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THE RELATIONSHIPS BETWEEN NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) AND LAND SURFACE TEMPERATURE (LST) IN ROHTAK DISTRICT, HARYANA: A SPATIAL ANALYSIS

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ABSTRACT

Vegetation cover significantly affects the regulation of surface temperature of any area. Numerous research investigations have consistently shown that there is a negative correlation between the volume of vegetation covering an area and the temperature of the ground. Studies also indicates that the temperature at the built-up areas is lower than the temperature in open space. Based on these factors, a study has been conducted on Rohtak district in Haryana. The district of Rohtak is located centrally within the state and has undergone significant changes in land utilisation over the past twenty years because of urbanisation. The southern and western boundaries of the district delineate the semi-desert districts from the remaining districts of the state. This study employed remote sensing techniques and multiple additional methods of data collection. The satellite images from Land Set 8 were utilised to generate required results for the study. The study focused on relationship between normalized difference vegetation index (NDVI) and land surface temperature (LST)

Keywords: *normalized difference vegetation index (NDVI), land surface temperature (LST), Normalized difference built-up index (NDBI), Landsat 8, remote sensing*

INTRODUCTION

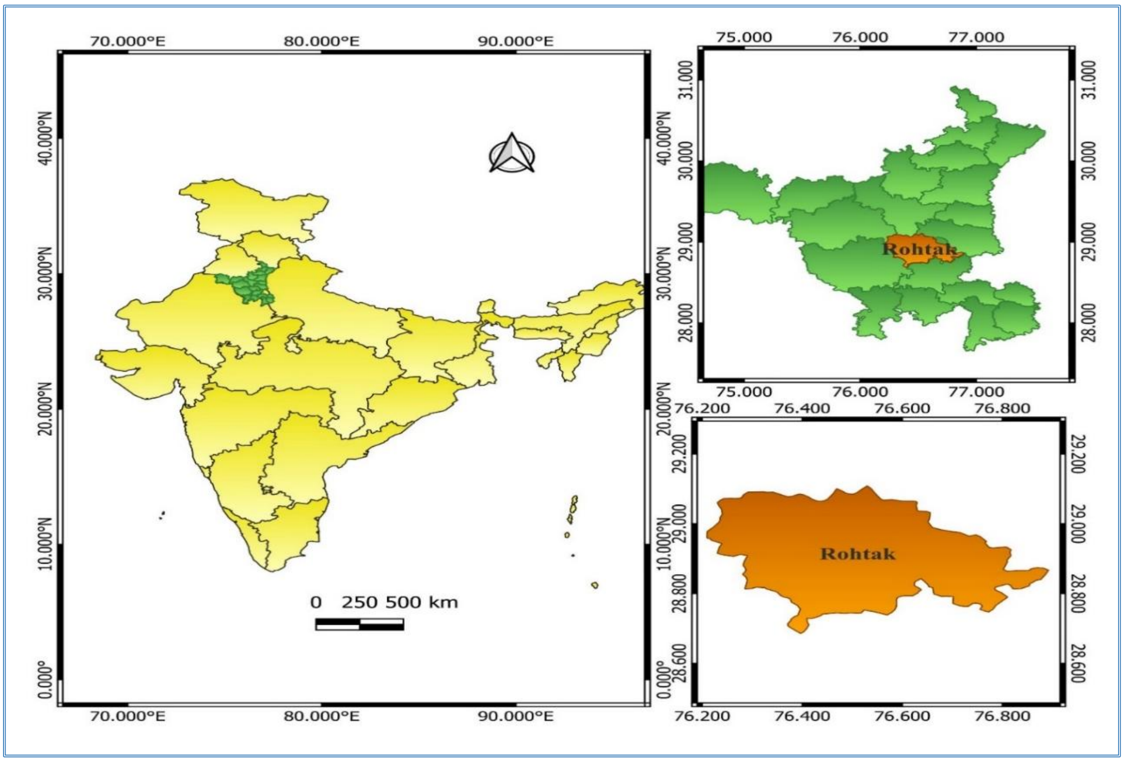
The increased urbanisation that is currently occurring in the Rohtak District of Haryana has raised concerns regarding its environmental implications, including an increase in temperature. The relationship between vegetation cover index (NDVI) and land surface temperature (LST) has become an important field of study in both Geography and Environmental Sciences. The present study specifically examines the impact of vegetation cover on land surface temperature (LST) in Rohtak District. Various studied found that vegetation has a significant impact on land surface temperature in a specific area. NDVI controlled surface temperature by various way like; evapotranspiration, shading, and reflecting solar radiation [6]. The district Rohtak, which has both urban and rural areas, has a perfect location to study these processes because the land is used her for many different activities. The rapid urbanisation growth and intensive agricultural activities leads a major change of land surface temperature. Considering the rapid urban growth and land use changes in Rohtak District, it is crucial to investigate the impact of these development projects on the relationship between vegetation cover and Land Surface Temperature (LST).

Previous researches have indicated the notable correlation between vegetation cover and land surface temperature, with a specific focus on the moderating impacts observed in different urban settings across the globe. Different studies indicate that implementing urban greening activities to increase vegetation cover can successfully decrease the severity of the surface temperature phenomenon and improve the resilience of urban climates. Furthermore, studies have shown that it is crucial to consider the variation in vegetation cover and land use patterns across different areas when studying the dynamics of land surface temperature (LST) [4] [12]. Atmospheric components, such as vegetation and soils, are important components that control the NDVI and leaf area index (LAI) [11]. Understanding the complexity of climatic conditions in a specific area requires an examination of the crucial interconnections between them. The analysis of satellite data clearly demonstrates the influence of surface temperature on both the characteristics of the surface and the spatial arrangement of vegetation cover [10]. Prior research has established that the surface temperature of a region has an impact on the distribution of air temperature and the presence of vegetation cover. The study conducted in the desert area indicates that the presence of vegetation cover and built-up areas can lower the land temperature in comparison to bare land [9]. A study examines the efficacy of water bodies compared to vegetation in mitigating heat intensity in urban environments. The study demonstrates a direct relationship between the temperature of built-up area and the open land area. The research indicates that policy makers should advocate for the implementation of environmentally-friendly urban development [7]. The research on the urban heat island (UHI) in the Shanghai region from 1997 to 2004, conducted using GIS technology, concludes that newly developed open land in the distant islands of the coastal region has a cooling effect due to water and vegetation. However, the increasing temperature is primarily attributed to urbanisation. The urban heat island (UHI) effect is becoming more pronounced in the surrounding satellite cities [8]. A study of the Manchester urban area, specifically centric at green infrastructure in relation to climate change, reveals that the unique physical features of the urban area, such as the influence of the urban heat island effect (UHI), change in surface water flow caused by expanding land use, and the presence of vegetation cover, will mitigate the effects of climate change in the future [3]. A research of temperature patterns in major U.S. cities over the past century reveals that metropolitan areas have seen a temperature rise of about 0.5–3.0°C since around 1940. The temperature trend is caused by a lack of vegetation cover and the absorption of high levels of solar radiation, resulting in increased pollution and higher energy demand for cooling. Implementing mitigation measures can lead to an annual cost reduction of more than $10 billion by decreasing energy usage by 20% [1] [5].

Study Area

The Rohtak district is situated in the central part of the state of Haryana. Jind and Sonipat districts border it to the north and east, Jhajjar district to the south, and Bhiwani and Hisar districts to the west. The Rohtak district spans a physical area of 1682.83 square kilometres (1682.83) square kilometres according to village documents). The location of the district is located between 28° 40' 58" N and 29° 06' 13" N latitude, and 76° 12' 47" E and 76° 51' 43" E longitude. The district is 1668 square kilometres in size, with a length of 62.5 kilometres and a breadth of 44.0 kilometres. The plains in the district have a mean sea level elevation of 220 metres. The northern part of the district exhibits a gradual incline from north to south, specifically at a rate of 19 cm per km, until it reaches Jhajjar town. Furthermore, there is a substantial slope that extends from the west to the east. The Rohtak District, with its different land uses encompassing urban-rural areas and agricultural fields, offers an ideal setting to examine the dynamics within a heterogeneous landscape. The rapid growth of urbanisation and the intense methods used in agriculture have caused major change in the land's surface, resulting in changes to its thermal and vegetation cover qualities.

Fig.1: Study Area Mam



OBJECTIVE

1. The objective is to apply remote sensing techniques to identify the extent of vegetation cover in Rohtak District.
2. To measure the land surface temperature in different parts of the district.
3. To examine the geographic relationship between normalized difference vegetation index (NDVI) and land surface temperature (LST).
4. The objective is to examine the changes in vegetation cover and land surface temperature over the last ten years.
5. To provide recommendations for policy makers that will mitigate the negative impacts of elevated temperatures.

METHODOLOGY

The study of vegetation cover and surface temperature has been conducted using satellite imagery data obtained through remote sensing, including Landsat 8. To verify the accuracy of the remote sensing data, field studies have been applied. Secondary data additionally includes temporal information on vegetation and temperature from environmental and meteorological agencies. Examine the Landsat 8 satellite images' diverse bands to identify the extent of vegetation cover and land surface temperature. The quantitative data of vegetation cover and surface temperature is derived by utilising the Normalised Difference Vegetation Index (NDVI) and land surface temperature (LST). Temporal analysis measures the evolution of changes over the past decade, while spatial analysis employs QGIS software to map and analyse the geographic relationship between vegetation cover and surface temperature.

NDVI is a valuable tool for evaluating changes in vegetation cover and comprehending vegetation density. It is also employed to quantify vegetation greenness. In the conventional manner, NDVI is determined as the ratio of red (R) to near infrared (NIR) values: In Landsat 8-9, NDVI

$$NDVI = \frac{NIR-Red}{NIR+Red}$$

(Band 5 – Band 4) / (Band 5 + Band 4)

LST is determined by calculating the radiative temperature using the top of atmosphere brightness temperature, the wavelength of emitted radiance, and the Land Surface Emissivity.

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

where BT represents the Top of Atmosphere Brightness Temperature in degrees Celsius, W represents the wavelength of emitted radiance, and E represents the Land Surface Emissivity.

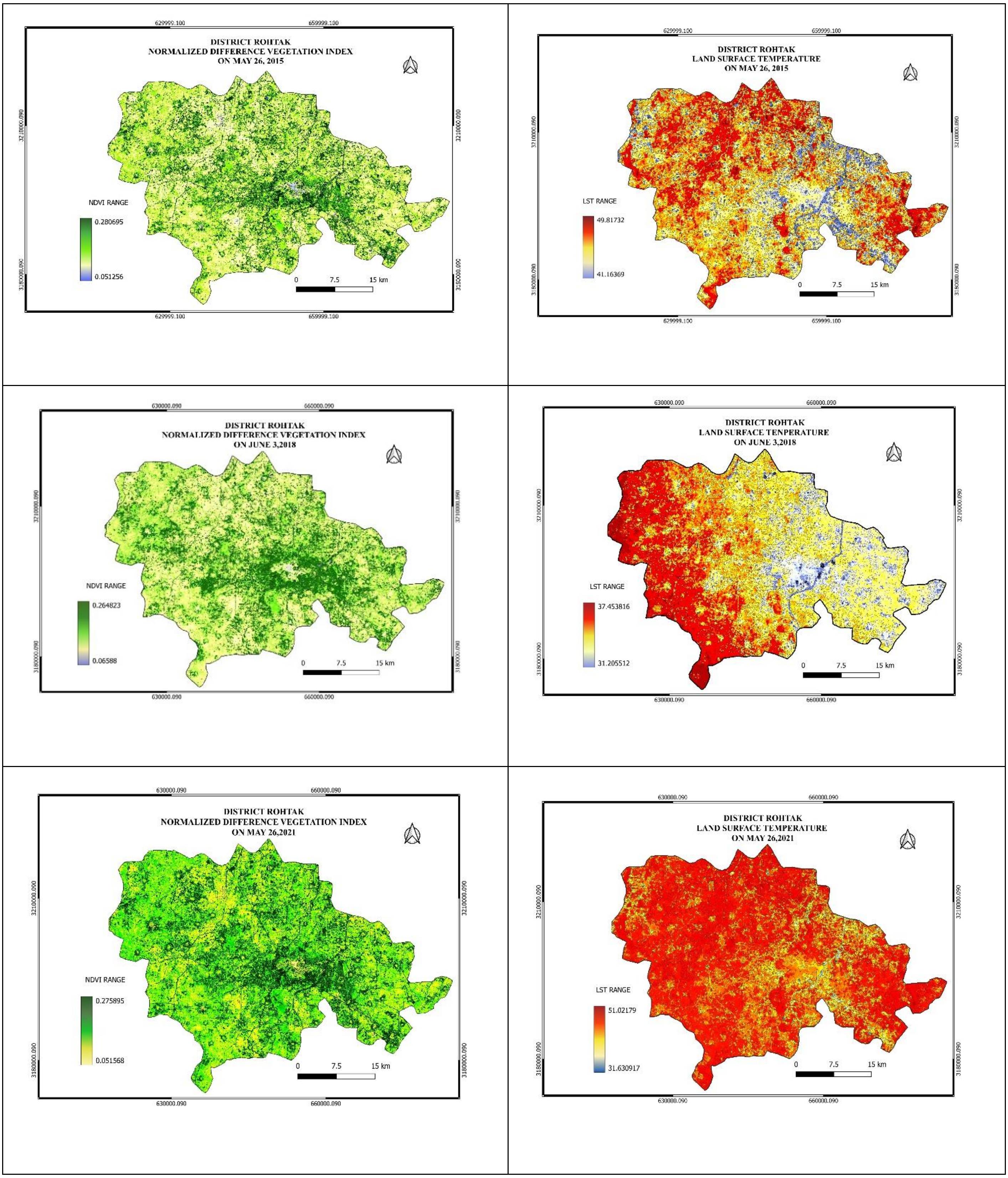
Table 1: Specification of Landsat 8 data sets

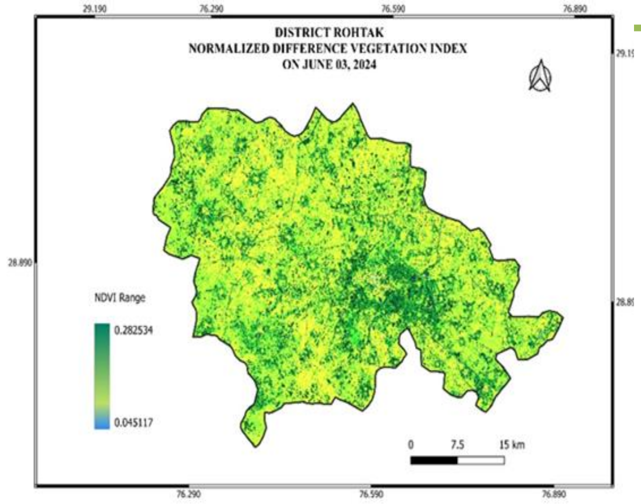
	Bands	**Wavelength (micrometres)**	**Resolution (Meters)**
Landsat 8 Operational Land Imager (OLI) Thermal Infrared Sensor (TIRS)	Band 1 – Coastal aerosol	0.43- 0.45	30
	Band 2 – Blue	0.45 – 0.51	30
	Band 3 – Green	0.53 – 0.59	30
	Band 4 – Red	0.64 – 0.67	30
	Band 5 – Near Infrared (NIR)	0.85 – 0.88	30
	Band 6 – SWIR 1	1.57 – 1.65	30
	Band 7 – SWIR 2	2.11 – 2.29	30
	Band 8 – Panchromatic	0.50 – 0.68	15
	Band 9 - Cirrus	1.36 – 1.38	30
	Band 10 – Thermal Infrared (TIRS) 1	10.60 – 11.19	100
	Band 11 – Thermal Infrared (TIRS) 2	11.50 – 12.51	100

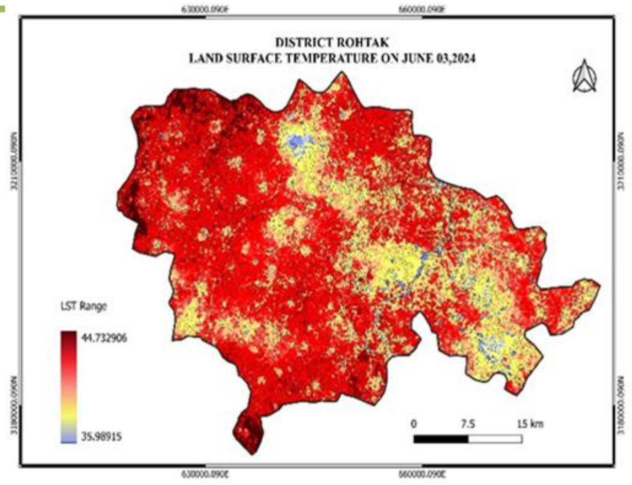
(Source: USGC)

Result and Discussion

Fig.3: NDVI and LST of District Rohtak, Haryana 2015 to 2024







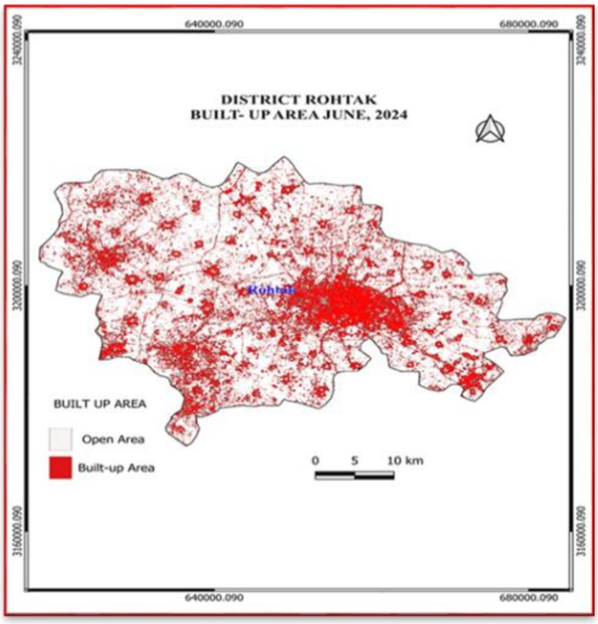
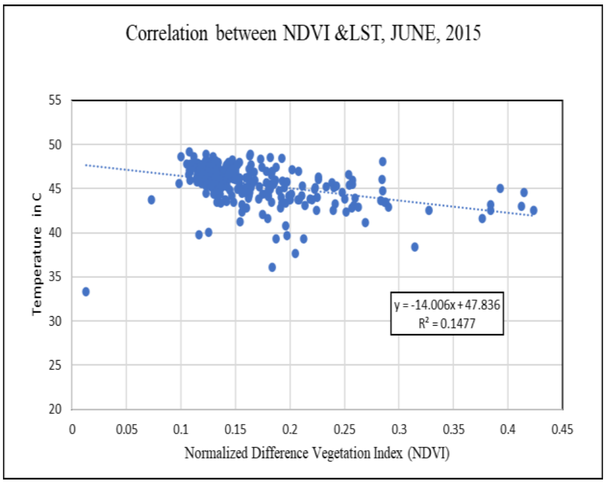
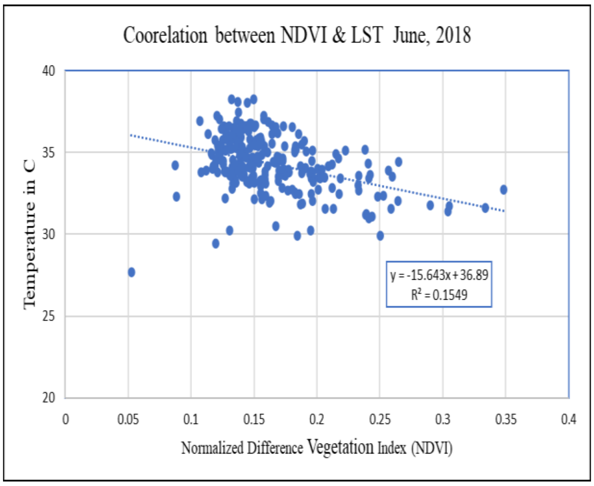
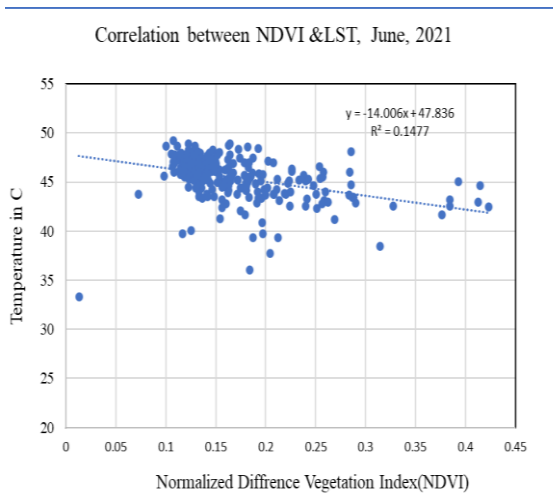


Fig.4: Correlation Between NDVI & LST of District Rohtak, Haryana 2015 to 2024







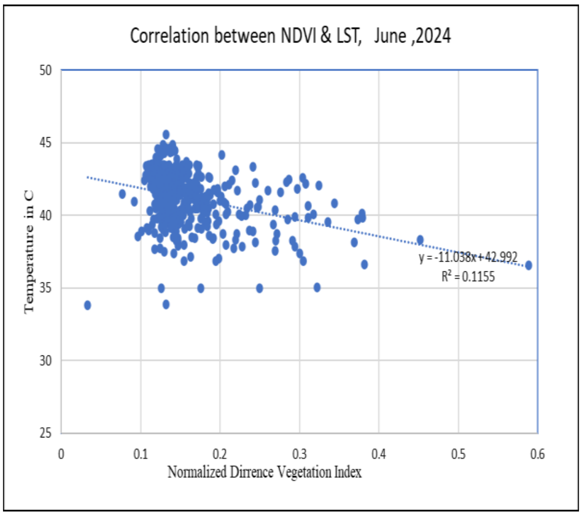


Table 2: Minimum & Maximum Values of NDVI & LST

Year	NDVI/ LST	Maximum	Minimum
2015	NDVI	0.28	0.05
	LST	49.81	41.63
2018	NDVI	0.26	0.06
	LST	37.45	31.20
2021	NDVI	0.27	0.05
	LST	51.02	31.63
2024	NDVI	0.29	0.04
	LST	44.73	35.98

The temporal variation & spatial distribution of LST and NDVI

Table 2, displays the NDVI (Normalised Difference Vegetation Index) and LST (Land Surface Temperature) values derived from Landsat imagery of Rohtak district during the years 2015 to 2024. In June 2021, the highest recorded LST (Land Surface Temperature) reached 51.02 °C, while the lowest recorded LST was 31.20 °C in 2018. According to table 2, the LST (Land Surface Temperature) values for the years 2015, 2018, 2021, and 2024 are as follows: 49.81 °C and 41.63°C in 2015, 37.45°C and 31.20°C in 2018, 51.02°C and 31.63 °C in 2021, and 44.73 °C and 35.98°C in 2024. The highest value for NDVI remains constant over time (table 2). In June 2024, the NDVI values reached their peak at 0.29, whereas the lowest value was recorded at 0.26 in 2018. The satellite imagery from June 2015 reveals a constant NDVI values between 2015 and 2024. The data indicates a steady rise in the proportion of vegetation in the district over time, along with an adverse relationship between NDVI and LST.

The spatial distribution relationship between NDVI &LST revealed in (figurer 1-8). The southern and western part of district including Kalanaur and Mehem block have low level of NDVI and very high level LST. The state high way from Beri to Mehem make a boundary between low level of NDVI and high level of LST in the district. The central part which is Rohtak urban centre have the highest level of NDVI and lowest level of LST. Northern and Eastern part including Lakhan Majra and Sampla block have medium level of NDVI and medium level of LST.

LST, NDVI and NDBI

The Normalised Differential Built-up Index (NDBI) in the district shown an association with the levels of Land Surface Temperature (LST) and Normalised Difference Vegetation Index (NDVI). The district covers a total land area of 1682.83 square kilometres, with 70.56% (1187.40 sq.km) classified as open space and 29.44% (495.43sq.km) as built-up area. The Kalanaur and Mehem blocks exhibit a substantial amount of open area, while the Rohtak Sampla and Lakhan Majra blocks possess a significant amount of built space. The data highlights a clear negative correlation between the size of open areas and the Normalised Difference Vegetation Index (NDVI), indicating that open areas have a low NDVI value. Additionally, there is a positive correlation between the size of open areas and the Land Surface Temperature (LST), indicating that open areas have a high LST value.

CONCLUSION

Recognising the correlation between the land surface temperature (LST) and the normalised difference index (NDVI) in Rohtak District is required to find efficacious strategies to mitigate the increasing levels of heat-related issues. The study identified a direct correlation between NDVI (Normalised Difference Vegetation Index) and LST (Land Surface Temperature) in the district by integrating remote sensing techniques, geographical analysis, and field surveys. However, the districts of Jhajjar and Bhiwani are in the western and southern regions of the district, and the neighbouring areas that these districts share with Rohtak district are characterised by high land surface temperatures (LST) and low NDVI (Normalised Difference Vegetation Index) along with sandy and dry soils. The Normalised

Difference Built-Up Index (NDBI) is a significant component that influences surface temperature. The district has an absence of dense forest vegetation and has a high Normalised Difference Built-up Index (NDBI), both of which significantly affect the Land Surface Temperature (LST).

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