© 2019 IJSRSET | Volume 6 | Issue 1 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET19612

Impacts of Urban Expansion on Urban Heat Island - A Geospatial Approach

Bindi Dave*, Shaily Gandhi
M.Tech, Geomatics Program, Faculty of Technology, CEPT University, Ahmedabad, Gujarat, India

ABSTRACT

Growing urbanisation has led to increase in the built up area, reduction in open and green spaces with in the cities and the periphery. The urban saturation and the enlargement of the built space have determined environmental changes, increasing the already precarious condition of the natural systems in these spaces of high saturation. It results in to the formation of Urban Heat Island (UHI). Over the last few years, Ahmedabad has experienced rapid urbanization and associated Urban Heat Island (UHI) effects. This study aims at analysing spatially and temporally, the impact of urban form expansion on UHI in Ahmedabad using Landsat thermal images. The Mono Window Algorithm has been used to retrieve Land Surface Temperature (LST) from the thermal bands of LANDSAT-5, 8 TM satellite data. Various spatial analysis techniques were used to explore the relationships between area, compactness ratio, the gravity centers of urban land, and UHI. Under the similar urban land area condition, UHI and compactness ratio of urban land were in positive correlation. The moving direction of the UHI gravity center was basically in agreement with urban land sprawl. The encroachment of urban land on suburban land is the leading source of UHI effect. The results suggest that urban design based on urban form would be effective for regulating the thermal environment.

Keywords : Urbanization, Urban expansion, Urban Heat Islands, GIS, Remote Sensing

I. INTRODUCTION

Around half of the world's human population lives in urban areas. In the near future it is expected that the global rate of urbanization will increase by 70% of the present world urban population by 2030, as urban agglomerations emerge and population migration from rural to urban/suburban areas continues. Urbanization negatively impacts the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere, and the covering of the soil surface. Considered to be a cumulative effect of all these impacts is the Urban Heat Islands, defined as the rise in temperature of any man-made area, resulting in a well-defined, distinct "warm island" among the "cool sea" represented by the lower temperature of the area's nearby natural landscape. Though heat islands may form on any rural or urban area, and at any spatial scale, cities are favored, since their surfaces are prone to release large quantities of heat. Nonetheless, the UHI negatively impacts not only residents of urban-related environs, but also humans and their associated ecosystems located far away from cities. In fact, UHIs have been indirectly related to climate change due to their contribution to the greenhouse effect, and therefore, to global warming.

Various techniques have been used by different scientist. Spit window and Mono-window algorithms were applied on Landsat TM data and ASTER data by Lin Liu and Yuanzhi Zhang (Liu & Zhang, 2005). Mohan, Kandya & Battipro studied the urban heat island effect in NCR. They analyzed the 40 to 100 years of temperature data. The study analyses the annual mean maximum and minimum temperature, annul mean temperature, seasonal mean maximum and minimum temperature and the temperature anomalies at different time period from 1906 to 2005. The methodology adapted was firstly, data was collected from IMD. Secondly, calculated annual mean maximum and minimum and seasonal mean temperature. Thirdly, data was analyzed. (Mohan, Kandya, & Battipro, 2011). Divya Bajaj, Arun Inamdar and Vineet Vaibhav in 2012 studied the temporal variation of Urban Heat Island in Ahmedabad using Landsat data. They found the surface temperature has increased 2011 compared to 1999 in open land which is because of 7 % increase in the built-up area. UHI intensity reduced from 0.81 C in 1999 to 0.41 in 2011 in spite of increased overall mean LST and even the rural areas experienced temperature increase because change in land cover. (Baja, Inamdar, & Vaibhav, 2012). Shashank Srinivasan in 2013 tried to estimate surface temperature from Landsat 8 TIRS instrument in Delhi. It was estimated using radiation band information from the two electromagnetic spectral bands. LST was obtained firstly by converting the Digital Number to top-of-the atmosphere (ToA) radiance value to ToA brightness temperature in kelvin and finally converted into degree Celsius. (Srinivasan, 2013).

II. METHODS AND MATERIAL

In order to conduct the study the following detailed methodology was adapted, wherein the analysis was divided into two scales, i.e. Macroscale and Mesoscale analysis. Macroscale analysis involves the study of LST and related parameters at the city level, in order to observe the overall spatio-temporal scenario of surface temperature and its possible relation with parameters like NDVI (Normalised Difference Vegetation Index), Emissivity, and changing landcover of the city. Thereafter using the ward level administrative boundary provided by the Ahmedabad Municipal Corporation (AMC), a Mesoscale analysis using zonal statistics was done for the former mentioned parameters, in order to observe the most prone UHI areas across the city, and its related reasons for being higher/ lower temperature zones. The study greatly helped in observing the impact of changing landuse for a particular areas and its effect on the surface temperature, which thereby led to creation of the heat island. At this level, a pilot study was conducted to obtain feature level (walls, trees, waterbody, roads, etc) surface temperature readings using ground based Thermal IR gun. These reading greatly helped to show the impact of material characteristics (emissivity) on temperature and its contribution to the heating of the surrounding. Urban Thermal Field Variance Index (UTFVI) and Correlation analysis was performed to evaluate ecologically the UHI prone areas spatio- temporally, and to find out the most effective parameter contributing to the UHI effect.

The spatiotemporal data used for this study are for the year 1999, 2009 and 2017.The Dataset used are of Landsat-5 (30m resolution) and Landsat-8(30m resolution).

III. STUDY AREA

Ahmedabad City lies between 22^{o} 55' and 23^{o} 08' North Latitude and 72^{o} 30' and 72^{o} 42' East Longitude. The city is devoid of any major physical features except for the river Sabarmati, which is cutting the city into two parts: eastern walled city and western Ahmedabad on either side of its banks. The Ahmedabad-Mumbai Golden Corridor has long been recognized as an important development axis in western India. The city acts as a terminal, rather than as an intermediate node in this linear influence. It has seven major roadways, one expressway and five rail networks. A new corridor between Ahmedabad and

Pune has recently emerged, connecting the city to other metropolitan cities including Vadodara, Surat and Mumbai. All these factors have resulted in the axial growth of the region.

Figure 1: Study Area

Ahmedabad has a tropical monsoon climate, which is hot and dry, except in the rainy season. Summer days are very hot with mean maximum temperature of 41.3°C while, nights are pleasant with mean minimum temperature of 26.3°C. The mean maximum and minimum temperatures in winter are 30°C and 15.4°C respectively. The average annual rainfall of the area is 782mm, although there is a considerable variation from year to year. It occurs generally during the months of June to September. The average relative humidity is 60% with a maximum of 80% to 90% during the rainy season.

IV. RESULTS AND DISCUSSION

It has been observed from results of NDVI and the satellite image that the sprawl has been considerably increased on the eastern side of river from 1999 to 2010 .The eastern side of river also known as old city has many small scale industries. There has been considerable development along the south eastern side of the river which is due to NH8, urban explanation has taken place along Sanand Region and then connected Ahmedabad via Sanand Sarkhej Highway.

NDVI shows amount of vegetation in an area. From the Figure 2, 3 and 4 it can be observed that there has been considerable decrease in amount of vegetation .In october 1999, the amount of vegetation is dense, which is because of the monsoon season and in May 2009 there has been some cloud cover in the image and it adds to the error by showing reflection like urban. Even some of the Fallow Land in the South Western part has mixed pixels and shows reflection like urban. Overall the amount of vegetation has considerably decreased along the southern patch near the river. Riparian Vegetation has been considerably increased in April 2017 which may be due to change in cropping pattern and the same pattern was observed in May1999.

The LST observed from 1999 to 2017 shows a considerable change in temperature from minimum of 30°C to maximum of 61°C.The Land Surface Temperature of Open Lands is observed to be maximum, whereas the vegetation and water bodies show minimum of surface temperature. Land Surface Temperature also depends on the type of material, size and shape of the object. Maximum temperature is observed on the north western side, of the west side.

Zonal statistics shows the mean land surface tempertaure of an area. From the above statistics it can be observed that the wards near western side of river such as Navrangpura and Paldi, wards on the eastern side of river such as Maninagar, Kankaria, Wards on the North Eastern Side of River such as India Colony,Viratnagar has been the coolest wards over the period of time.Wards like Paldi, Vatva ,Kalupur, Gota, Sarkhej has been the warmest wards . It is because there has been Development of Industries In these Regions.

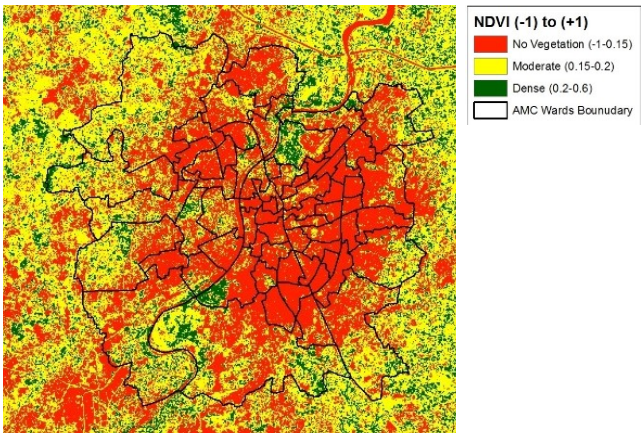


Figure 1 NDVI May 1999

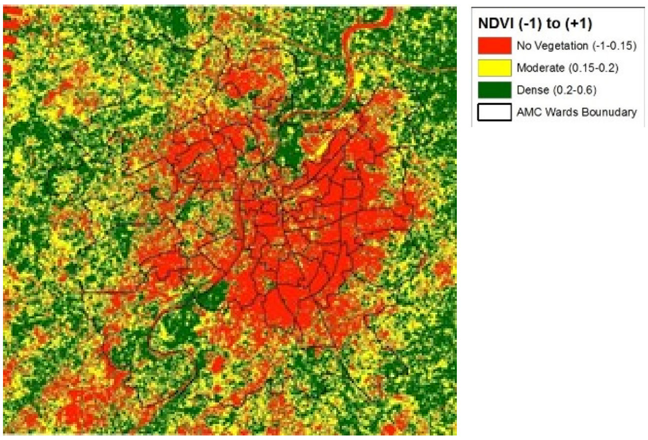


Figure 2 NDVI May 2009

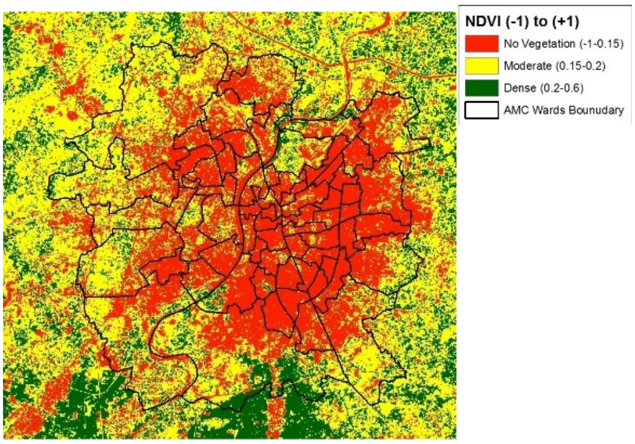
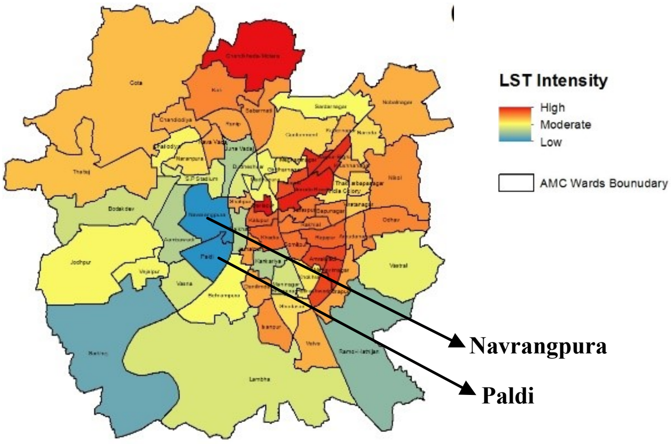


Figure 3 NDVI May 2017

Figure 4 Zonal Statistics for LST May 1999



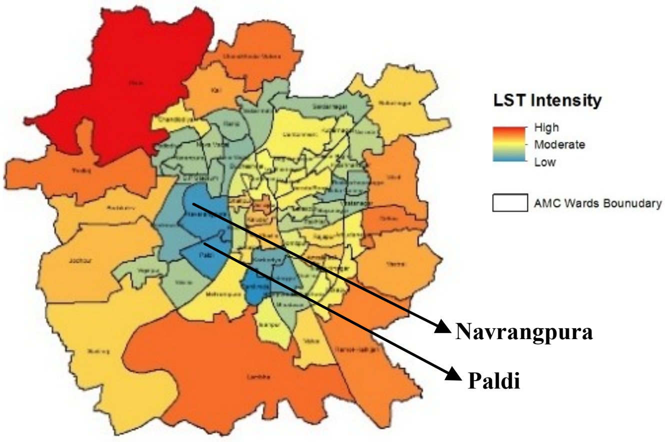


Figure 5 Zonal Statistics for LST May 2009

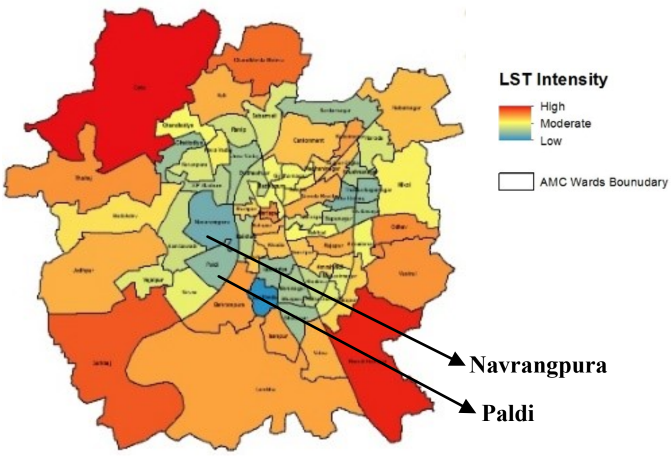


Figure 6 Zonal Statistics for LST May 2017

V. CONCLUSION

It can be concluded from this study that the temporal change in the urban development shows direct correlation with the increases in the mean temperature of Ahmadabad, Although Navrangpura and Paldi are the cooler wards of Ahmadabad but mean temperature of these wards are also increased nearly 20 °C. Which is almost same rate on that mean temperature of Ahmadabad was increased. Mean temperature of Ahmadabad in May 2009 was less than 35 °C. But in April 2017 mean temperature of Ahmadabad is almost 47 °C.

VI. REFERENCES

[1]. Baja, D. N., Inamdar, A. B., & Vaibhav, V. (2012). Temporal Variation of Urban Heat Island using Landsat Data: Acase study of Ahmedabad, India. Ahmedabad.

[2]. Liang, S. (2000). Narrowband to Broadband Conversion of Land Surface Albedo I Algorithms.

[3]. Liu, L., & Zhang, Y. (2005). Urban Heat Island Analysis Using the Landsat TM data and ASTER Data: case of Hong Kong. Hong Kong.

[4]. Mohan, Kandya, & Battipro. (2011). Urban Heat Island Effect over NCR of India: A study using teperature trends. Delhi.

[5]. Ramchandra, & Kumar. (2010). Emerging Urabn Heat Island: Case of Greater Bangalore. Bangalore.

[6]. Srinivasan, S. (2013). Using data from Landsat 8 TIRS instrument to estimate surface temperature. Delhi.

Cite this article as :