Impact analysis on change in climatic conditions due to the development of highway roads and other infrastructures at Coimbatore - an evidence

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Abstract. Global warming, a major threat is mainly due to the increase in population. This leads to an increase in infrastructural facilities and vehicles. The major reasons for the increase in temperature may be due to pollutant gases from Industries and Vehicles, other infrastructural development, etc. Because of this, trees are being cut down which increases the temperature thereby reducing the rainfall. Also, rainfall decreases because of the destruction of trees leading to decreased groundwater levels. The proposed study primarily focuses on the change in climatic conditions such as temperature, relative humidity, and rainfall due to the development of infrastructures such as highway roads, bridges, etc. The above indicators were being addressed by many authors earlier, but there exists a gap in addressing the growth of infrastructure on the above-said factors. This proposed study presents a chance to address the gap that exists in the earlier literature based on the indicators specified above due to the infrastructural developments. Hence an Impact analysis is required to address the issues of infrastructure development especially for Coimbatore – Pollachi highway road. The detailed meteorological data of the past five years are taken for analysis and suggestions for Smart City projects, Policymaking decisions are addressed.

1. Introduction
The total population of Coimbatore in 2011 as per the population statistics census of 2011 is 34, 58,045 [8]. With the increase in population, there would be an increase in the infrastructural development which leads to a rise in the migration of people to urban sectors. As a result of increased population, the number of industries and vehicles increases. The impact of these on to the different sectors due to industrial development and urbanization has been listed in table1. Various meteorological factors like rainfall, temperature, humidity, wind speed, etc. are essential while designing an Infrastructure. Bridges, roads are being constructed to make the transportation easier and to accommodate the existing population of vehicles and people. As a result, trees the sources of oxygen are being. This study attempts to consider the climatic change due to the roads and bridges built.
Table 1. Impact on different sectors due to urbanization & industrial development.

| Parameters                        | Key impacts                          | Segment subjected to impact                                           | Adaptation strategies                                      |
|-----------------------------------|--------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------|
| **Increase in population:**       | Movement of people from rural areas to cities | **Transportation:** Increase in the number of vehicles which leads to an increase in Pollutant gases from vehicles | Switch to Electric and / or Hybrid vehicles. Strict norms to reduce pollutant gases for conventional vehicles |
| Urbanization and Industrial development | Causes an increased infrastructural developments such as roads and bridges built | **Climate Changes:** Increase in temperature which makes difficult for Human survival | Green and resilient buildings                                |
|                                   |                                      | **Agriculture:** Decreased rainfall leads to reduced vegetation and makes us to depend on underground water | Plantation of more trees on the road sides and trees accommodating infrastructural development. |
| Lead to a diverse cultural effects |                                      | **Cultural and Economic Change:** Diversity in economic status & cultural status | Adaptability of varied socio-economic cultural policies     |

Several authors have explained the relationship between infrastructural development, climatic conditions, and economy. Bibrian et al [1] in the paper presents the study related to the assessment of life cycle of newly constructed buildings and the environmental studies related to these structures. The occurrence of temperature surges and increased temperature of about >7°C at urban sites were well described by the authors Nelson K C et. al. [2]. The economic aspects which occur due to global warming damage were well elaborated by the author Fankhauser S [3]. Meteorological factors like rainfall, temperature, humidity, wind speed, etc. is very much essential while designing an Infrastructure as described by authors Zareaian S and Zadeh K A [4]. The deforestation, its impact on the climate change are detailed by Ojekunle O Z [5].

2. Methodology

2.1. Study Design

Impact analysis to reduce the rise in temperature has to be made and the proposed research is done for places in and around Coimbatore City, Tamilnadu especially in Coimbatore - Pollachi Highway road where the infrastructural developments made are more. Also, the effect of Meteorological factors that are influenced more is accounted for the study due to the development of structures on high way roads. The study involves two Parts: I contributes to the infrastructural developments like several roads, bridges built and the trees demolished for that specific cause. II describes the meteorological data which causes the change in climate due to infrastructural development and the workflow is as shown in figure 1.

2.1.1. Part I- Infrastructural Development. Due to urbanization, infrastructural developments like roads, bridges are being built since 2016 from Coimbatore to Pollachi Highway road. The distance between the Periyanaickenpalayam to Pollachi Town is about 59 km. As a measure of increased population, the initial measure was to widen the Mettupalayam road. The National Highway Authority of India (NHAI) planned to widen the road in three phases [9] namely, 36.5 m wide four-lane road from Periyaickenpalayam to Thhekupalayam Piruvu, VG hospital and from Chinnamathampalayam to Thaneer pandhal, from Sundarapuram to Eachanari, with 15.7 m wide four-lane road, and Eachanari temple to Achipatti in Pollachi. The flyovers built and under progress are an extension of Flyover...
along Athupalam and Ukkadam, Eeachanari, Othakalmandapam, Kinathukadavu for 1.6 km, and Mullupadi. Approximately around 2500 trees were cut down as a result of road widening and flyovers built.

2.1.2. Part II – Climatic Change. Based on these infrastructural developments, the change in climate has to be analysed based on the indicators like minimum and maximum air and soil temperature (in °C), relative humidity (%), wind speed (in Kmph) and annual rainfall (in mm) of Madukkarai block is considered for a duration of five years since 2015 to 2019. The variation of these data before and after the infrastructural developments are analysed based on the results obtained from the Agro-Climate Research Centre (ACRC) of Tamil Nadu Agricultural University (TNAU), Coimbatore.

3. Results and Discussions
The first step of analysis is the collection of above said data relevant to the climate change since 2015 has been made. For this study, a complete set of data for all the 365 or 366 days were chosen and analysis is made with the available data and the average values are given below in table 2. Results show that there is a considerable decrease in the average rainfall from 2015 to 2019.

The wind speed has decreased from 6.3 to 4.5 Kmph which implies that the flyovers built across had made a major impact of 33.33%. The percentage rise in maximum air temperature + 4.68%. The results obtained clearly depicts the increased minimum and maximum air and soil temperature and decreased rainfall during the period of study.
Table 2. Average Meteorological Data.

| Year | Maximum Air Temperature (°C) | Minimum Air Temperature (°C) | Relative Humidity (%) | Wind Speed (Kmph) | Soil Temperature (°C) | Rainfall (mm) |
|------|-----------------------------|------------------------------|-----------------------|-------------------|-----------------------|--------------|
| 2015 | 32.0                        | 22.9                         | 73.5                  | 6.3               | 33.1                  | 2.2          |
| 2016 | 32.9                        | 23.0                         | 68.3                  | 5.8               | 34.0                  | 0.8          |
| 2017 | 32.3                        | 22.8                         | 72.3                  | 6.0               | 33.1                  | 1.5          |
| 2018 | 33.3                        | 21.9                         | 74.4                  | 4.5               | 31.9                  | 1.1          |
| 2019 | 33.5                        | 22.8                         | 67.3                  | 4.5               | 33.4                  | 1.2          |

Table 3. Standard deviation and maximum value of meteorological data.

| Year | Maximum Air Temperature (°C) | Relative Humidity (%) | Wind Speed (Kmph) | Soil Temperature (°C) | Rainfall (mm) |
|------|-----------------------------|-----------------------|-------------------|-----------------------|--------------|
|      | Standard deviation Maxi mum value | Standard deviation Maximum value | Standard deviation Maximum value | Standard deviation Maximum value | Standard deviation Maximum value | Standard deviation Maximum value |
| 2015 | 2.3                         | 38.5                  | 13.6              | 96.9                  | 1.8          | 12.2          | 3.0          | 39.2          | 8.3          | 79.5          |
| 2016 | 3.0                         | 40.3                  | 12.6              | 95.6                  | 2.2          | 12.7          | 3.2          | 41.4          | 4.4          | 58.0          |
| 2017 | 3.1                         | 39.6                  | 13.7              | 96.9                  | 1.5          | 10.4          | 3.5          | 42.6          | 6.4          | 74.0          |
| 2018 | 2.8                         | 39.8                  | 10.8              | 98.9                  | 1.9          | 10.5          | 3.5          | 40.0          | 5.8          | 62.5          |
| 2019 | 3.0                         | 39.9                  | 13.8              | 98.2                  | 2.1          | 12.7          | 3.1          | 41.4          | 7.8          | 132.5         |

Figure 2. Soil Temperature from 2015-2019.

The entire range of values of soil temperature (°C) is shown in figure 2 and this increases as the number of trees being cut down increases. Similarly the annual rainfall (in mm) is shown in figure 3. The maximum rainfall in the year 2019 is more as shown in table 3 but the average annual rainfall in 2019 is less when compared to 2015.
The infrastructural developments in this area is more as referred to figure 4 and hence the wind speed is reduced. When the wind speed decreases, the increased air temperature may not be carried away because of these structural developments. Hence proper design of bridges and other high infrastructural buildings has to be made which allows the free flow of wind.

**Figure 3.** Annual rainfall since 2015.

**Figure 4.** Wind speed since 2015.

**Figure 5.** Maximum air temperature from 2015 - 2019.
Similarly the maximum air temperature had increased from 38.5°C to 39.9°C. These results obtained almost match with the results of the Abolghasem Sayadi et al. [6]. Figure 5 shows that the maximum temperature have raised by 1.5°C. This will bring us a shift from high-carbon sequestration level to low-carbon level and would cause extreme heat and drought. As per the report of Kelly Levin [7], half a degree raise in temperature would cause 2.6 times extreme heat. This is mainly due to the destruction of trees and should be compensated by planting more trees, building green and resilient buildings to accommodate high carbon sequestration and also including this as a policy. Further, awareness to public in this regard should be made.

4. Conclusion
The current study implies that there is a considerable change in the climate from 2015 to 2019 due to the infrastructural development along the highway road of Coimbatore to Pollachi. The meteorological data were taken for analysis and the inclusion of risk perspective is not taken into account while choosing the model. The implications obtained as a result of this study are that there is a change in the climatic conditions and the adaptability of people to the present conditions becomes challenging. The study made indicates that immediate solutions to suit the future change should be adopted and structures have to accommodate trees or plants to promote healthy conditions. This gives valuable insight into the policymakers, public, etc., to implement green and resilient building during smart city development.

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