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Analysis of Impact of Change in Land use Land Cover on Variation of Land Surface Temperature in Unnao

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Abstract: ***Rapid changes in land use / land cover due to urban expansion, industrialization affect biodiversity and ecosystem activities, as well as local and regional climate. One of the most serious impacts of urbanization is the formation of the Urban Heat Island (UHI) effect. Unnao is the main urban area between the two metros connected by transport corridors. Unnao faced rapid urban development in the Unnao region due to its industrial development, with the rapid change of the LULC model which significantly influenced the LST. Rapid changes in land use and land cover types have brought significant changes to the LST. Urban development affects the environment. This study attempted to study the effect of land use / land cover (LULC) on soil surface temperature in the Unnao region using multi-temporal satellite data. LST was extracted using Landsat 4-5 TM and Landsat 8 OLI during the periods 2005, 2011 and 2019. Result will be analyzed by change in land use of Unnao to the change in LST in the three respective years.***

Keywords: Industrialisation; Urbanization; Urban Heat Island (UHI); Land Surface Temperature (LST); Land use Land Cover (LULC)

1. Introduction

Industrial development guarantees a high employment potential of the population and improves the general infrastructure of the region. Contrary to these high-quality effects, there are some negative effects. After industrialization, there have been changes in agricultural land, water resources, green areas and integrated areas (Ding & Shi, 2013).

We see that the developing world has a large slice of high-pollution work in its industrial area. The decay of the main agricultural land and the desert is an important agricultural area that connects to the forest, causing environmental stress and destroying people by destroying their natural resources.

Industrial processes play an important role in global environmental degradation. Areas of industrial problems are emerging, such as greenhouse gas emissions, air and water pollution, increased waste production, desert and chemical contamination (Chan & Yao, 2008). Land use / land cover change has become a major environmental concern in recent decades. This unstable growth and decline, gives rise to natural plants that lead to the formation of urban heat islands. For fast-growing rural-urban migrations, land cover has increased the surface temperature of the soil covered.

One of the most serious effects of industrialization is the formation of the UHI effect (Ramachandra, 2012). The UHI is a case in which an urban area is considerably heated and the surrounding area is due to the high density of the impermeable surface (Xie & Zhou, 2015). UHI is an important aspect of urban environment planning because it has a very negative impact on its residents. User interface studies are based on the elevation of soil surface temperature (LST) from remote sensors due to implicit availability due to high spatial and temporal resolution (Yuan & Bauer, 2007).

Uttar Pradesh is the main metropolitan area between Lucknow and Kanpur, two metropolitan cities connected by an important transport corridor passing through an urban city i.e. Unnao. The urban population of Unnao has increased by 15.11%. Rapid urban development has brought significant changes to the LST, so a broad understanding of the changing LU / LC dynamics is needed to monitor and analyse the environmental impact of Unnao. Over the past 15 years, much of the land, which covers the plant, has turned into settlements, largely responsible for the growing trend of surface temperatures in the region. Does this article attempt to point to a study that has shown how the temperature of groundwater in the city of Unnao has changed over the past 15 years?

2. Study Area

The Unnao district consists of 16 blocks and tehsils, of which the Unnao tehsil is considered a field of study. The main rivers of the district are the Ganges, Kalyani and Sai. Latitude and longitude are 26^{O}8' N at 27^{O}2' and 80^{O}3' E at 81^{O}3'E. The population has increased from 2,700,324 in 2001 to 3,108,367 in 2011 (Unnao District: census 2011-2020 Data). The population growth between 2001 and 2011 is 15.11%

The region's climate is characterized by high temperatures in summer, moderate to heavy rainfall in the rain and dry winters. During summer and winter, the maximum and minimum temperatures are 44 ° C and 5 ° C. The average annual rainfall is 850 mm. The predominant terrain in this region is the low land.

The city is listed under the Unicorn Council. Transportation is simplified. Unnao is also basically an industrial city with three industrial suburbs.

3. Data & Software for Simulation

Data from Landsat TM (2005 and 2011) and OLI (2019) were obtained from the United States Geological Survey Global Visualization Viewers (USGS). To process the data, Arc GIS 10.4 and MS Excel were used for the entire study (Choudhury, Das, & Das, 2019). Landsat TM data (Thematic Mapper) for 2005 and 2011, band no. 1-5 and 7 were used for mapping land use, band no. 6 is not used because it is a thermal band, in which Lands Wally (Operational Land Imager) is the only band no. 1-7 were used. Image classification techniques have been used to supervise the most feasible method to show land use / land cover change over time. Many signatures were collected to obtain five separate land use classes. A total of 1,500 signatures were collected from the three images and each land use class was grouped to identify them appropriately (Choudhury, Das, & Das, 2019). There are thermal band requirements for lifting LST data, Landsat 5TM thermal band (band 6) for 2005 and 2011 and Landsat 8 OLI (band 10 and band 11) for 2019. Six different steps are required to extract the LST data from the thermal band of the soil using the ArcGIS 10.4 software.

4. Method

The following measures have been taken to raise the surface temperature of the ground from a heat band to a Landsat emergency (Ding & Shi, 2013).

a) Conversion to TOA radiance

Every object in the world shows a certain thermal electromagnetic energy because it is at temperatures above 0 (zero) K, known as absolute 0 (zero). Using this principle, heat sensors (ETM +) receive signals that can be converted into sensor radiation.

The spectral brightness (L_λ) is calculated using the following equation (1) (office, 2003).

$$L_\lambda = ML * QCAL + AL \qquad (1)$$

Where, L_λ = TOA Spectral Radiance
ML = Radiance Multiband (X)
AL = Radiance add band
QCAL = Quantized and Calibrated Standard Product Pixel Values

$$\text{TOA Spectral Radiance} = ((LMAX\lambda - LMIN\lambda)/(QCALMAX - QCALMIN)) * (QCAL - QCALMIN) + LMIN\lambda \qquad (2)$$

Where, QCALMIN = 0, QCALMAX = 255, QCAL = DN of each pixel. LMINλ AND LMAXλ are the spectral radiance of thermal band.

b) Conversion to spectral radiance to At-satellite Brightness Temperatures

The corrected surface temperature emissivity is calculated using the following equation (3) (Artis & Carnahan, 1982).

$$T = \frac{K_2}{In\left(\frac{K_1}{L_\lambda}+1\right)} - 273.15 \qquad (3)$$

Where, T = At-Satellite Brightness Temperature
L_λ = TOA Spectral Radiance
K1 = Constant Band
K2 = Constant Band

The values of K1 for Landsat 8 OLI bands 10 and 11 were respectively 774.8853 and 480.8883, and K2 and 11 for band 10 were 1321.0789 and 1201.1442 respectively. The Landsat TM value of K1 for band 6 is 607.76 and K2 1260.56 respectively for band 6.

273.15 The value is subtracted from the data for each pixel with GIS, since the value of the Kelvin scale (K) is 273.15 higher than the Celsius scale.

c) Proportion of Vegetation (Pv) (Choudhury, Das, & Das, 2019).

$$Pv = \{(NDVI - NDVI_{MIN})/ (NDVI_{MAX} - NDVI_{MIN})\}^2 \qquad (4)$$

d) The land surface emissivity (e) (Choudhury, Das, & Das, 2019)

$$e = 0.004 * PV + 0.986 \qquad (5)$$

e) Land surface temperature (LST) (Choudhury, Das, & Das, 2019)

$$BT/1 + W*(BT/P) *Ln(e) \qquad (6)$$

Where, BT = At-satellite Brightness Temperatures
W= Wavelength of emitted radiance

f) Method to calculate spatial indices (NDVI, NDWI, NDBI) and relationship with LST

Three separate indices were calculated with three separate indices, to show the relationship between the surface temperature with NDBI (Normalized Differential Built-up Index), NDWI (Normalized Differential Water Index) and NDVI (Normalized Differential Vegetation Index), respectively. It is done Using Landsat data with the ArcGIS software. NDVI is obtained using the following equation (7) (Townshend & Justice, 1986):

$$NDVI = \frac{\text{NIR band} - \text{R band}}{\text{NIR band} + \text{R band}} \qquad (7)$$

NIR means band near infrared and R means red band. Landsat TM data for lands 3 and 4 and Landsat OLI data bands 4 and 5 were used to calculate the NDVI. NDVI was used to Indicates the vegetation index of a region.

NDWI can be calculated by given equation (8) (McFeeters, 1996):

$$NDWI = \frac{\text{Green band} - \text{NIR band}}{\text{Green band} + \text{NIR band}} \qquad (8)$$

Green means near the green band and NIR is the infrared band. The NDWI was calculated for the Landsat TM 2 and 4 data bands and for the Landsat OLI 3 and 5 data bands. NDWI is used to indicates the water index of a region.

NDBI is calculated by using the formula given below (9) (Choudhury, Das, & Das, 2019):

$$NDBI = \frac{\text{MIR band} - \text{NIR band}}{\text{MIR band} + \text{NIR band}} \qquad (9)$$

The MIR is the medium infrared band and the NIR is the nearest infrared band. Landsat TM data for lands 5 and 4 and Landsat OLI data bands for NDBI 6 and 5 were used for the calculation. NDBI is used to indicate the building index of region.

g) Establishing Relationship Between LULC and LST

Table 1 and table 2 are showing relationship between LULC and LST. Analysis will be explained in results.

5. Results

The result from image analysis through ArcGIS 10.4 shows that, agriculture land in 2005 was 77.84%, in 2011 was 55.46 and in 2019 it was 52.86% (refer Table 1). Built up area was 1.28%, 2.43% and 7.83% in 2005, 2011 and 2019 respectively (refer Table 1). Vacant land in 2005, 2011 and 2019 was 7.92%, 14,61% and 0.11% respectively (refer Table 1). Vegetation in 2005, 2011 and 2019 was 12.01%, 22.55% and 28.65% respectively (refer Table 1). Water bodies in 2005 was 0.95%, in 2011 it was 4.77% and in 2019 it was 10.37% (refer Table 1). At the same time, LST for NDBI in the year 2005 for upper limit was 46.1611 and lower limit was 24.1896, for year 2011 upper limit was 39.3974 and lower limit was 17.5098, for year 2019 upper limit was 32.411 and lower limit was 21.367 (refer Table 2). LST for NDVI in the year 2005 for upper limit was 45.6825 and lower limit was 24.2946, in the year 2011 upper limit was 39.1611 and lower limit was 17.4765, in the year 2019 upper limit was 32.353 and lower limit was 21.353 (refer Table 2). LST for NDWI in the year 2005 for upper limit was 45.1733 and for lower limit was 24.1902, in the year 2011 upper limit was 39.4074 and lower limit was 17.5098, in the year 2019 upper limit was 32.3904 and lower limit was 21.3627 (refer Table 2).

6. Conclusion

Instead of declining agriculture land, LST for NDVI vegetation has been decreasing constantly due to increase in vegetation land. Fishing trade in Unnao has been increasing due to which water bodies are increasing. LST for NDWI has been decreasing from 2005 to 2019 due to increase in waterbodies. Rise in waterbodies will decrease the surface temperature. Due to rapid industrialization built up has been increasing constantly. Hence LST for NDBI is decreasing.

Statement of author contribution- Ashwani Kumar Rawat presented the idea, Prerika Garg developed the theory, Prerika Garg and Anupam Anand carry out the analysis with the help oF GIS 10.4. Dr. Subhrajit Banerjee helped to supervise the paper. All authors discussed the result and contributed to the final manuscript.

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Result of the analysis are given in the table below:

Table 1: Landuse of Unnao

LAND USE	2005 (in%)	2011 (in%)	2019 (in%)	Change from 2005-2019
Agriculture Land	77.84	55.46	52.86	-24.97
Built up Area	1.28	2.43	7.83	6.55
Vacant land	7.92	14.61	0.11	-7.81
Vegetation	12.01	22.55	28.65	16.64
Water Bodies	0.95	4.77	10.37	9.42

Source: ArcGIS 10.4

Table 2: NDBI, NDVI, NDWI of Unnao

	NDBI		NDVI		NDWI	
	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit
2005	46.1611	24.1896	45.6825	24.2946	45.1733	24.1902
2011	39.3974	17.5098	39.1611	17.4765	39.4074	17.5098
2019	32.411	21.367	32.353	21.353	32.3904	21.3627

Source: ArcGIS 10.4