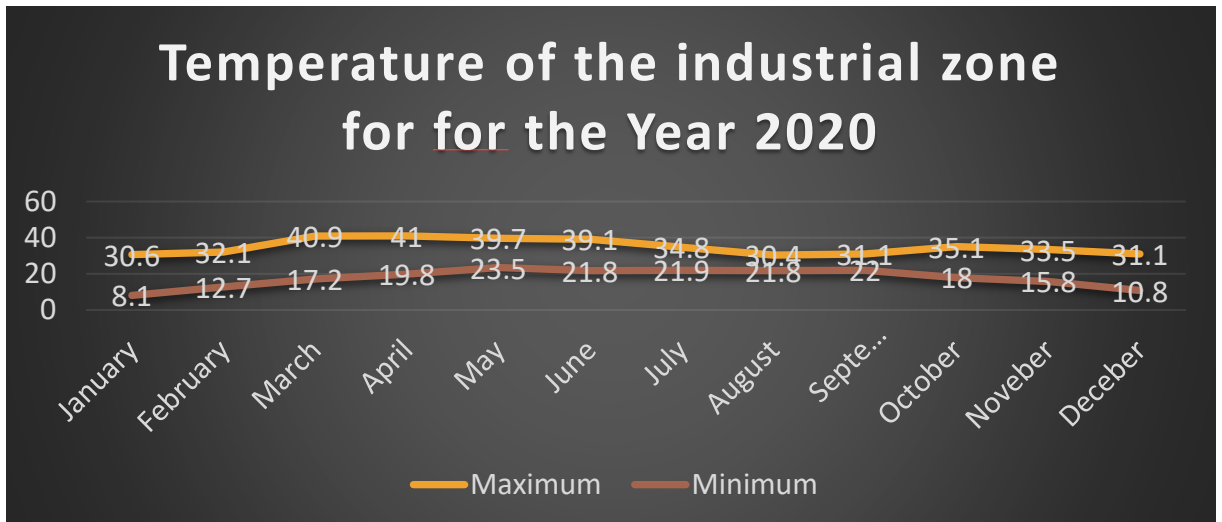


chart 7.2 Temperature of the industrial zone for the Year 2020

## 7.2 Future Scope

- This project initially cost will be very high but after that they reduced and low down the temperature of this zone.
- Main demerits of this project is to maintenance & care this green patches which design because of which is very important, now after that they will be fail or dry carding situation.
- The maintaining the green patch they would work better, After They become more effective to reduce the carbon emission.
- this is first initially starting project after we will design parking base and more effective designing patch. Like that internal part of the company, walkway design, some a escape space we were design green park so on.
- The main future work point is to include industrial fume which is affect the people in residential area. Because of the residential area which nearest to the industry as well as the windward direction of the city is that residential zone side.
- After the completion of the project, this project has been one an only which design to reduce the carbon emission in Vadodara industries.

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