



## A Balloon Test

Where does the wind flow?

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Where does the wind flow?

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LEAF is engaged in research and publication in the area of landscape design and environmental planning. It supports research programs of varying durations every year. Over the years, LEAF has increased its areas of exploration to developing city management matrices, governance and administration studies, urban generation and open space outreach efforts.

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## Introduction

Ahmedabad, as a city is spread across a flat horizontal terrain with hot and dry climate conditions. The city consists of many different regions, varying in parameters such as urbanity, density, materiality and functionality. All of these parameters influence the behavior of the wind in one way or another.

The predominant average wind direction in Ahmedabad varies throughout the year. Major change in the direction of wind occurs when the seasons change. Minor changes can be seen on a daily as well as hourly basis. From March to October, for a period of 6-7 months, the wind flows from the West, and Southwest direction. The period from October to December has winds flowing dominantly from the East direction. For the remaining 2 months, January and February wind flows from the North.

The data stated above is on the basis of wind maps generated by meteorological department. This data is represented for entire cities and towns on a larger scale but it does not define the localized wind directions and wind intensities at smaller urban parts or areas. The meteorological department uses different tools and devices to gather data and store it by using a suitable data logger.

The aim of this document is to observe the behavior of wind in different areas of the city with different parameters that can potentially influence the wind. It hopes to determine localized wind directions and wind intensity in different areas of the city.

It will look at the following-

- Factors that influences the direction and intensity of wind.
- Find out whether the wind is affected by temperature, humidity and precipitation level.
- Observe patterns of wind flow at different times of day.

The study began by identifying different areas in the city, and understanding parameters that can influence wind such as density of area (built up vs. open space ratio), materiality/physical context of the area and height of buildings in the area.

The study includes wind maps of three areas at different times of day. It allows for documentation and comparison of wind patterns for different times of day, within these areas.

## Methods of Mapping

The meteorology department in Ahmedabad uses different tools to measure winds such as anemometers, wind vanes and windsocks. Anemometers most commonly use rotating cups or propellers where the velocity of the rotation of cups is directly proportionate to the velocity of wind. This is defined to be the intensity of wind. Wind vanes are used to determine direction of wind. Data is collected through these devices per minute, and per hour. The average mean of all the data collected is defined to be the wind direction and wind intensity of a particular day.

Sustained wind speeds are reported globally at a 10 meter (33 feet) height, and are averaged over a 10 minute time frame. India typically reports winds over a 3 minute average, knowing the wind sampling average is important, as the value of a one-minute sustained wind is typically 14% greater than a ten-minute sustained wind.

The wind is often referred to as per the strength and direction from which it flows. For example, a northerly wind blows from the North to the South direction. Weather vanes pivot to indicate the direction of the wind. At airports, windsocks indicate wind direction, and can also be used to estimate wind speed by the angle of hang.

This study aimed at collecting data at different places in the city with a variety of materiality and diverse urban fabric. Unlike the meteorology department, wind is measured on the ground at different spots in selected area. Wind maps were generated on the basis of these observations. Three wind maps of three different times of day were generated for better understanding of how winds might behave differently. In each slot, wind is studied at multiple spots as well as at the same spot, multiple times for better comparison and more authenticity between data gathered at different times. All wind maps have been compared to see semblance and disparities in the pattern.

Particularly for this study, a balloon full of helium gas was used, tied down to a small rock and put down at different spots. At every spot the direction of wind was observed along with the intensity of wind which was classified into high, medium and low intensities. Wind direction at that spot can be determined by mapping the sway of the balloon. The displacement of the balloon from its original space denotes the intensity of wind.

## Observed Regions

Ahmedabad city consists of many different urban fabrics represented in different manners. A transect cutting across the Sabarmati river, central walled part of the city (situated on the east side of the river which has a very dense built mass and narrow streets going through it) and the central part on the west side of the river. The Eastern edge of the city comprises of industrial factories; at the Western edge, lay high-rise buildings and wide highways. The Northern part of the city has agriculture lands at the banks of an offshoot of Sabarmati, known as Chandrabhaga. There are also many suburban residential areas in city.

Three particular areas having maximum diversity amongst the urban fabric and materiality were selected for this study.

1. Parimal Garden, a public park in a residential neighborhood with a large water body and clusters of trees, on the west side of the river.
2. South Bopal, developed high-rise buildings around wide open roads at the western edge.
3. Ratan Pol, a dense street with minimum quanta of open spaces within the walled city.

Because of the differences between these areas, diverse wind patterns are studied and can be understood at micro level. Density of the built mass is different and heights of the buildings vary in all regions. For example Parimal garden has considerable green cover where Ratan pol has dense built mass instead.

Map of Ahmedabad



1. Parimal Garden
2. South Bopal
3. Ratan Pol

Source: Google Earth



Base Map



## Parimal Garden

A garden situated on the western central part of the city, Parimal Garden consists of a dense layer of trees on the periphery, and a large pond and lawns within its boundaries. On the south and east side of the garden, a wide road goes around the edges. Built up mass is located on the south of the road. Heights of the buildings in this area vary from G+0 to G+9.

Contrasting materiality of this area, such as varying heights of the buildings, dense tree cover, and a large water body, influences wind in many ways. A variety of wind patterns are observed in this area.

Because of the dense layer of trees and large water body, temperature of a particular area within the park drops down. This influences the behavior of wind and causes changes in direction and intensity. Trees and buildings on different sides of the road create a wind funnel. If the direction of the funnel is aligned with the broad wind direction, then it can increase the intensity of wind.



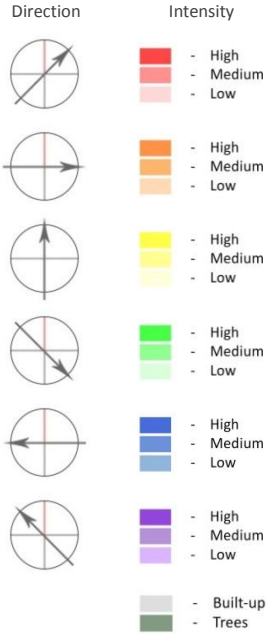
Context Plan



- Roads
- Paved Area
- Ground
- Water
- Lawn
- Trees
- G+1
- G+2
- G+3
- G+4
- G+5
- G+6
- G+9

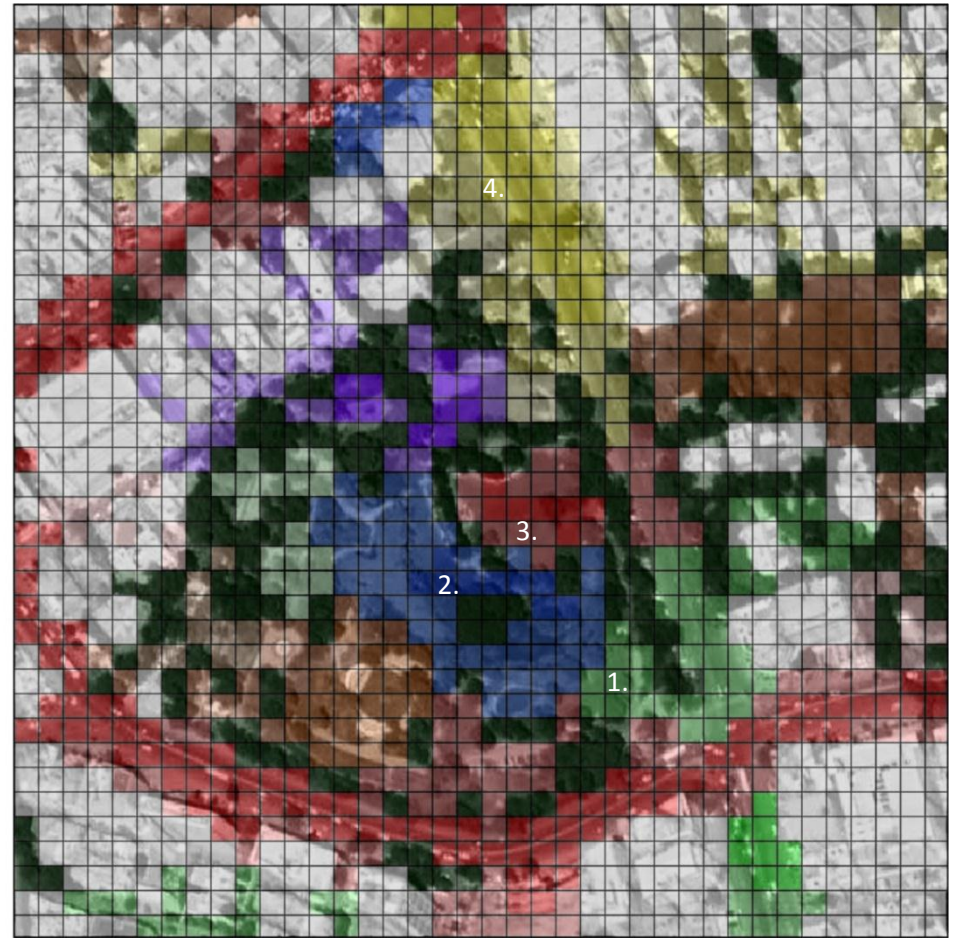


Parimal Garden



Wind Map

10:00 AM to 11:30 PM



Key Plan

Parimal Garden





1.  
Direction of wind: From Northwest  
Intensity of wind: Medium  
Time: 10:10 AM  
Description: On a pathway covered with trees, near entrance of garden.



2.  
Direction of wind: From East  
Intensity of wind: Medium  
Time: 10:50 AM  
Description: In the middle of garden, at the edge of the pond.

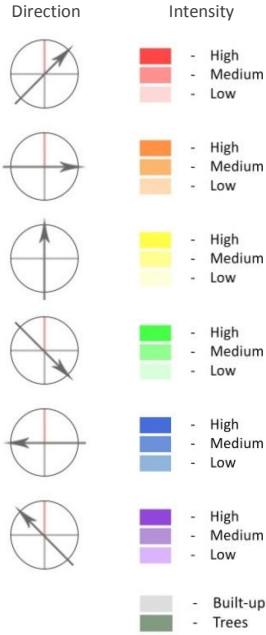


3.  
Direction of wind: From Southwest  
Intensity of wind: High  
Time: 11:10 AM  
Description: On a pathway around open lawns.



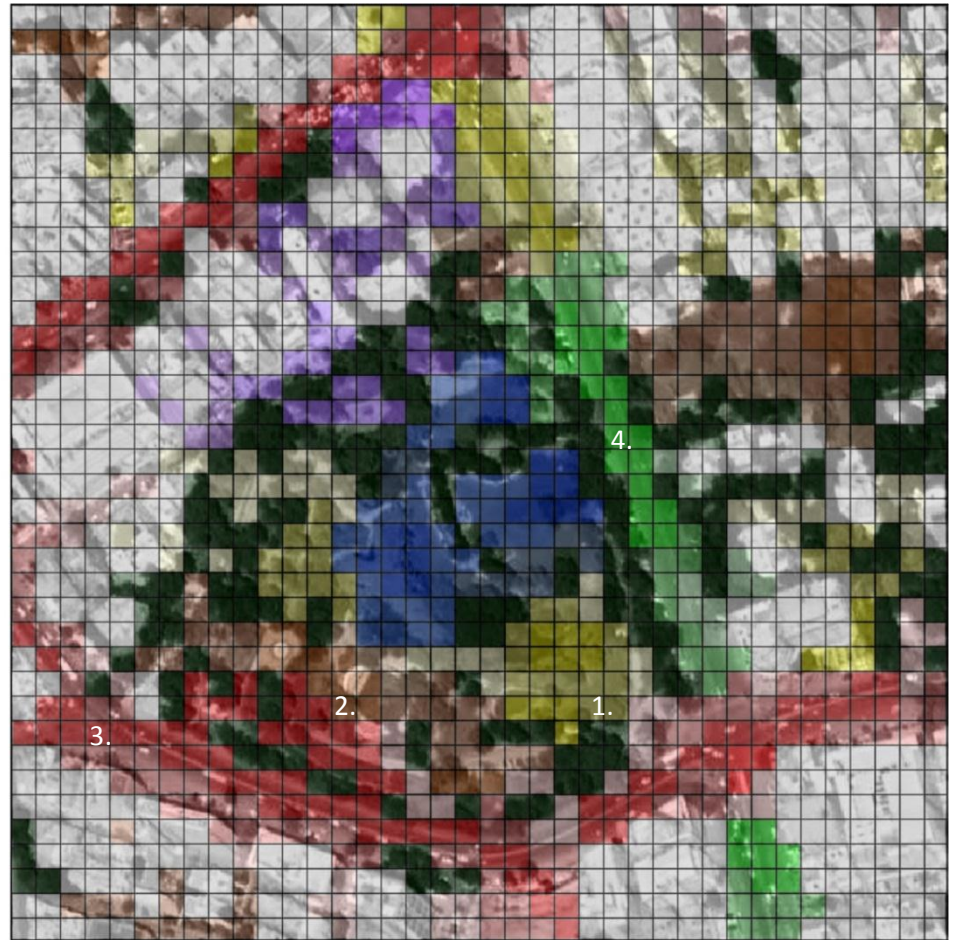
4.  
Direction of wind: From South  
Intensity of wind: High  
Time: 11:25 AM  
Description: On a side of the road, which is perpendicular to the primary road.





Wind Map

04:00 PM to 06:00 PM



Key Plan

Parimal Garden





1.  
Direction of wind: From South  
Intensity of wind: Low  
Time: 04:15 PM  
Description: On a pathway covered with trees, at the edge of garden.



2.  
Direction of wind: From West  
Intensity of wind: Medium  
Time: 04:35 PM  
Description: At the western end of garden, on an open pathway.

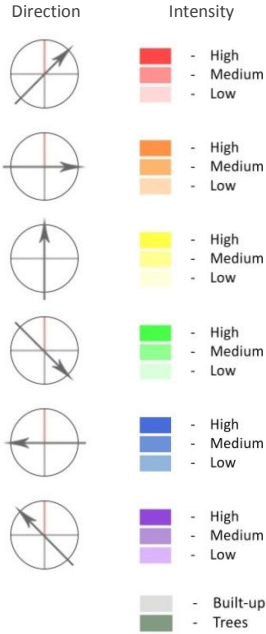


3.  
Direction of wind: From Southwest  
Intensity of wind: High  
Time: 05:00 PM  
Description: At the junction of a road, at the west end of garden.



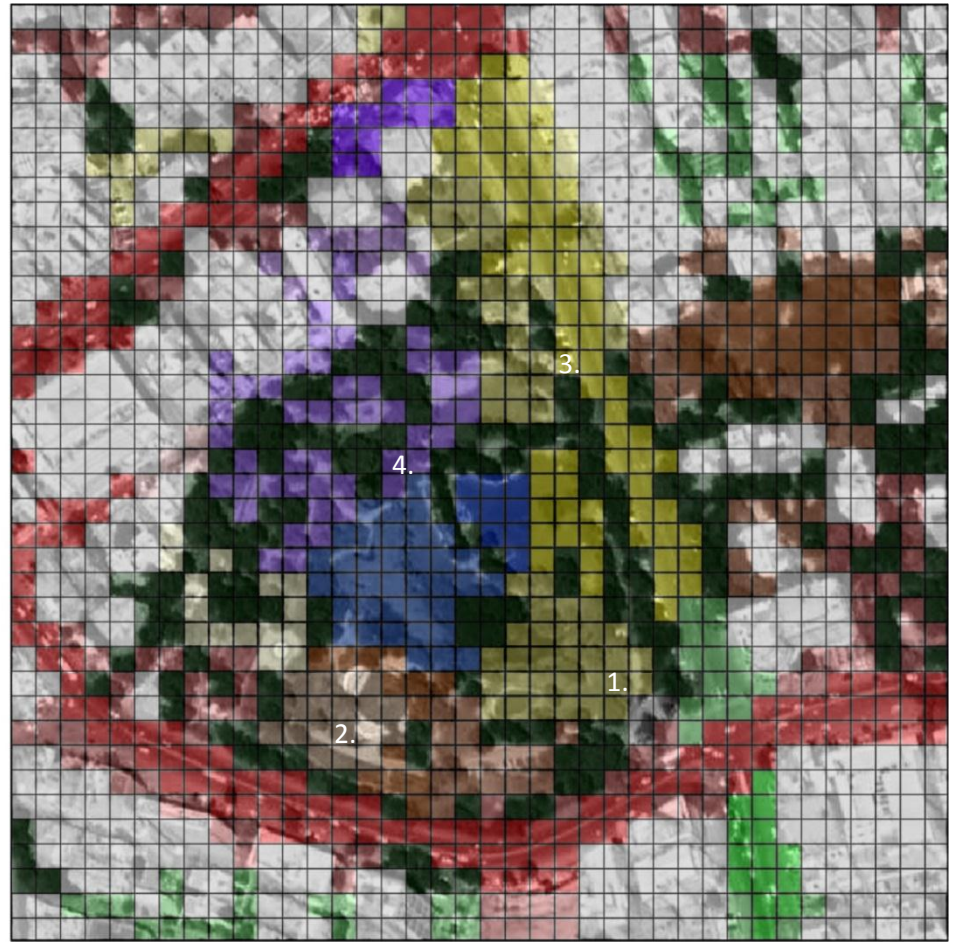
4.  
Direction of wind: from Northwest  
Intensity of wind: Medium  
Time: 05:40 PM  
Description: On the divider of the road with trees on both sides.





Wind Map

09:00 PM to 10:30 PM



Key Plan

Parimal Garden





1.  
Direction of wind: From South  
Intensity of wind: High  
Time: 09:05 PM  
Description: On a pathway covered with trees, at the edge of garden.



2.  
Direction of wind: From West  
Intensity of wind: Low  
Time: 09:20 PM  
Description: In the middle of garden, at the edge of the pond.



3.  
Direction of wind: From South  
Intensity of wind: High  
Time: 09:40 PM  
Description: On a side of the road, which is perpendicular to primary road.



4.  
Direction of wind: From Southeast  
Intensity of wind: Medium  
Time: 10:15 PM  
Description: In the middle of garden, near the bridge over pond.



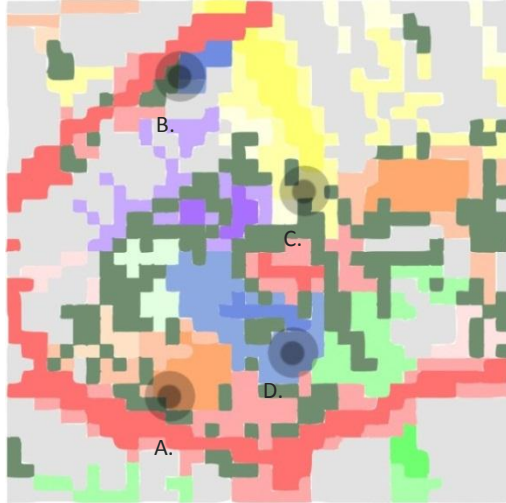
## Observation

As observed on site, the temperature difference between morning and noon is about 15°C-20°C. As temperature changes, pressure changes. This leads to a change in wind patterns. The difference between the wind maps of different times is minor, yet noticeable.

Summer wind from the Southwest direction more or less remains the same throughout the day on the roads aligned with the direction. However, minor changes are observed in the intensity of wind. Intensity of winds flowing in South to North direction increase, as the temperature is low in the morning and night, but the intensity of winds decreases in the noon as the temperature increases.

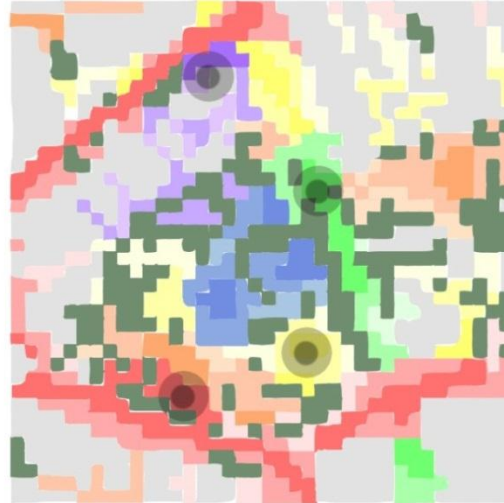
According to the meteorology department, wind flows from the Southwest to the Northeast direction at the height of 10 meter from ground. However, according to observations made at the ground level, in the middle of the garden there is a particular area where wind flows in the opposite direction. Because of the water body, the temperature remains low in that particular area, as compared to other parts in and around Parimal Garden. This causes the wind to flow in the opposite direction. Throughout the day, as the temperature rises and drops, area and intensity of wind flowing from East to West change accordingly.

10:00 AM to 11:30 AM



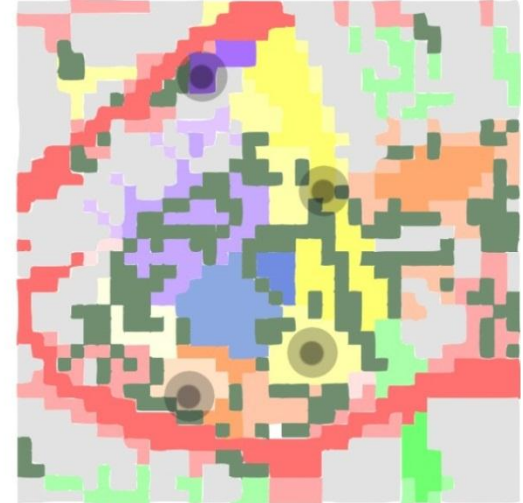
Temperature: 25-27° C  
Cool breeze  
High intensity

04:00 PM to 06:00 PM



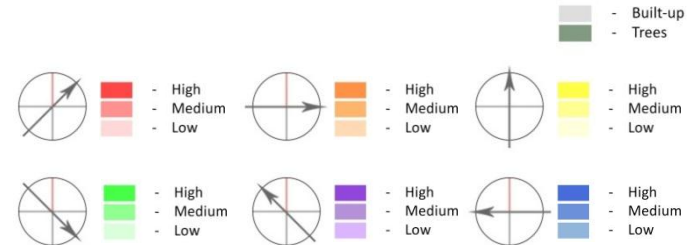
Temperature: 40-43° C  
Hot breeze  
Medium intensity

09:00 PM to 10:30 PM



Temperature: 28-30° C  
Warm breeze  
High intensity

- A. West to East – high, Southwest to Northeast – high, West to East – low.
- B. East to West – high, Southeast to Northwest – medium, Southeast to Northwest – high.
- C. South to North – medium, Northwest to Southeast – high, South to North – high.
- D. East to West – medium, South to North – high, South to North, medium.



Base Map



## South Bopal

Situated on the western edge of the city, South Bopal is located in the outskirts of Ahmedabad, consisting of clusters of high-rise buildings with courtyards. Almost all of the high-rise buildings are residential and have been constructed recently and many are still under construction. Heights of the buildings start from G+4 and go up till G+12.

One primary road aligned with west to east direction passes through the high rise buildings, and meets the Sardar Patel ring road. Other secondary roads are perpendicular to the primary road. Trees are planted linearly on the sides of the road, foliage of the trees is not so large which indicates that the trees were planted recently.

Context Plan

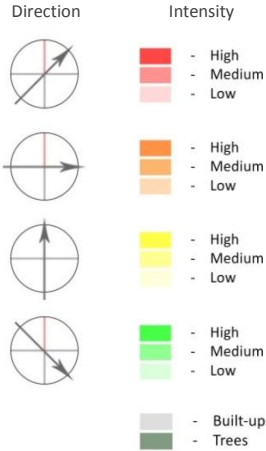


- Roads
- Paved Area
- Ground
- Lawn
- Trees
- G+0
- G+4
- G+9
- G+10
- G+11
- G+12



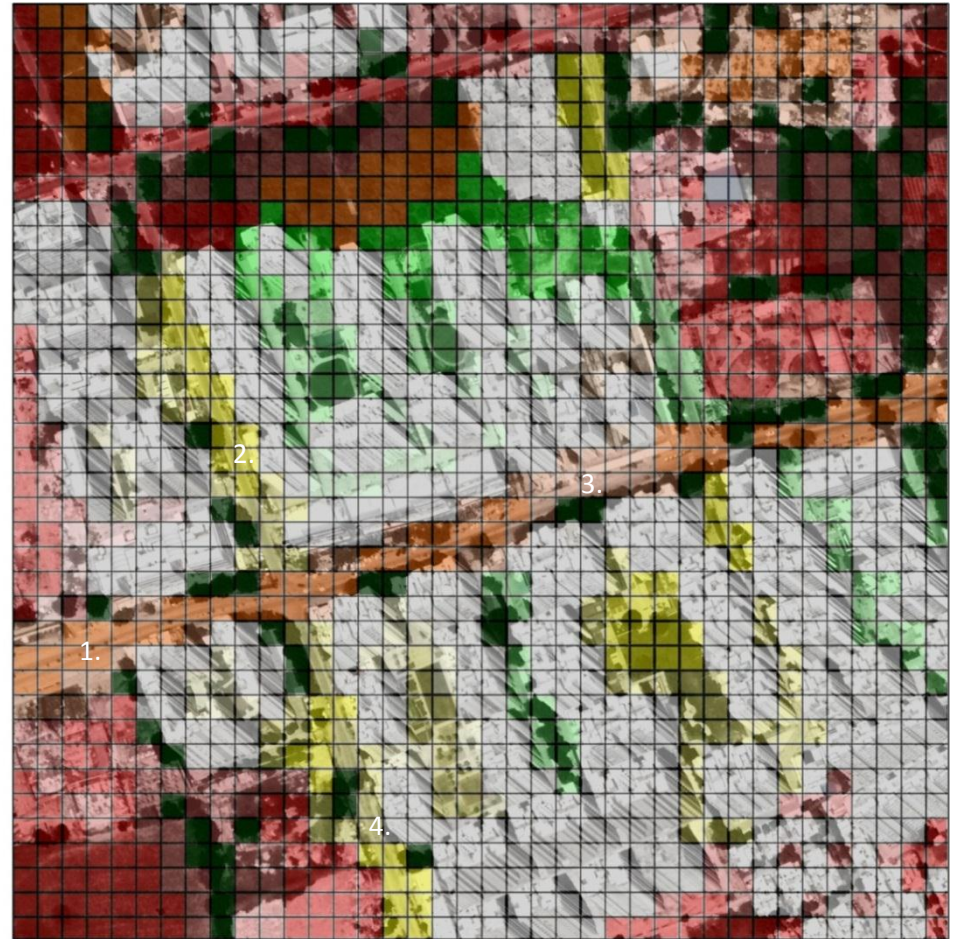
South Bopal





Wind Map

10:00 AM to 11:30 PM



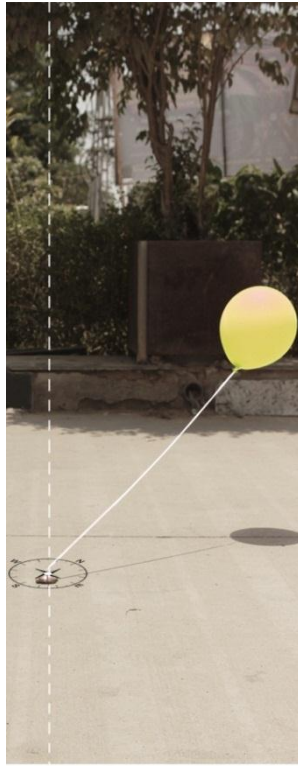
Key Plan



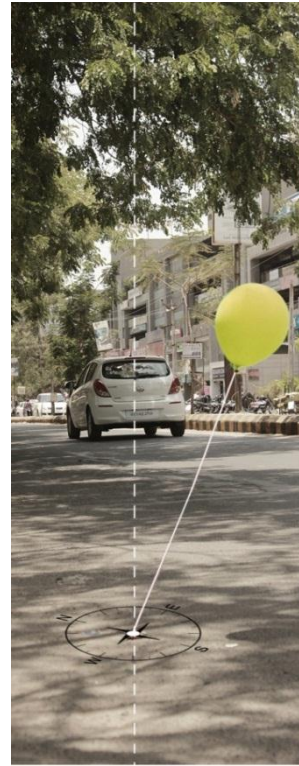
South Bopal



1.  
 Direction of wind: From West  
 Intensity of wind: Medium  
 Time: 10:10 AM  
 Description: On the divider of primary road.



2.  
 Direction of wind: From South  
 Intensity of wind: High  
 Time: 10:30 AM  
 Description: Near a G+12 height building.

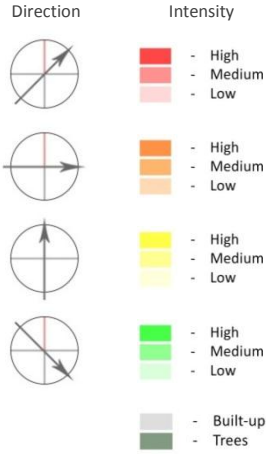


3.  
 Direction of wind: From West  
 Intensity of wind: Medium  
 Time: 10:50 AM  
 Description: On the side of a road covered with large foliage trees.



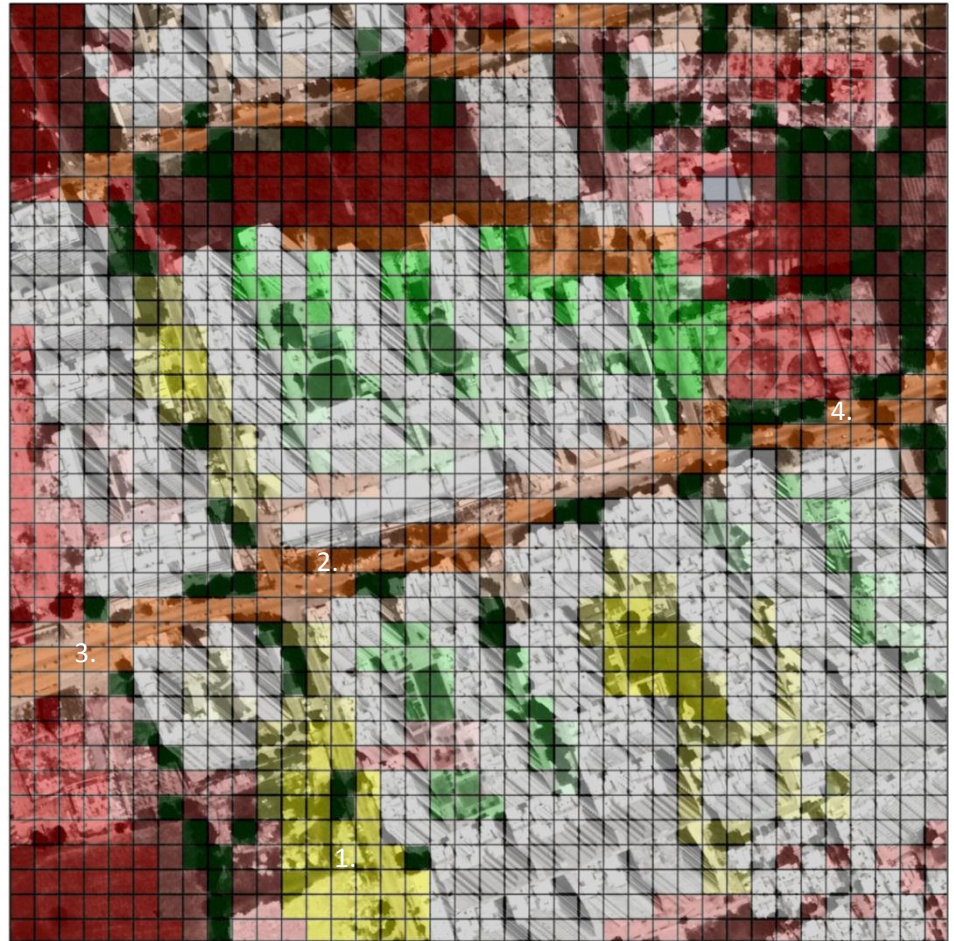
4.  
 Direction of wind: From South  
 Intensity of wind: Medium  
 Time: 11:20 AM  
 Description: On a road with high rise buildings on both sides.





Wind Map

05:00 PM to 06:30 PM



Key Plan

South Bopal







1.  
Direction of wind: From South  
Intensity of wind: High  
Time: 05:00 PM  
Description: On the entrance of a construction site.



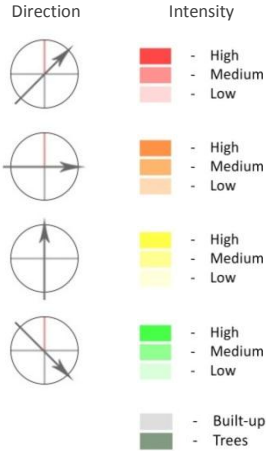
2.  
Direction of wind: From South  
Intensity of wind: Medium  
Time: 05:30 PM  
Description: Near a G+12 height building.



3.  
Direction of wind: From West  
Intensity of wind: Medium  
Time: 05:55 PM  
Description: On the divider of primary road.

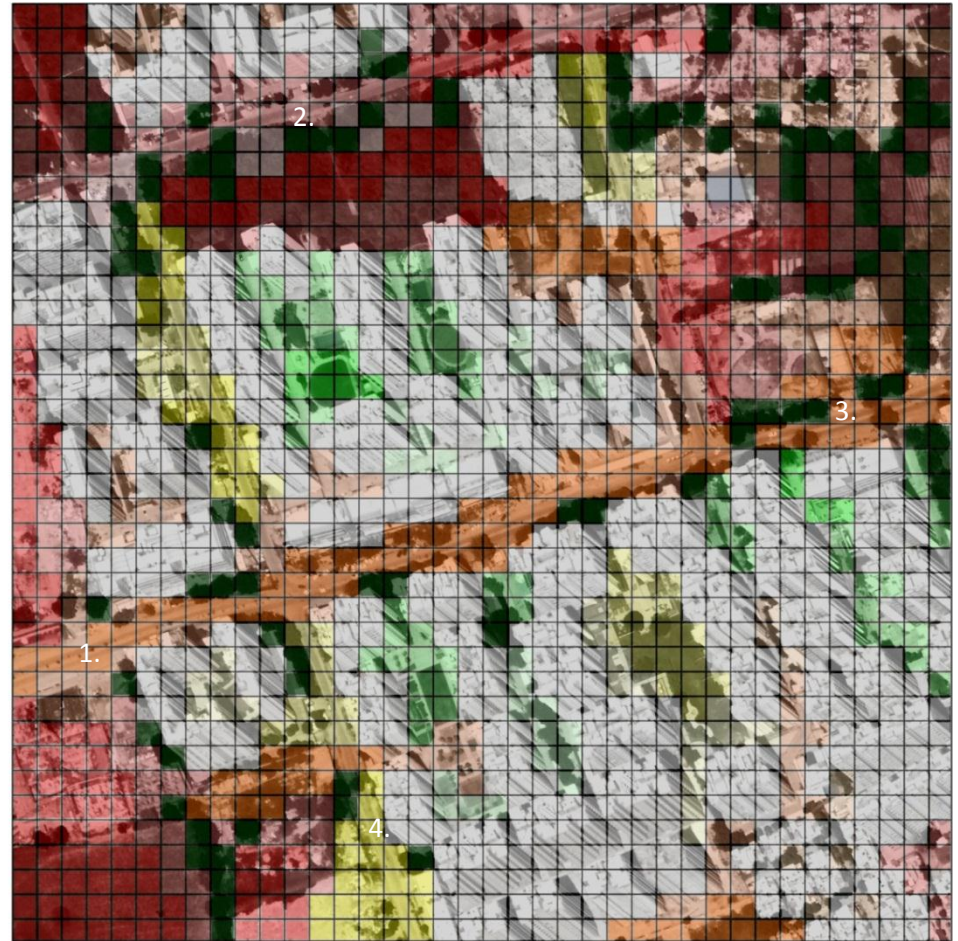


4.  
Direction of wind: from West  
Intensity of wind: Medium  
Time: 06:15 PM  
Description: On a footpath with garden at one side, trees at other.



Wind Map

08:30 PM to 10:00 PM



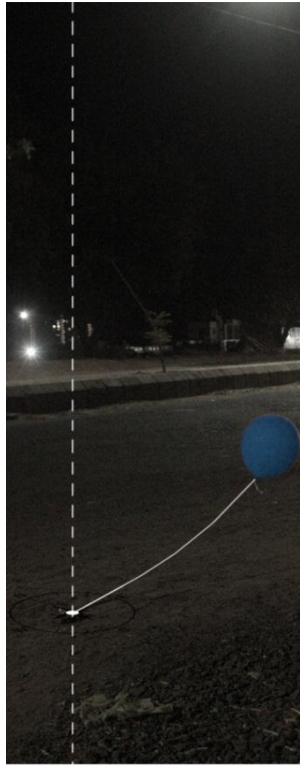
Key Plan

South Bopal





1.  
Direction of wind: From West  
Intensity of wind: Medium  
Time: 08:35 PM  
Description: On the divider of primary road.



2.  
Direction of wind: From Southwest  
Intensity of wind: High  
Time: 09:05 PM  
Description: On the side of road with high rise building on back.



3.  
Direction of wind: From West  
Intensity of wind: Medium  
Time: 09:40 PM  
Description: At the corner of a junction of primary and secondary road.



4.  
Direction of wind: From South  
Intensity of wind: High  
Time: 09:55 PM  
Description: On the side of a road with high rise building on both sides.

## Observation

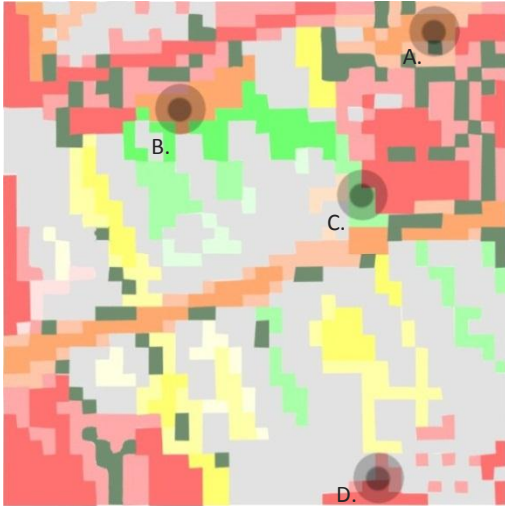
The overall wind intensity in this area is higher as compared to the others, since it is in the outskirts of the city with flat open grounds at all sides. The wind here is not presented with too many obstacles. Winds blowing from the Southwest direction are prominent in this region as there are a number of open grounds around the built mass. Throughout the day the Southwest wind will remain consistent. However, the intensity of these winds varies, depending on the temperature. The only parameter to influence the direction and intensity of wind are the high-rise buildings in this part of the city.

A wind funnel is created on the primary road because of the high-rise buildings on both sides. Since the road goes from West to East, wind direction on that road remains the same. Similar behavior is observed on the other road, which is parallel to the primary road.

A majority of the buildings in this area are residential. Almost all of the flats are housing schemes with large courtyards in the center. Winds coming in the courtyards are already diverted because of the building blocks around it. The wind direction in the courtyards will depend on the gaps between buildings from which winds enter in the courtyards.



10:00 AM to 11:30 AM



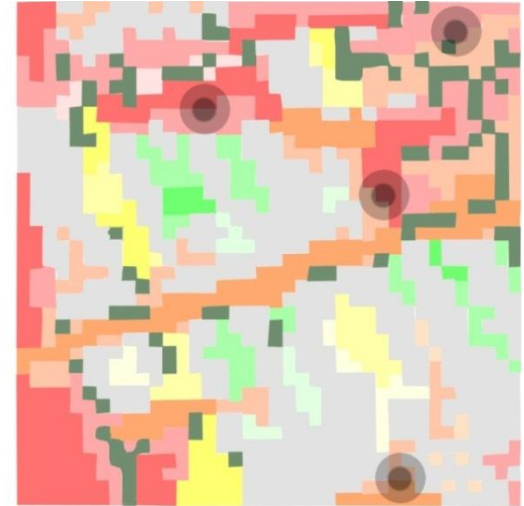
Temperature: 29-32° C  
Warm breeze  
High intensity

05:00 PM to 06:30 PM



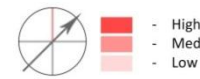
Temperature: 38-41° C  
Hot breeze  
High intensity

08:30 PM to 10:00 PM



Temperature: 26-28° C  
Cool breeze  
High intensity

- Built-up  
 - Trees



- A. West to East – high, West to East – medium, Southwest to Northeast – medium.
- B. West to East – high, Southwest to Northeast – high, Southwest to Northeast – medium.
- C. Northwest to Southeast – medium, Northwest to Southeast – high, West to East – medium.
- D. Southwest to Northeast – high, Southwest to Northeast – medium, West to East – high.

Base Map



## Ratan Pol

Ratan pol is a very long and narrow street in the heart of the old city. This area has a very dense built mass on both sides of every road and minimum quanta of open spaces. Heights of the buildings vary from G+0 to G+5. Buildings on the sides of the roads and streets are of three, four and five stories.

A primary road can be seen which goes to the railway station and secondary roads connect to the primary road perpendicularly. Secondary roads are parallel to each other. Ratan Pol is one of these secondary roads which are also connected through narrow streets. All these narrow streets are not parallel or perpendicular to each other but laid out irregularly.

For the materiality of both the areas studied before green cover and open flat grounds were considered but for Ratan Pol built up mass is considered. The only open spaces are the courtyards on the back side of the buildings on Ratan Pol; they are very low in numbers.

Context Plan

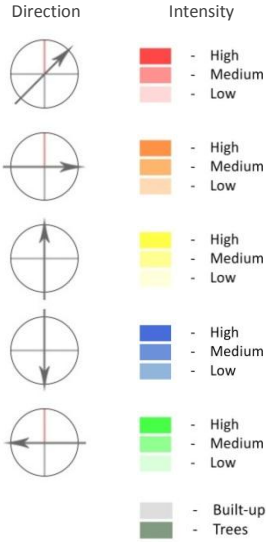


- Roads
- Paved Area
- Ground
- Trees
- G+0
- G+1
- G+2
- G+3
- G+4
- G+5



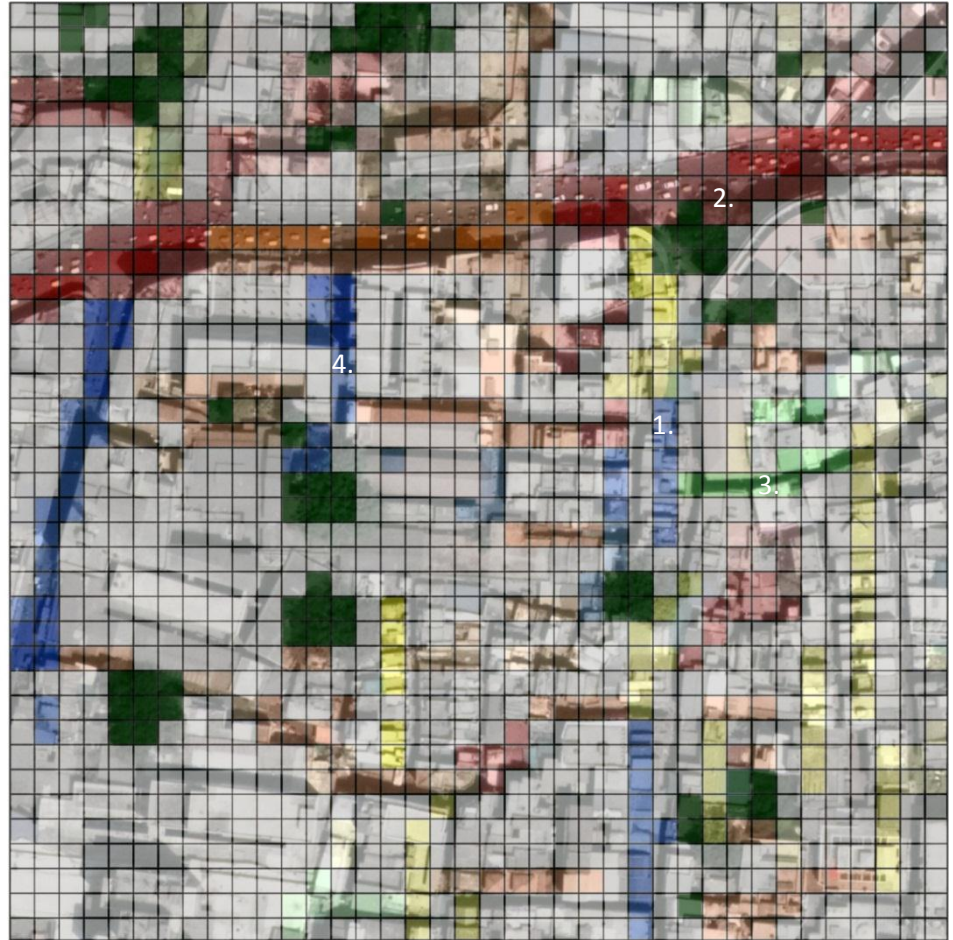
Ratan Pol





Wind Map

09:00 AM to 10:30 AM



Key Plan

Ratan Pol





1.  
 Direction of wind: From North  
 Intensity of wind: Low  
 Time: 09:15 AM  
 Description: In the middle of Ratan Pol, besides a shop.



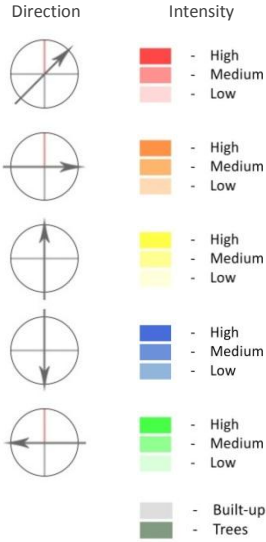
2.  
 Direction of wind: From Southwest  
 Intensity of wind: Medium  
 Time: 09:30 AM  
 Description: On the side of primary road.



3.  
 Direction of wind: From East  
 Intensity of wind: Medium  
 Time: 09:50 AM  
 Description: On one of the streets which joins Ratan Pol

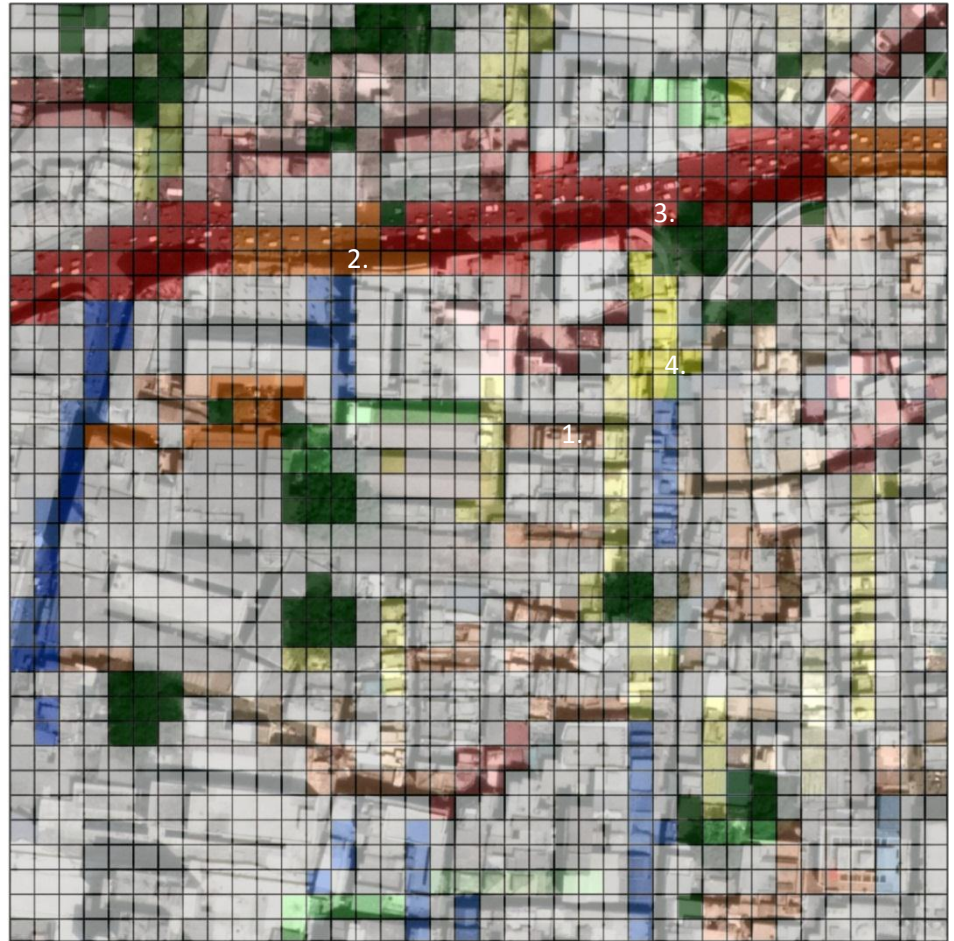


4.  
 Direction of wind: From North  
 Intensity of wind: Medium  
 Time: 10:25 AM  
 Description: On a thin street parallel to Ratan Pol.



Wind Map

04:30 PM to 06:00 PM



Key Plan

Ratan Pol







1.  
Direction of wind: From West  
Intensity of wind: Medium  
Time: 04:45 PM  
Description: In a thin street meeting ahead at Ratan Pol.



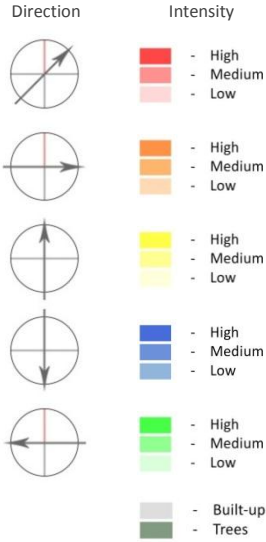
2.  
Direction of wind: From West  
Intensity of wind: High  
Time: 05:05 PM  
Description: On the side of a street parallel to Ratan Pol.



3.  
Direction of wind: From Southwest  
Intensity of wind: Medium  
Time: 05:30 PM  
Description: At the corner of a junction of primary road and Ratan Pol.

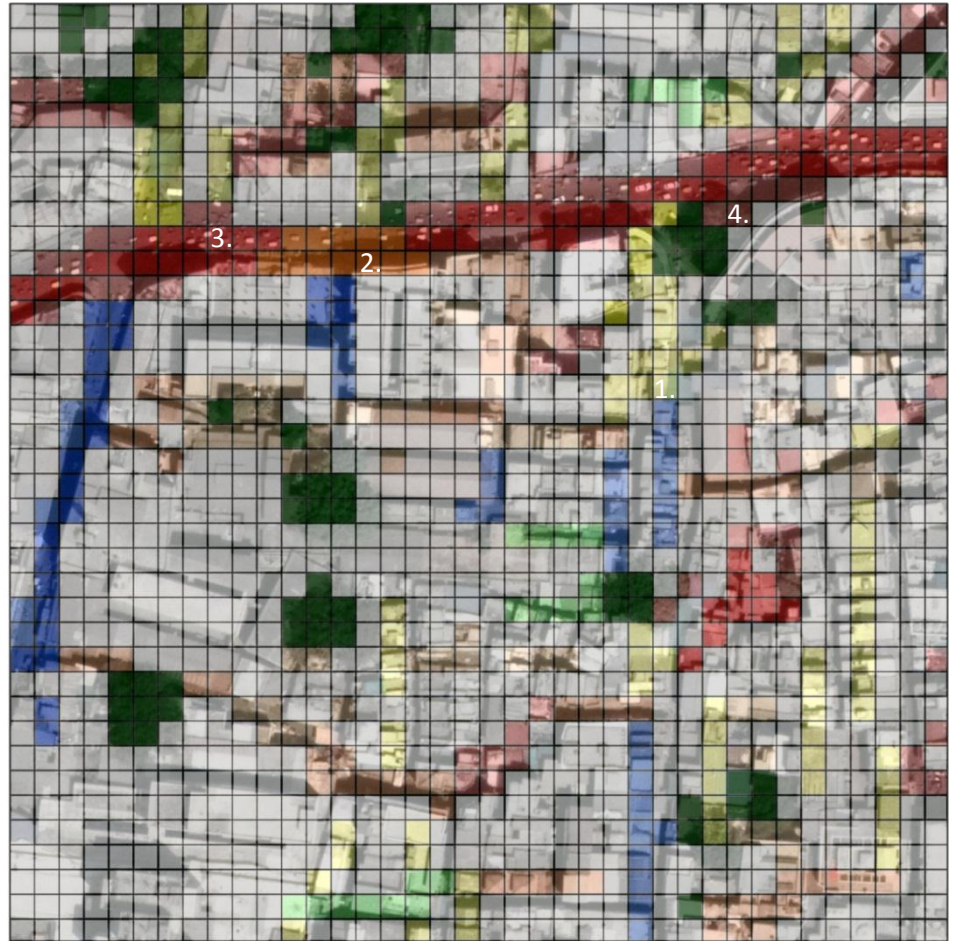


4.  
Direction of wind: From South  
Intensity of wind: High  
Time: 05:40 PM  
Description: At the mouth of the Ratan Pol.



Wind Map

09:30 PM to 10:30 PM



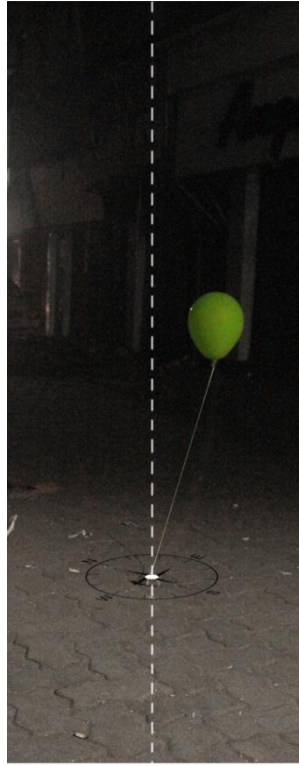
Key Plan

Ratan Pol

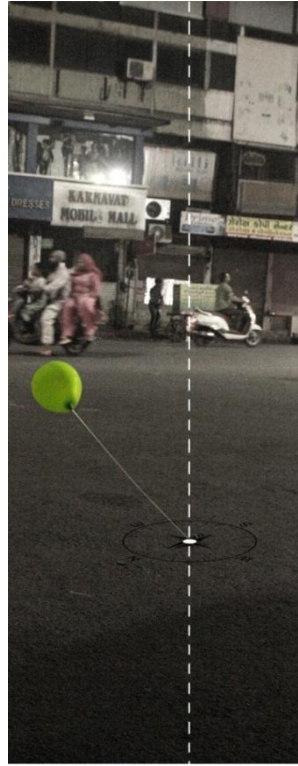




1.  
Direction of wind: From South  
Intensity of wind: High  
Time: 09:35 PM  
Description: At the mouth of Ratan Pol.



2.  
Direction of wind: From West  
Intensity of wind: Low  
Time: 09:50 PM  
Description: On the side of a street parallel to Ratan Pol.



3.  
Direction of wind: From Southwest  
Intensity of wind: Medium  
Time: 10:05 PM  
Description: On the side of primary road.



4.  
Direction of wind: From Southwest  
Intensity of wind: High  
Time: 10:20 PM  
Description: At the corner of a junction of primary road and Ratan Pol.

## Observation

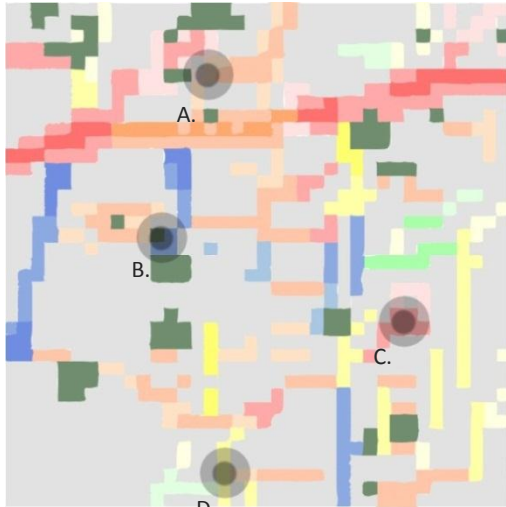
Winds flows with a very limited intensity in this area because the built up density of this area is very high. Almost all the buildings are built next to each other with no space in between. Paths of wind are formed according to the layout of streets in this area; the intensity of wind is influenced by the width of the streets. If the streets are wide enough then the wind will flow with high intensity but if the streets are narrow then wind will flow with low intensity.

Narrow streets and buildings are laid out in a complex, yet random manner in this area which results into pathways ending abruptly because of buildings ahead, and parted in two directions perpendicular to original path. At such spots, when a wind flow on the original pathway comes to a block, it gets separated in opposite directions.

Many of the clusters of buildings have open spaces within, and wind enters in these open spaces through any available gaps. Direction of wind in these courtyards depends on the position of the gaps from which wind enters. Change in wind direction affects wind intensity as well.

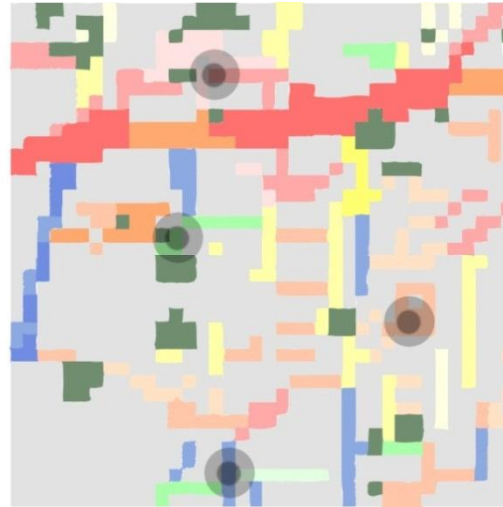


09:00 AM to 10:30 AM



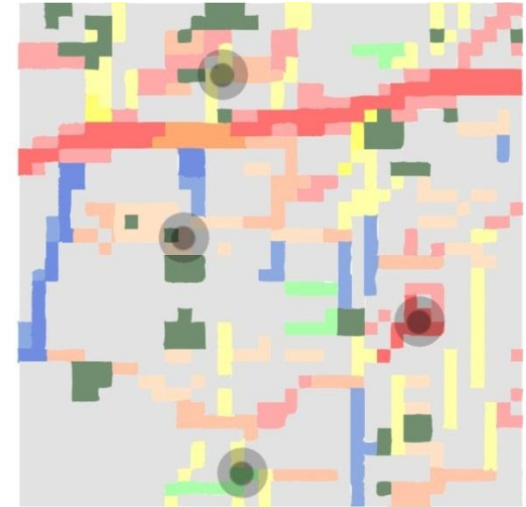
Temperature: 31-33° C  
Warm breeze  
Low intensity

04:30 PM to 06:00 PM



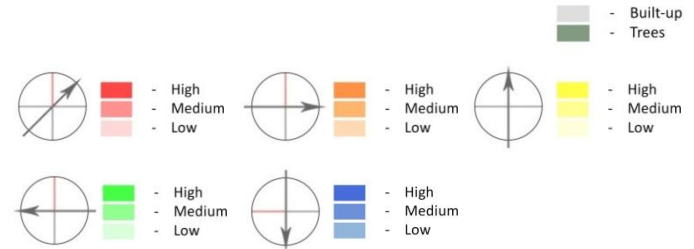
Temperature: 36-40° C  
Warm breeze  
Medium intensity

09:30 PM to 10:30 PM



Temperature: 28-30° C  
Cool breeze  
Medium intensity

- A. West to East – low, Southwest to Northeast – medium, South to North – medium.
- B. North to South – medium, East to West – medium, West to East – low.
- C. Southwest to Northeast – medium, West to East – medium, Southwest to Northeast – high.
- D. South to North – medium, North to South – medium, East to West – medium

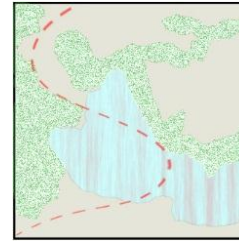


## Inferences

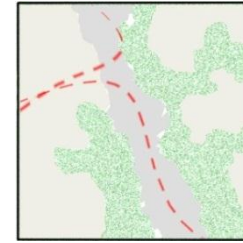
Different patterns of wind are recorded on the basis of the observations made in each area. Each pattern is described in terms of how the wind is influenced. To understand how the behavior of wind changes according to factors affecting direction and intensity of wind, the direction from which the wind was coming, and the direction in which the wind is going to, are shown. Wind routes help in understanding varying patterns of wind. Sometimes wind patterns affected by the time of the day and temperature, or by more tangible physical parameters such as high-rise buildings, narrow streets and water bodies.

### Wind patterns in Parimal Garden.

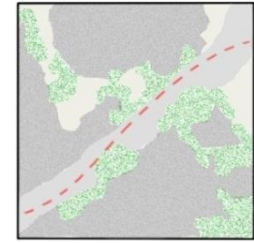
- A. **Influence of water:** Water body in the central area causes temperature to drop down and as a result, pressure also decreases. A cluster of trees that lie on the West of water body, block the winds coming from Southwest direction, which leads the winds to flow in opposite direction.
- B. **Barrier of trees:** On the ground, for winds coming from Southwest direction, trees and buildings act as barriers and divert winds in a slightly different direction. For example, winds flowing from Southwest direction will divert to South or West.
- C. **Alignment with the summer winds:** Roads or open spaces, which are aligned from the Southwest to Northeast direction, or aligned with the direction of the summer winds, have no obstacles to influence the winds. Hence, the wind intensity would remain high, and the wind direction remains unaffected.



A.  
From SW-NE to E-W.



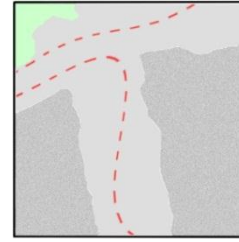
B.  
From SW-NE to NW-SE and S-N.



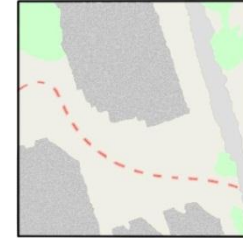
C.  
From SW-NE to SW-NE.

### Wind patterns in South Bopal.

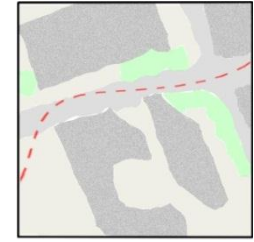
- A. **Diversion due to high-rises:** High-rises act as large blocks standing as obstacles in the direction of summer winds, blowing at high intensity from Southwest direction. Unlike smaller objects, these blocks would change the direction of wind completely. For example, winds flowing from the West would be diverted in the North instead of East direction.
- B. **Barriers:** On the ground, for winds coming from Southwest direction, smaller buildings act as barriers and divert winds into a slightly different direction. For example, winds flowing from Southwest direction will divert to the South or West.
- C. **Creating a funnel:** A wind funnel is often created in the case where an open, linear space has tall obstacles (such as trees or high-rises) on either of its longer sides. Winds coming from South-west direction will be diverted towards the funnel. Intensity of the winds is initially lower at the starting end of the funnel but increases drastically while traversing through the funnel.



A.  
From W-E to NW-SE.



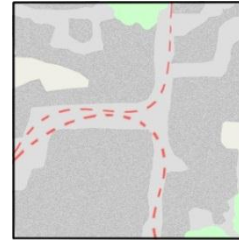
B.  
From SW-NE to W-E.



C.  
From SW-NE to W-E.

### Wind patterns in Ratan Pol.

- A. **Divergent in opposite directions:** Observed in Ratan pol, whenever a gust of wind comes to a dead end created by a dense built mass, the wind parts in two, mutually opposite directions, and flows further until another barrier changes its flow.
- B. **Entering crevices and gaps:** Winds coming from Southwest direction are diverted in a different direction because of the built mass. However, when there are gaps or spaces within the cluster, it allows winds to come within, which leads to a change in wind direction and also reduces the intensity of the wind.



A.  
From W-E to S-N and N-S.



B.  
From W-E to N-S.

- Blocks
- Tree cover
- Open space
- Roads
- Water
- Wind route



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Samarth Vyas is a student from APIED, Vallabh Vidhyanagar and studying architecture. This study is a part of his training at M/s Prabhakar B. Bhagwat for 6 months and was undertaken for a period of 3 weeks.

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