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Case Study: Climatic Changes in three Major Cities

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Abstract: Climate change refers to changes in modern climate, including the rise in average surface temperature. Using the obtained meteorological data such as temperature, wind & precipitation and comparing satellite images of these 3 cities, shows an increase in average temperature and decrease in precipitation over the years, it also shows a rapid decrease in green cover in all three cities. Human activities such as deforestation and exploitation of other natural resources is one of the leading causes of the rapid changes in climate and its effects over the past century. To get a general idea of the people's perception of all this, a survey was conducted by us and the statistics of the survey is analyzed.

Keywords: Climate, Temperature, Deforestation, Satellite Imagery, Green Cover.

I. INTRODUCTION

Climate is the long-term pattern of weather conditions in a particular area. It is measured by analyzing and observing the patterns of variation in temperature, atmospheric pressure, humidity, wind, precipitation and other meteorological factors that tend to vary in a given region over a long range of time [1].
A region's climate is generated by the climate system, which has five constituents: biosphere, lithosphere, cryosphere, hydrosphere and atmosphere.

The climate of a place is defined by virtue of its position. Its distance from water bodies, its altitude from the sea level, and the shape of the land the place lies on, that is its terrain, and also latitude and longitude.

The climatic conditions of India host a wide array of weather conditions. Classified based on the Köppen system, India has 6 major climatic conditions. Ranging from glaciers and snow fed mountains in the north to arid deserts in the west, and dense tropical rainforests supported by humidity in the south west [3].

Every year India has four major seasons:

- The Winter season: starting in January going up to February
- The Summer season : starting around March and ending around May
- The Monsoon season: the most celebrated season of the country begins around June and closes by September.
- The post Monsoon season: this goes on from October to December.

But these season's dates are subject to climate change. The timing of these seasons affects the way and how people will plant and grow their crops. Bad timing can result in severe losses in the crop yield the result of which there will be food shortage, famine and drop in economy because India is nation that is severely dependent on her agriculture and agricultural products.

Thus there is an arising need to observe and report the rapid changes in climate and its potent causes.

Climate change refers to change or variation in conventional or regular weather patterns that take place of a period of time. These changes can take place and last over decades to millions of years.
Climate change can also be explained as the time variation of weather when compared to long term average pre-recorded climatic conditions.

According to the United Nations framework for climate change: Climate change means a change of climate which happens directly or indirectly due to human activity that alters the composition of the earth's atmosphere globally and which is not due to but summed up to natural climate variations observed on a global scale over long periods of time[5].

Factors affecting climate change [4]**:**

- Global warming
- Green house gas concentrations
- Human activities such as:
  Deforestation
  Forest Land encroachment
  Pollution
  Fossil fuel combustion
  Land degradation
- Solar radiation
- Variations in earth's orbit
- Continental drift

Effects of climate change:

- Causes rise in temperatures worldwide
- Warmer air over land evaporates more water from soil and plants and can create or extend drought.
- Warmer air also warms glacier ice and starts their melting
- Thermal expansion of ocean water.
- Rise in sea levels
- increase in floods and droughts
- impact on food availability, food accessibility and food systems
- Agriculture is highly affected and crop yield will drop.
- World Bank confirms that 100 million people are likely to be slipping into poverty by 2050.

In our research as a case study of climate change we have focused on the three major cities in India namely:

Delhi [28°37′N 77°14′E / 28.61°N 77.23°E], Kolkata [22° 34′ 0″ N, 88° 22′ 0″ E] and Chennai[13.0827° N, 80.2707° E].

We have conducted a survey of how the people of these cities have experienced climate change, to what extent they have felt it and since when they have been experiencing it.

II. EXPERIMENTAL

We have compared satellite images of these 3 cities over the past 10 years and shown the relation between increase in developed area and depleting green cover change using the satellite images. The major observation drawn here is how the depleting greenery has led to the change in climate.

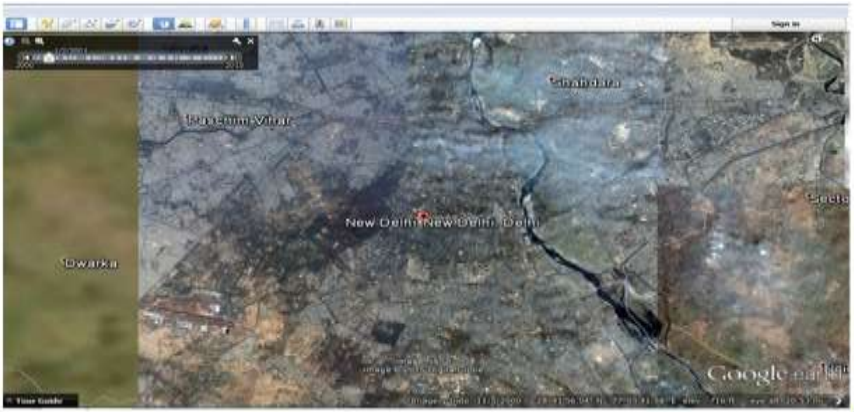
We believe that the most important reason for climate change is the loss in vegetation. Loss in vegetation leads to land degradation. The reasons for land degradation are as follows [7]:

- Population expansion
- Land encroachment
- Land clearing for agriculture
- Land clearing for settlement
- Cattle overgrazing

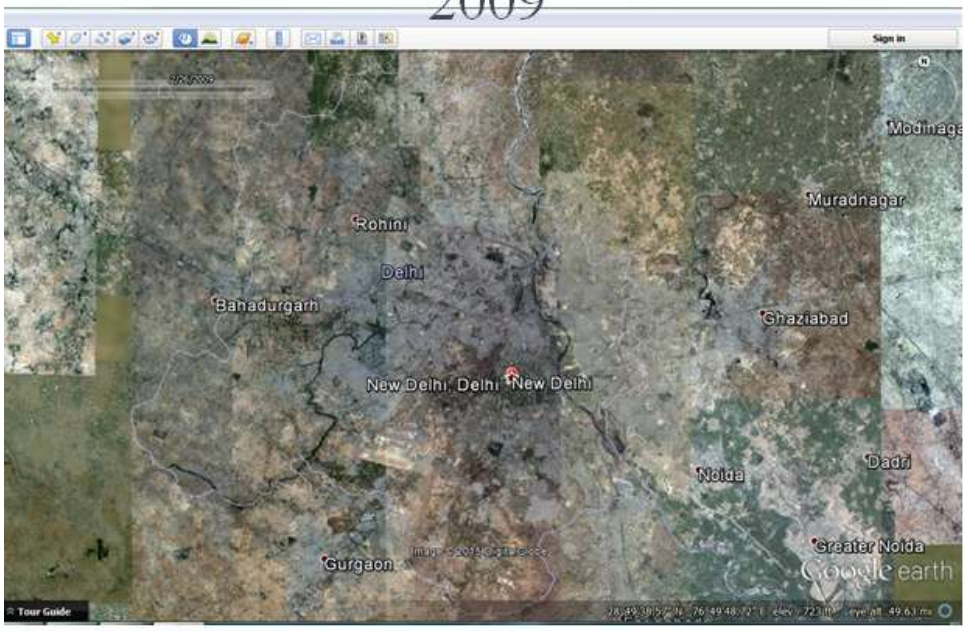
The images as follows:

- *New Delhi Satellite Data (2001 to 2015)*

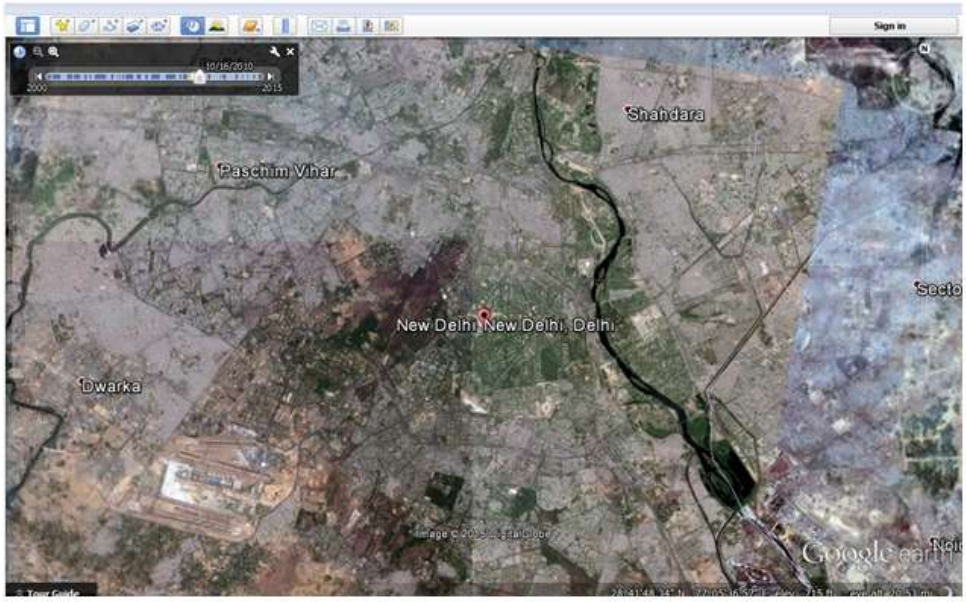
2001



2009

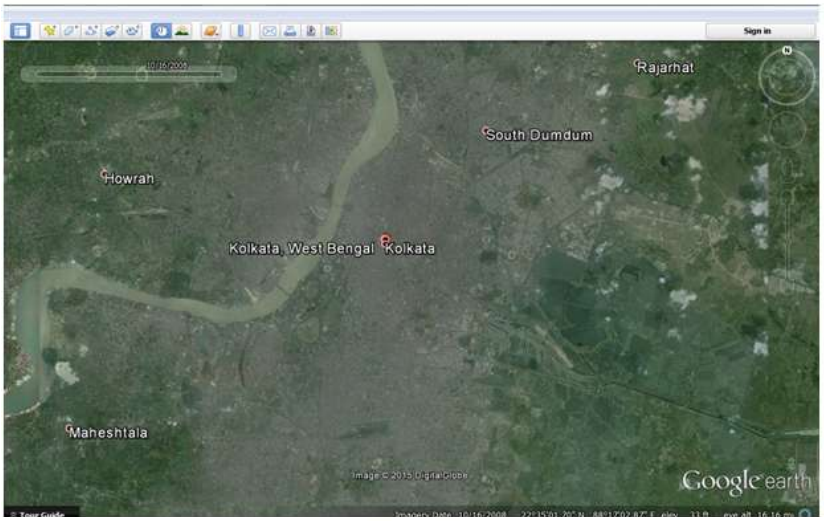


2010

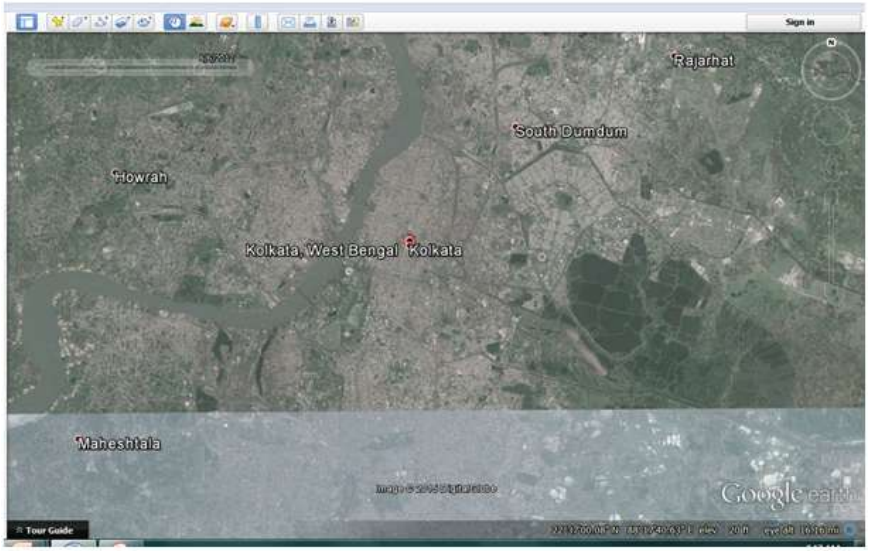


- *Kolkata Satellite Data (2008 to 2015)*

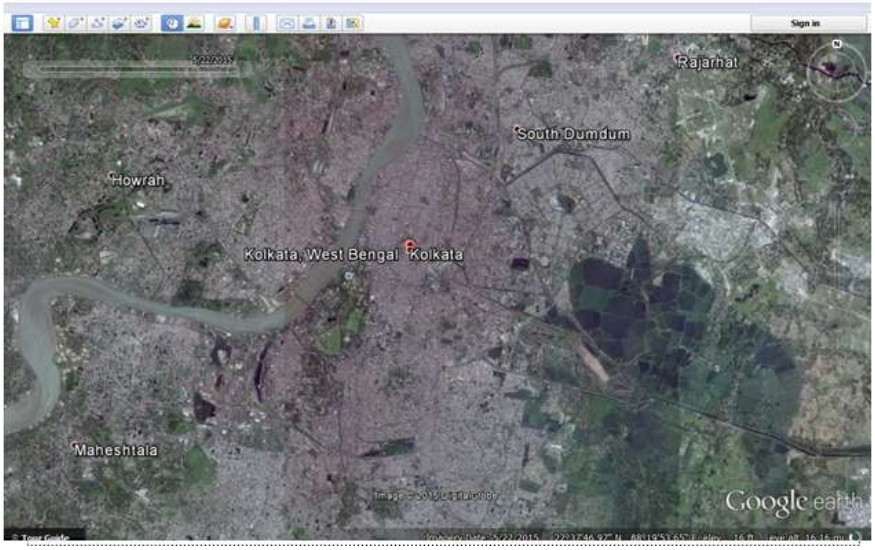
2008



2012

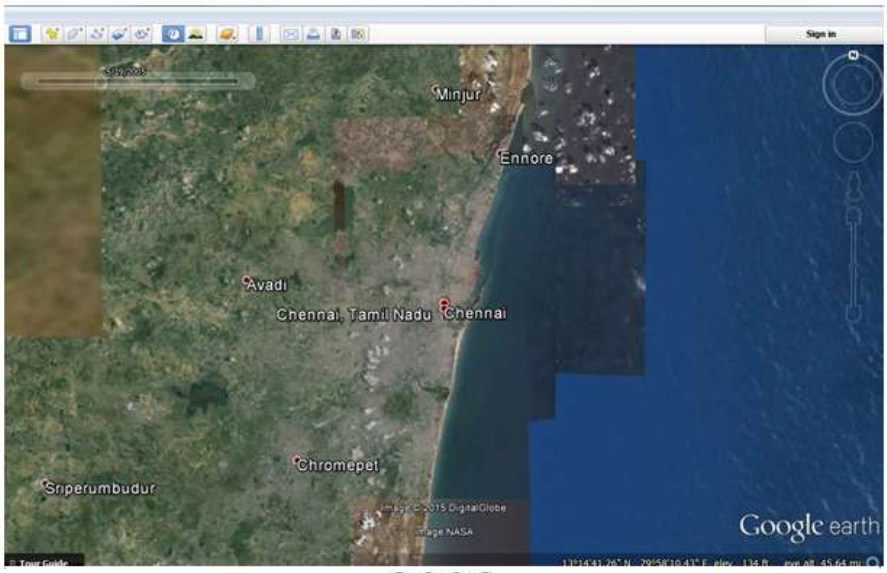


2015

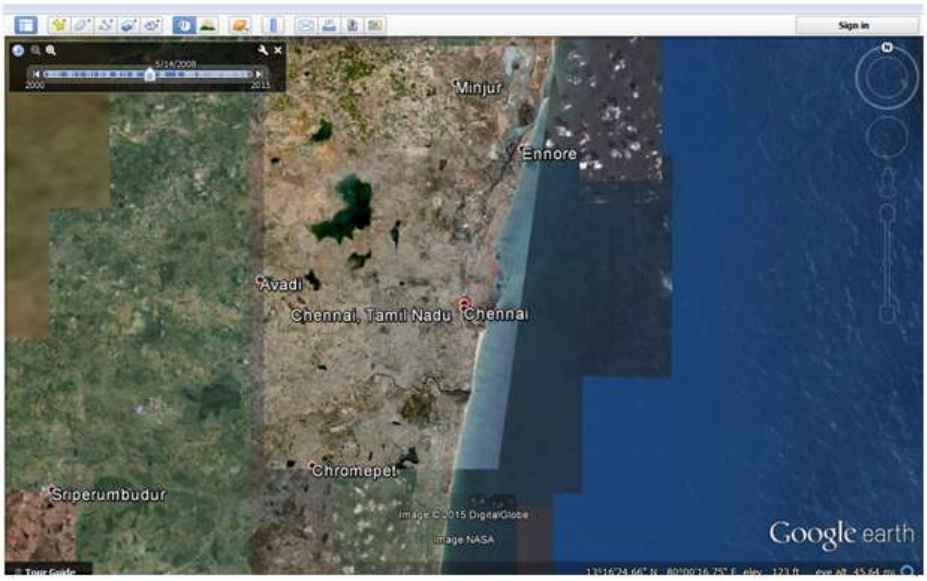


- *Chennai Satellite Data (2005 to 2015)*

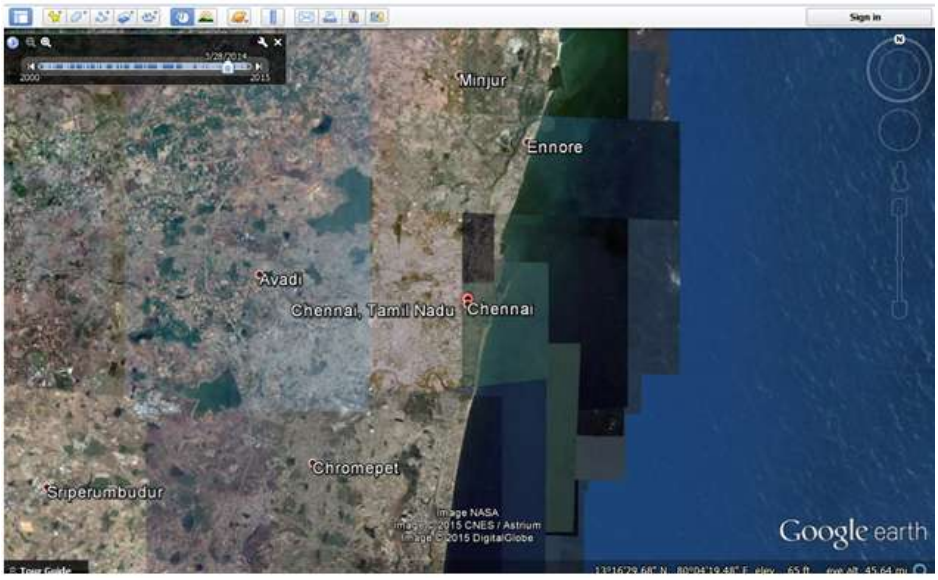
2005



2008



2014



To further confirm our doubts about environmental degradation in general we have checked out satellite imagery of a town, much unlike the major cities of above, Vellore [**12.9202° N, 79.1333° E**]:

2001

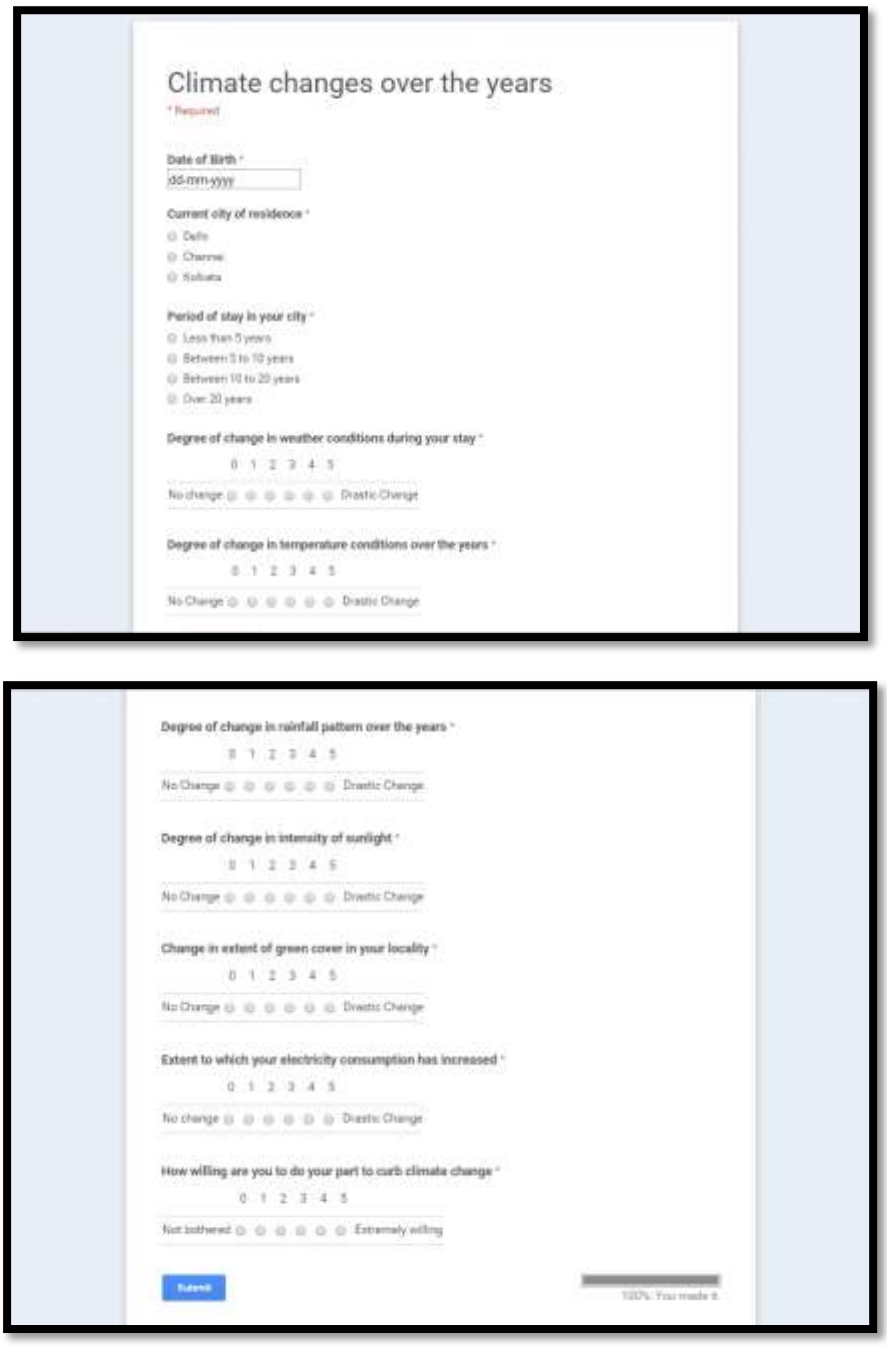
2005

2015

Clearly the loss in vegetation is alarming. Thus this confirms that fact that the loss in vegetation is linked to climate change. Not necessarily for the better. As we have seen a drastic rise in temperatures over the past few years.
We are not the only ones to have felt this.

To conduct further investigation we conducted a survey on locals living in **Delhi [28°37′N 77°14′E], Kolkata [22° 34′ 0″ N, 88° 22′ 0″ E] and Chennai[13.0827° N, 80.2707° E]** on climate changes they've observed over the past few years.
The survey's questionnaire was created on Google Forms and sent across to the people of the above mentioned cities.

Here's a picture of the form:



Based on their responses we have drawn graphs and charts as shown in the Results part.

III. RESULTS

Survey responses from Delhi

Date of Birth	Current city of residence	Period of stay in your city	Degree of change in weather conditions during your stay	Degree of change in temperature conditions over the years	Degree of change in rainfall pattern over the years	Degree of change in intensity of sunlight	Change in extent of green cover in your locality	Extent to which your electricity consumption has increased	How willing are you to do your part to curb climate change
12/10/1968	Delhi	Over 20 years	4	5	3	1	5	4	4
9/4/1974	Delhi	Over 20 years	4	5	2	1	4	3	5
11/22/1977	Delhi	Between 10 to 20 years	4	3	5	1	3	4	2
3/13/1997	Delhi	Between 10 to 20 years	3	3	3	0	1	5	0
1/10/1975	Delhi	Between 10 to 20 years	4	3	4	1	4	4	5
11/29/1983	Delhi	Between 10 to 20 years	3	4	3	0	5	3	2
9/7/1988	Delhi	Between 5 to 10 years	3	4	3	1	3	3	3
4/19/1991	Delhi	Between 5 to 10 years	2	3	3	0	2	1	2
8/3/1989	Delhi	Less than 5 years	2	2	2	1	2	2	5
8/16/1990	Delhi	Between 5 to 10 years	3	2	2	2	3	2	5
2/7/1991	Delhi	Between 5 to 10 years	3	3	3	2	2	3	2
4/22/1983	Delhi	Between 10 to 20 years	1	2	3	1	5	4	5
8/12/1974	Delhi	Between 10 to 20 years	5	5	5	0	5	5	0
12/18/1986	Delhi	Between 5 to 10 years	2	2	1	1	1	1	1
8/18/1989	Delhi	Between 10 to 20 years	5	5	3	0	4	4	1
11/15/1968	Delhi	Between 10 to 20 years	4	5	3	1	4	3	1
12/28/1958	Delhi	Between 5 to 10 years	3	3	3	0	2	1	4
12/25/1955	Delhi	Less than 5 years	3	2	2	1	0	3	4
10/4/1990	Delhi	Less than 5 years	2	2	1	0	4	3	5
10/16/1994	Delhi	Between 10 to 20 years	5	5	5	1	4	3	3
5/20/1986	Delhi	Over 20 years	3	2	2	1	3	3	3
10/12/1976	Delhi	Over 20 years	3	3	3	0	3	3	3
3/8/1985	Delhi	Between 10 to 20 years	2	1	1	1	1	4	3
1/30/1997	Delhi	Between 5 to 10 years	3	1	2	2	3	2	3
6/25/1992	Delhi	Between 10 to 20 years	3	3	1	1	3	3	3

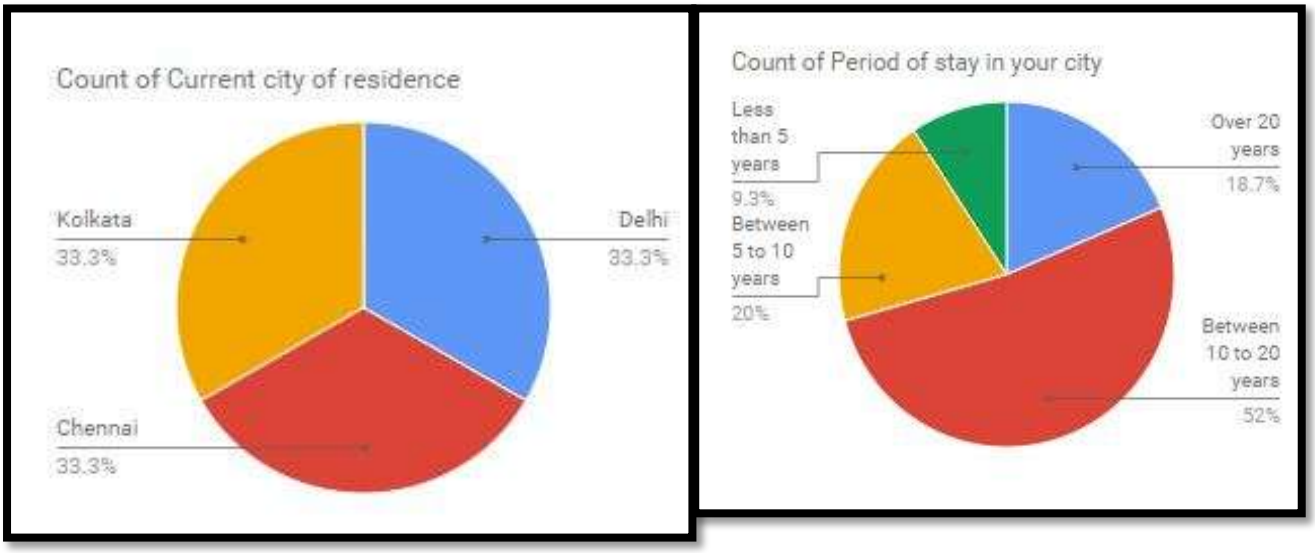
Survey responses from Chennai

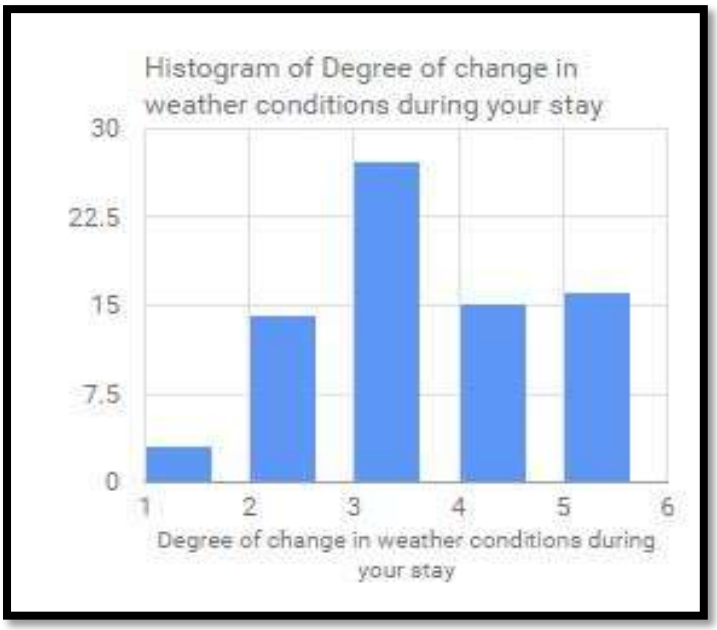
3/26/1957	Chennai	Between 10 to 20 years	5	5	5	1	5	5	4
8/29/1988	Chennai	Over 20 years	3	2	1	2	4	3	3
12/17/1989	Chennai	Between 10 to 20 years	1	3	3	1	4	4	3
5/29/1979	Chennai	Between 10 to 20 years	3	3	3	1	3	3	3
5/20/1986	Chennai	Over 20 years	3	2	2	2	3	3	3
3/27/1972	Chennai	Between 10 to 20 years	3	3	2	1	1	5	3
8/17/1990	Chennai	Between 10 to 20 years	4	4	4	0	4	4	4
3/14/1967	Chennai	Between 5 to 10 years	5	4	4	1	2	3	2
9/13/1974	Chennai	Between 10 to 20 years	5	4	3	2	5	5	2
11/22/1953	Chennai	Between 10 to 20 years	3	4	3	0	3	2	4
3/11/1997	Chennai	Between 5 to 10 years	3	3	4	2	2	3	4
1/5/1975	Chennai	Less than 5 years	3	4	2	1	3	3	3
1/29/1983	Chennai	Less than 5 years	4	3	3	0	3	2	3
9/10/1985	Chennai	Between 10 to 20 years	4	3	3	0	5	3	4
4/23/1992	Chennai	Over 20 years	3	2	2	1	3	4	2
8/27/1988	Chennai	Between 10 to 20 years	2	2	1	0	1	4	3
8/11/1994	Chennai	Between 5 to 10 years	2	3	5	1	3	3	3
5/5/1981	Chennai	Between 10 to 20 years	3	3	3	2	3	5	3
1/30/1995	Chennai	Between 10 to 20 years	2	1	1	0	3	2	4
8/12/1938	Chennai	Over 20 years	5	5	2	2	4	3	2
10/18/1977	Chennai	Between 10 to 20 years	2	2	1	1	2	3	2
8/1/1990	Chennai	Between 10 to 20 years	5	5	5	2	5	2	4
12/16/1968	Chennai	Over 20 years	5	4	1	2	3	3	4
9/25/1958	Chennai	Between 10 to 20 years	3	3	3	1	1	4	3
11/24/1955	Chennai	Between 10 to 20 years	2	3	3	1	1	4	5

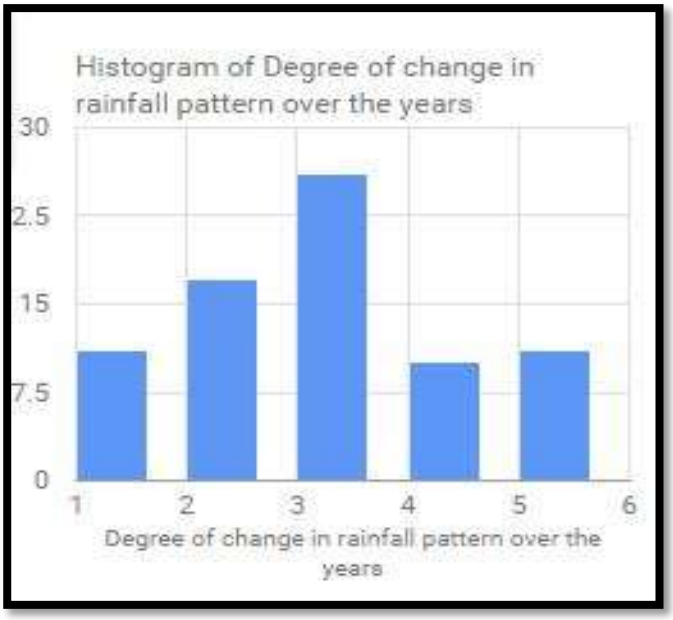
Survey responses from Kolkata

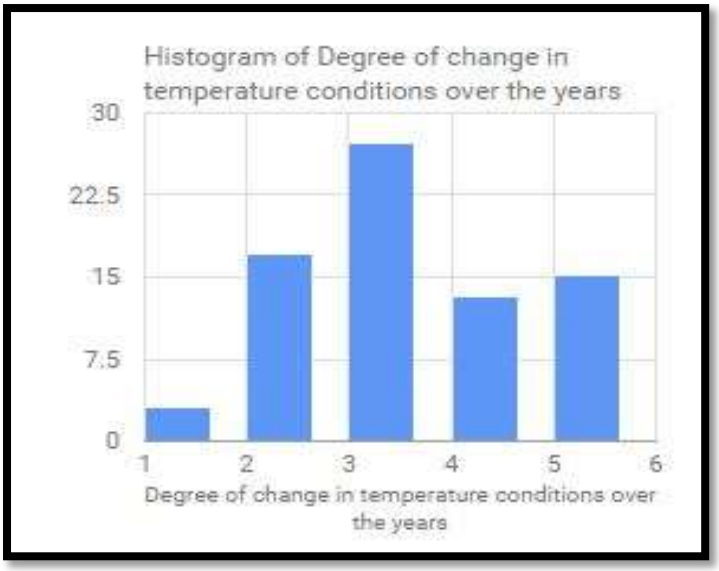
5/31/1969	Kolkata	Over 20 years	3	3	3	3	3	3	2
12/7/1992	Kolkata	Between 10 to 20 years	5	5	5	1	3	5	2
9/21/1988	Kolkata	Between 5 to 10 years	4	3	1	0	3	3	5
12/9/1965	Kolkata	Between 10 to 20 years	3	3	5	2	3	1	4
12/18/1986	Kolkata	Between 10 to 20 years	5	3	2	0	3	1	2
2/18/1963	Kolkata	Between 5 to 10 years	4	4	4	1	4	3	3
11/13/1996	Kolkata	Less than 5 years	5	4	3	3	2	5	2
4/2/1965	Kolkata	Less than 5 years	1	3	2	2	3	2	4
9/9/1954	Kolkata	Between 10 to 20 years	5	2	4	0	5	3	5
1/4/1993	Kolkata	Over 20 years	2	2	5	1	3	3	3
1/21/1957	Kolkata	Between 10 to 20 years	4	3	4	3	4	2	2
1/12/1967	Kolkata	Between 5 to 10 years	3	2	2	0	3	3	4
8/29/1944	Kolkata	Between 10 to 20 years	2	5	5	2	3	4	5
6/3/1997	Kolkata	Between 10 to 20 years	4	2	3	3	5	4	2
7/4/1992	Kolkata	Over 20 years	5	5	4	0	4	4	3
4/15/1957	Kolkata	Between 10 to 20 years	3	5	3	1	3	4	2
8/13/1978	Kolkata	Between 10 to 20 years	4	3	2	2	5	3	1
1/5/1981	Kolkata	Over 20 years	2	2	5	0	2	4	5
5/24/1945	Kolkata	Between 5 to 10 years	3	3	3	1	3	3	3
1/3/1968	Kolkata	Between 10 to 20 years	4	5	3	2	3	3	2
6/9/1969	Kolkata	Between 10 to 20 years	5	4	2	1	2	2	1
4/19/1943	Kolkata	Over 20 years	3	3	4	1	3	2	4
4/4/1987	Kolkata	Between 10 to 20 years	2	5	1	1	4	3	5
10/13/1996	Kolkata	Between 10 to 20 years	5	4	2	2	4	4	2
8/31/1989	Kolkata	Between 5 to 10 years	4	4	4	0	4	3	3

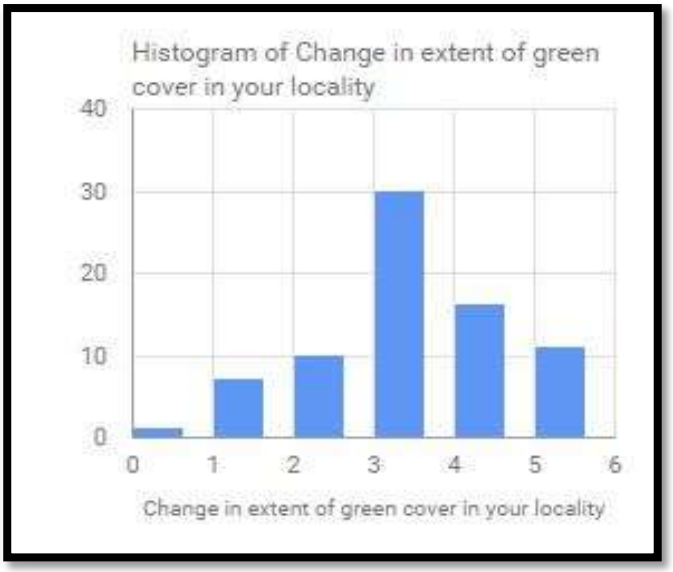
Based on their answers we compiled the data and drew our analysis from the graphs:

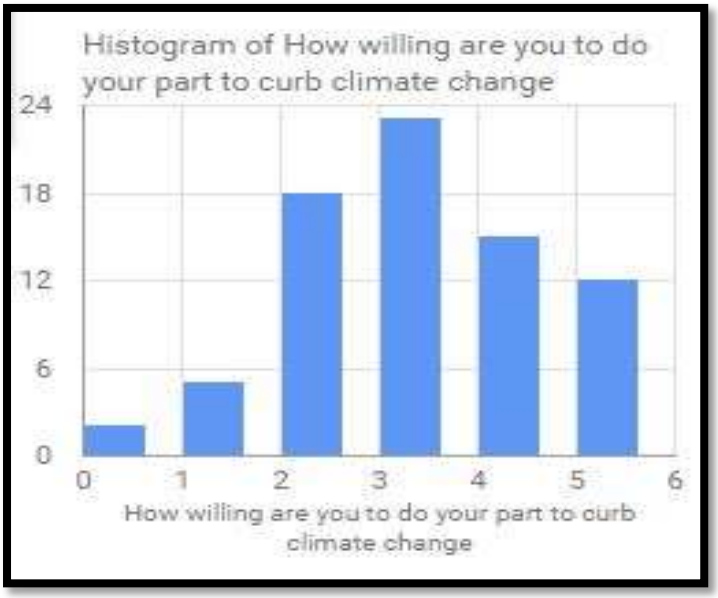


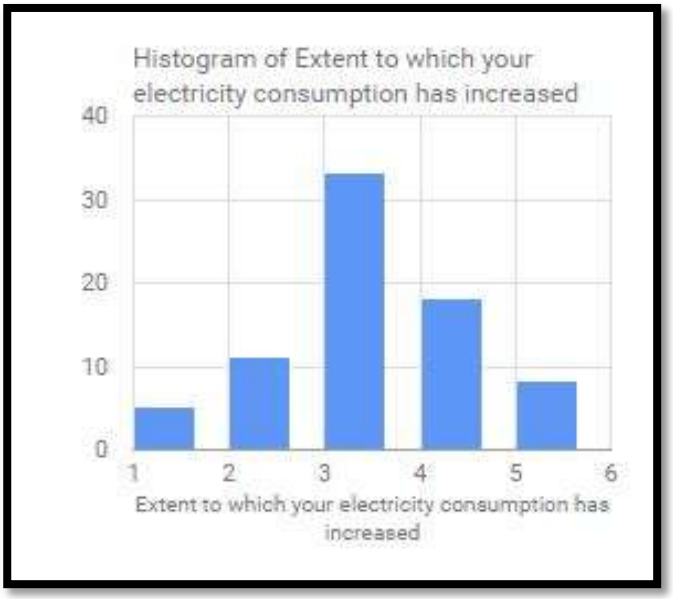












IV. DISCUSSION

Therefore, we can see that there is a direct link between environmental land degradation and the rise in temperature leading to the inevitable change in climate.
The people's opinion leads us to confirm that the change in climate is prominent and not a negligible phenomenon; nor is it likely to be ignored.

We believe that the loss in greenery is leading to rise in temperature in the following way:

- Deforestation and land encroachment leads to loss invaluable flora and fauna. Plants are hit the most.
- Loss in plant life leads to lack of *transpiration* that leads to disturbed rain and wind patterns.
- Loss in plant life leads to degradation of soil quality. This means that the land being converted is now barren, loose and waste land.
- It is easily exposed for soil degradation due to multiple factors like wind, water, and meteorological factors, and biological and other environmental factors.
- The consequence of which is that the soil is now exposed and moisture evaporates and again the rain pattern gets affected.
- Trees are like store houses for gasses like CO_2, CO, N_2, N_2O, and to some extent CH_4, and other green house gasses.
- The absence of the trees and plants leads to the atmospheric accumulation of the Green House gasses. Resulting in the entrapment of heat in those sectors. Further supporting Global Warming and increasing the temperature of that place.
- Leguminous plants host nitrogen fixing bacteria in their roots. These nitrogen fixing bacteria convert atmospheric inert nitrogen to organic nitrogen to help in the nitrogen nutrition cycle [8].

$$N2 + 8\,H^+ + 8\,e^- \rightarrow 2\,NH3 + H2$$

- Nutrition cycles such as this are badly affected and lost because of vegetation loss. This is another factor affecting the climate change.
- These events set into motion the reduction in carbon sequestration.

This leads to increase extreme events like draughts, floods, fires, etc. This once again attacks the vegetation in that area and causes the above mentioned problems again and here begins an endless loop.

Thus we conclude our report on the climatic changes occurring and the major cause for them.

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