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EFFECT OF URBANIZATION ON ENVIRONMENT – A UHI BASED STUDY USING REMOTE SENSING & GIS

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ABSTRACT: ***The temperature increase in the city compared to the surrounding rural areas, produces among other factors through the emission of anthropogenic heat and high heat capacity of urban surfaces, is the urban heat island (UHI) effect. The urban study area which is Nashik city has been developing rapidly.To observe the UHI effect in the study area Landsat 8 data for the summer period of 2013-2018 is used. To calculate Land Surface Temperature (LST) from the Landsat 8 dataan algorithm was applied.Also, to observe the impact of vegetation changes on the urban heat island the land surface temperature (LST) and normalized difference vegetation index (NDVI) were correlated. In the results the effect of urban heat island is located in observed five sub-urban areas of the Nashik city.The five observations of LST results indicate that the decrease in vegetation index, strengthen the effect of urban heat island in the study area.***

KEY WORD: Effect of Environment, UHI, Remote sensing, GIS, Landsat 8.

I INTRODUCTION:

Rapid urbanization and widespread urban sprawl have depleted green cover and increased urban vulnerability to climate change. However, rapid growth of urban population is exerting tremendous Pressure on the atmosphere. Loss of green cover, deteriorating air quality, polluted water resources etc. Congested and unsustainable planning and increasing in the emissions from industries and vehicles in certain areas of the city has given birth to many climatic issues. Therefore, a study of the climate change in urban India, and exploration of economically viable avenues for its amelioration assumes urgent importance, and remains an issue of global concern. Rapid Urbanization a result has grown over the years leads to an environmental consequence called "Urban Heat Island" (UHI). In other words there is Temperature difference between cities and Areas surrounding them. Some of the major reason for higher UHI is restoration of huge natural land with built area especially of concrete and asphalt. This absorbs heat through isolation and emits during the night time. Dispersion of aerosol particles from industries also trap heat leading to increased UHI and climatic change.

a) Objectives of work:

Remotely sensed data is a tool to study the urban environment. This data provides the information for the city, covering the entire urban area at the same period. This is the advantages of using remote sensing data over the use of conventional data.

The main objectives of this study are:

- To evaluate the growth of the urban built up areas and to analyse Land Surface Temperature (LST) trends using Remote Sensing and GIS.
- To analyse and correlate the temperature profile trend and land use/land cover for the study period.
- Mitigate measure that can be adopted to reduce UHI.

b) Problems associated with Urbanization:

Emergence of urban clusters and their expansion consumes significant proportions of agricultural land and substantially impacts biological diversity. Increase in population has adversely affected the green cover in urban India.

c) Need for the study:

Increase in population in any city will also effect in environment. This can be analysed in the following manner:

- **Increase in energy consumption** – Increase in temperature leads to increase in demand for cooling, which subsequently puts pressure on electricity supply during the peak periods of demand.
- **Increase in emission of air pollutants and GHGs** – As more electricity is needed to cool the surfaces, demand on energy supply leads to emissions of air pollutants and greenhouse gases from the power plants. Even use of ozone depleting refrigerants such as CFCs (chlorofluorocarbons) in the air-conditioning system cause depletion in stratospheric ozone layer. Elevated temperature also promotes the formation of ground-level ozone.
- **Demand on water** – As the surface and air get hotter, people consume more water for both indoor and outdoor usage and it puts pressure on water supply.
- **Ecosystem** – Hot surfaces transfer the absorbed heat to water features such as rivers, streams, ponds, lake etc. increase the surface water temperature and alerting the aquatic ecosystem structure and functions
- **Quality of life** – Elevated day and night temperatures along with higher air pollution can cause respiratory diseases, discomfort, heat stress and decrease productivity and increase heat related mortalities.

- **Loss of agricultural land** – Increase in Urban land leads to decrease in agricultural land.

IILITERATURE REVIEW:

Yaoping Cui, et. al, Here he studied, based on global LST data, gross domestic product (GDP), urban spatial domain data and population data, He analysed the influence of the urbanization factors on global surface urban heat island intensity (SUHII).

Pooja Sharma, et. al, In this paper she overviews the trend of urbanization captured by growing population and temperature variations from period 1951 to 2001 for the four mega cities of India.

Sainu Franco, et. al, In This study he observesthe growth of the urban areas within the study area using remote sensing and GIS, apart from this analysis he observed the temperature profiles over various land uses and land covers.

Alexander Buyantuyev, et. al, Here he examined the diurnal and seasonal characteristics of the Surface UHI in relation to land-cover properties in the Phoenix metropolitan region, located in the northern Sonoran desert, Arizona, USA. Surface temperature patterns derived from the Advanced Space-borne Thermal Emission and Reflection Radiometer for two day-night pairs of imagery from the summer (June) and the autumn (October) seasons were analysed.

J.A. Voogt, et. al, In this paper author reviews the use of thermal remote sensing of urban climates, focusing on the urban heat island effect and results answering the methodological questions. His review demonstrates that while progress has been made, the thermal remote sensing of urban areas has been slow to advance beyond qualitative description of thermal patterns and simple correlations.

III STUDY AREA:

A) Geography of study area:

Maharashtra has been in the forefront to economic development and is often called the economic power house of the country. Nashik is one of the most important city of northern Maharashtra. The city has become the canter of attraction because of its beautiful surroundings and pleasant climate. However, rapid growth of urban population is exerting tremendous pressure on the natural resources and urban services. Loss of green cover, deteriorating air quality, due to rapid growth of urbanization, tremendous pressure on the natural resources and urban services, deteriorating air quality, polluted water resources, problem of solid waste in urban areas. These problems are increasing, day by day.
The population growth of city for a decade was 50% which was more than the average growth of the state. The population in 2011 was approx. 15 Lakhs and the expected population by 2036 will be approx. 33 Lakhs.
As Nashik is the important cityof Northern Maharashtra. InMaharashtra, Nashik is situated on Golden Triangle (Nashik-Pune-Mumbai) about 180 km away from Mumbai and 210 km from Pune. The city has become the canter of attraction because of its beautiful surroundings and cool and pleasant climate. Nashik city has got historical, social, mythological importance from ancient period. Nashik has its own specialty of wineries. The river Godavari originates at Triambakeshwar and flows through the city. Temples and Ghats on the banks of Godavari have made Nashik one of the holiest places for Hindus all over the World.

B) Environmental status of Nashik:

Current status of resources in the city:

At the time of comparing the current resources status of city, 4 main points are considered

a. Land use
b. Air monitoring, noise level and water quality monitoring
c. Energy usage
d. Human resources

Basic facilities of the city:

Basic facilities is considered one of the important coordinator, it includes following points;

a. Provision of water supply in city
b. Sewage treatment & management
c. Solid waste management
d. Transport improvement facility provision

Initiatives taken by city for environmental conservation:

Initiatives have been taken by the city for environmental conservation which includes

a. Environmental awareness and education
b. Solid waste management
c. Slum rehabilitation
d. Transport
e. Water supply management.

Air Pollution:
The air pollution in Nashik city is mainly due to vehicular exhaust, industries and construction work. Continuous increase in vehicles is adding to the air pollution. To control the air pollution, a number of measures like Mandatory PUC for on road vehicles, road concretization, road widening, tar road, Compulsion on tree plantation to Residential as well as industrial projects, maintaining gardens and road side tree plantation etc. are being implemented by NMC, RTO & Traffic police department.

Water Pollution:
Water qualities from river, nallahs, under NMC area are monitored from time to time. Water samples from rivers at different locations, nallah connected to rivers are analyzed. Few locations are monitored by MPCB. Nirmalya disposed in rivers and Lakes, anthropogenic activity like washing, bathing etc. also causes pollution. Industrial effluent mixing in river or nallah also creates water pollution. NMC has started environmental ecofriendly Ganesh festival. Pollution that occurs due to the effluent generated from industries must be mandatorily treated in ETP. In this regard, MIDC is establishing CETP.

Noise Pollution:
High level noise pollution is observed at residential, commercial and silence zone in previous three years.

To control noise pollution, NMC has taken the following steps;
1. A total of 19 silence zones at different locations around schools & colleges, hospitals and courts are declared.
2. It is necessary to raise noise barriers on construction zones at various places.
3. Action is being taken by Police department towards complaints on noise pollution by citizens.

IV METHODOLOGY AND DATASETS:

A) Methodology:

Top of Atmosphere (TOA) Radiance:
Radiance is measured by remotesensing instruments. Radiance includes the radiation reflected from the surface, the radiation that bounces from neighbouring pixels and the radiation reflected from clouds. The light is then reflects off of the Earth's surface, travelling back through the Earth's atmosphere, enduring further scattering effects as it does. Some of these factors can be corrected by using Top of Atmosphere (TOA) reflectance values.

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers can be converted to TOA spectral radiance.

$$L\lambda = ML * Qcal + AL$$

Where:
Lλ = TOA spectral radiance (Watts/ (m2 * sr * μm))
ML = Radiance multiplicative Band (No.)
AL = Radiance Add Band (No.)
Qcal = Quantized standard product pixel values (DN)

Top of Atmosphere (TOA) Brightness Temperature:
Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

$$BT = K2 / \ln (k1 / L\lambda + 1) - 273.15$$

Where:
BT = Top of atmosphere brightness temperature (°C)
Lλ = TOA spectral radiance (Watts/(m2 * sr * μm))
K1 = K1 Constant Band (No.)
K2 = K2 Constant Band (No.)

Normalized Differential Vegetation Index(NDVI):
Calculation of the Normalized Difference Vegetation Index (NDVI), which is available on-the-fly, comes first.

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which Calculated using Near Infra-red (Band 5) and Red (Band 4) bands.

$$NDVI = (NIR (5) – RED (4)) / (NIR (5) + RED (4))$$

Where:
NIR = reflection in the near-infrared spectrum
RED = reflection in the red range of the spectrum

Land Surface Emissivity (LSE):
Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

$$PV = [(NDVI – NDVI\ min) / (NDVI\ max + NDVI\ min)]\ ^2$$

Where:
PV = Proportion of Vegetation
NDVI = DN values from NDVI Image
NDVI min = Minimum DN values from NDVI Image
NDVI max = Maximum DN values from NDVI Image

$$E = 0.004 * PV + 0.986$$

Where:
E = Land Surface Emissivity
PV = Proportion of Vegetation

Land Surface Temperature (LST):
The Land Surface Temperature (LST) is the radiative temperature which calculated using Top of atmosphere brightness temperature, Wavelength of emitted radiance, Land Surface Emissivity.

$$LST = (BT / 1) + W * (BT / 14380) * \ln(E)$$

Where:
BT = Top of atmosphere brightness temperature (°C)
W = Wavelength of emitted radiance
E = Land Surface Emissivity

B) Estimation of difference in land surface temperature:
ERDAS Imagine tool was used to calculate and analyse the temperature difference map. In this LST maps of 2013 and 2018 are used as an input, the negative operation is used between the LST of 2018 and LST of 2013. The output map is of the temperature difference map.

C) Time period and calculations:
In the study, the effect of UHI is analysed using Landsat 8 data in the summer period of 2013–2017 as a case study in Nashik, Maharashtra. In addition, the correlation between LST and the normalized difference vegetation index (NDVI) and the normalized difference build-up index (NDBI) were analysed to explore the impacts of the green areas and the build-up area on the urban heat island.

For this work, the following data inputs were used.
- Satellite Data: LANDSAT 8 multispectral images of 2013 and 2010
- Meteorological Data: Monthly Maximum, Minimum and Average temperatures along with humidity.

VRESULTS AND DISCUSSION:

A) Results of the NDVI analysis:
For the NDVI analysis of the study area, from the five pockets of the observation it is seen that the areas having the more vegetation in 2013 than that of the 2018. The overall NDVI value difference is seen that in 2013 the NDVI value is 0.62 which is reduced up to 0.59 in the 2018.

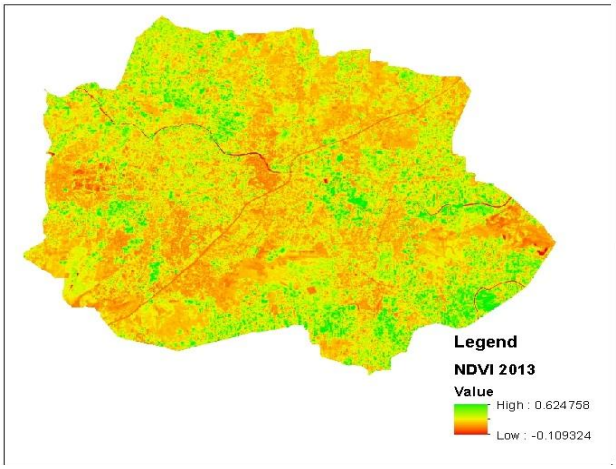


Fig.NDVI image of 4th may 2013.

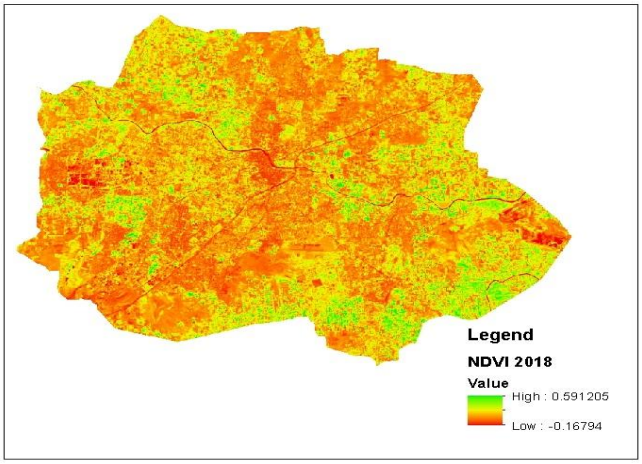


Fig. NDVI image of 2nd may 2018.

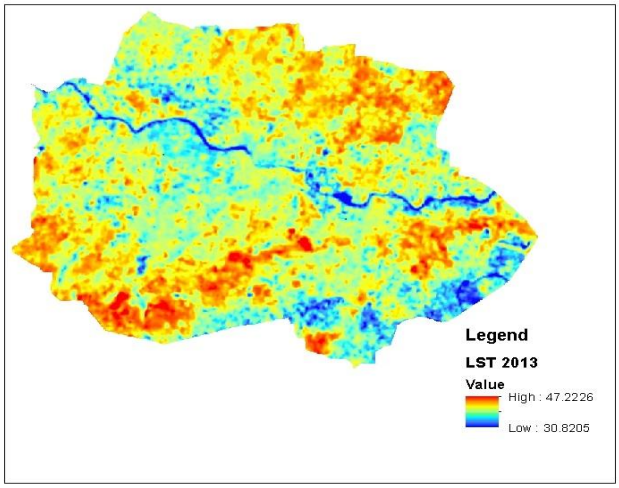


Fig.LST imageof 4th may 2013.

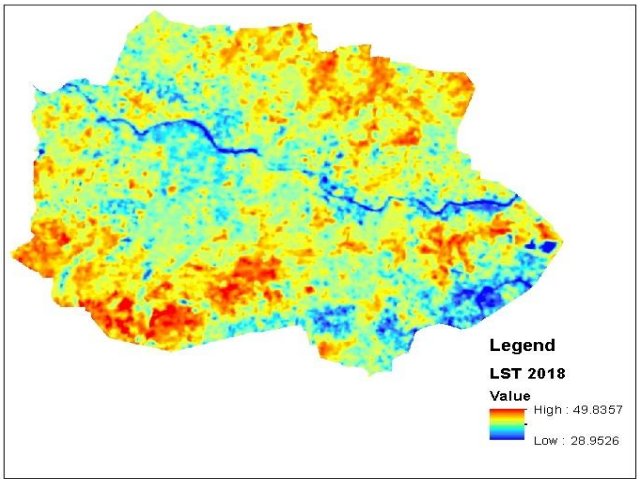
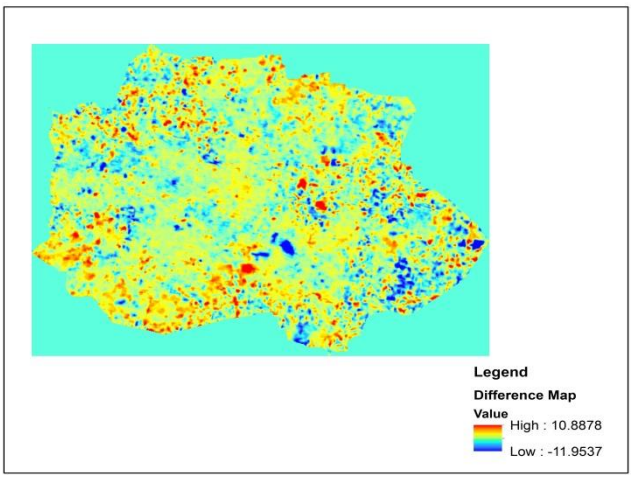
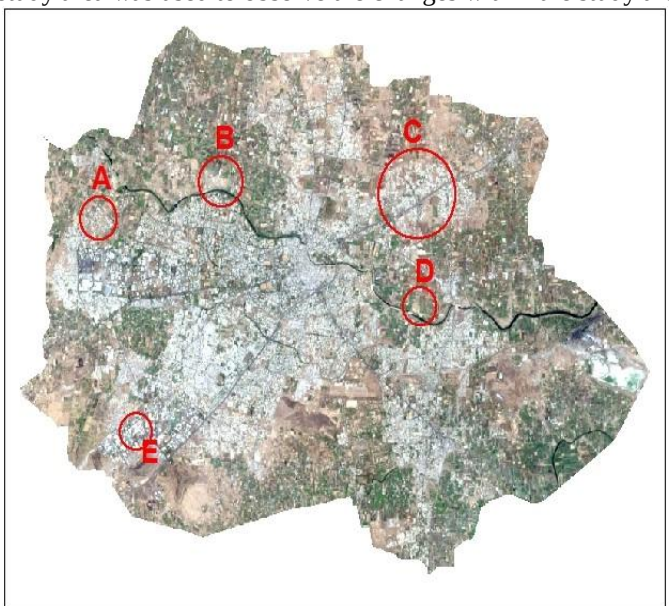


Fig. LST imageof 2nd may 2018.

For the analysis of the study area, 5 pockets of the study areas were observed, which are identified in the change within the period of May 2013 to May 2018. These observed changes are improving the effect of UHI over the study area.
The land surface temperature and the change in the raw images of 2013 & 2018 are shown in the following image.



B) Observations:
The following Raw Image of study area was used to observe the changes within the study area.



The changes in the temperature within these pockets are also to be observed which are shown in the table

Pocket	Change	Highest LST In 2013 (°C)	Highest LST In 2018 (°C)	Difference (°C)
A	Barren land - Residential	43.74	45.62	1.88
B	Barren & Agri. Land - Residential	43.05	43.79	0.74
C	Barren land - Residential	44.34	46.47	2.13
D	Agricultural Land – Barren land	34.15	42.91	8.76
E	Barren land – Industry	43.11	45.11	2.0

VI CONCLUSION:

The correlation analysis between different environmental variables (greenness, moisture presence, surface temperature) influence land changes on environment.

The analysis showed that LST is a function of other variables, where LST served as the variable which bears the ultimate impact of the change. Very high LST values were observed along industrial and residential parts of the city.

Newly built-up patches exhibit a progressive elevation in LST with increased built-up in their area over the study period. These five locations Shivajinagar, Chandsi, Aurangabad road, Agar takali&Ambad MIDC recorded an increase in LST of around 1.88, 0.74, 2.13, 8.76 & 2.0 °C respectively.

Built-up and green cover function were crucial factor controlling the LST distribution over the city from 2013 to 2018. Massive increase in built-up and decrease in green cover was observed in Nashik. This resulted in high LST patches in the city laying the foundation for development of Urban Heat Island (UHI), thus better planning at land distribution stage (primary case of UHI development) offers huge opportunities for mitigation of UHI.

Mitigation measures:

As an outcome of this study, it can be concluded that in order to reduce UHI effects, Local governments should increase the number of green areas in the intensive populated urban areas.
Some fundamental methods are:

- Increasing vegetation through planting of trees etc
- Increased use of Eco-friendly building materials and methods of construction

VI ACKNOWLEDGMENT:

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