Walchand College Of Engineering, Sangli.

(An Autonomous Institute)

Department of
Computer Science and Engineering

Mini-Project Report
on

Land Surface Temperature change detection using GIS and RS

Submitted by

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WCE, Sangli

2022-23

Walchand College of Engineering, Sangli
(An Autonomous Institute)

**Depart
ment
Of
Computer Science and Engineering**

CERTIFICATE

This is to certify that the Project Report entitled, **"Land Surface Temperature change detection using GIS and RS"** submitted by Mr. Prathamesh Raje, Mr. Samrat Jadhav, Mr. Raj Dalvi , to Walchand College of Engineering ,Sangli, India, is a record of bonafide Project work of course *" 5CS348" " Mini-Project-4"* carried out by them under my supervision and guidance and is worthy of consideration for the award of the degree of Bachelor of Technology in Computer Science & Engineering of the Institute.

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Acknowledgement

Today on completion of this project report, the persons I would like to thank the most who have helped us throughout the making of this project and without whose help it would not have seen the light of the day. Primarily, I submit our gratitude and sincere thanks to my project guide Prof. N. L. Gavankar for his constant motivation and support during the course of the work in the last six months. I truly appreciate and value his esteemed guidance and encouragement from the beginning to the end of this work. I'm very thankful to our Head of Department Dr. M. A. Shah for their unwavering moral support and motivation during the entire work.

I would also like to thank our Director Dr. U. A. Dabade who encouraged us and created a healthy environment for all of us to learn in best possible way.

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Declaration

I hereby declare that work presented in this project report titled **“Land Surface Temperature change detection using GIS and RS”** submitted by us in the partial fulfillment of the requirement of the award of the degree of Bachelor of Technology (B.Tech) Submitted in the Department of Computer Science & Engineering, Walchand College of Engineering, Sangli, is an authentic record of my project work carried out under the guidance of Prof. N. L. Gavankar, Computer Sci. & Engg. Dept,WCE, Sangli.

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1. Project Title

Land Surface Temperature change detection using GIS and RS

2. Abstract

Land Surface Temperature (LST) validation and change in Land Surface Temperature is needed in various applications like temporal analysis, identification of global warming, land use or land cover, water management, soil moisture estimation and natural disasters. The objective of this study is estimation as well as validation and change detection of temperature data in Sangli City of Maharashtra over the last 10 years with LST extracted by using remote sensing as well as Geographic Information System (GIS).

Satellite data considered for estimation purpose is LANDSAT 8 and LISS IV. Sensor data used for assessment of LST are OLI (Operational Land Imager) and TIR (Thermal Infrared). Thermal band contains spectral bands of 10 and 11 were considered for evaluating LST independently by using algorithm called Mono Window Algorithm (MWA). Land Surface Emissivity (LSE) is the vital parameter for calculating LST. The LSE estimation requires NDVI (Normalized Difference Vegetation Index) which is computed by using Band 4 (visible red band) and band 5 (Near-Infra Red band) spectral radiance bands.

Later on, validation of estimated LST through in-suite temperature data obtained from AWS station in Sangli city was carried out. The purpose of this study is to know the effect of urbanization on the land surface temperature and also the effect of global warming on land surface temperature. Study also enables to identify the trend of change in LST.

3. Introduction and Related Work

Introduction:

Land surface temperature (LST) is an important variable for understanding the physical properties of the Earth's surface and its interactions with the atmosphere. Remote sensing (RS) and geographic information systems (GIS) are powerful tools for monitoring and analyzing LST patterns and trends over time. This report aims to investigate the use of GIS and RS in analyzing LST and its relationship with land cover in a specific area.

Related Work:

Many studies have been conducted using GIS and RS to analyze LST and its spatial and temporal variations. For instance, Liu et al. (2020) used MODIS (Moderate Resolution Imaging Spectroradiometer) data to study the spatiotemporal patterns of LST in the Yangtze River Delta region of China. They found that urban areas had significantly higher LST values compared to rural areas, and that LST increased with increasing urbanization.

Similarly, Wang et al. (2019) used Landsat data to analyze the relationship between LST and land cover in the Pearl River Delta region of China. They found that built-up areas had the highest LST values, followed by croplands and water bodies. They also found that LST was significantly correlated with land cover, with built-up areas having the strongest correlation.

Other studies have investigated the use of machine learning algorithms for LST prediction using RS data. For instance, Ma et al. (2018) used a random forest algorithm to predict LST in the Beijing-Tianjin-Hebei region of China. They found that the model had high accuracy in predicting LST, and that land use and land cover were the most important predictors of LST.

In summary, previous studies have demonstrated the utility of GIS and RS in analyzing LST patterns and trends, as well as their relationship with land cover. This report will build upon these studies by analyzing LST in a specific area using GIS and RS techniques.

Study Area:

In case study, investigations were performed on Sangli district of Maharashtra. Sangli district lies in the southern part of the state, adjoining Karnataka and lies between north latitudes 16° 43' and 17° 38' and east longitudes 73° 41' and 75° 41'. Study area include the satellite image of area 16.75 N to 17.00 N and 74.50 E to 74.75 E which covers the part of the Sangli district.

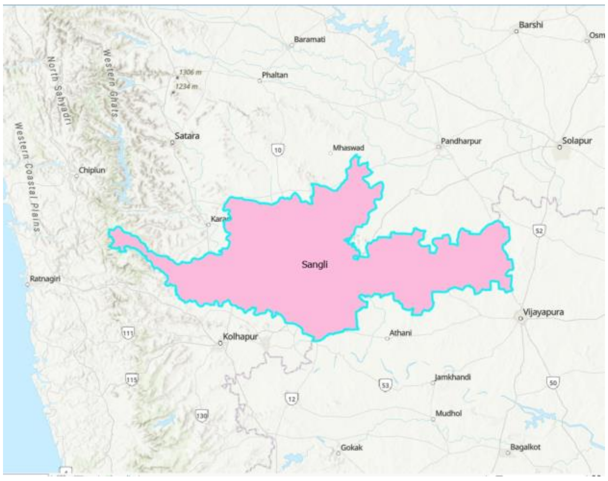


Fig 1. Study Area

Satellite Data:

LANDSAT 8 OLI/TIRS C2 L1

Landsat 8 carries two sensors. The Operational Land Imager sensor is built by Ball Aerospace & Technologies Corporation. The Thermal Infrared Sensor is built by NASA Goddard Space Flight Center.

Bands Used:

Band 4 Red (0.64 - 0.67 µm) 30 m

Band 5 Near-Infrared (0.85 - 0.88 µm) 30 m

Band 10 TIRS 1 (10.6 - 11.19 µm) 100 m

GIS Software Used:

ArcGis Pro 3.0.0

ArcGIS Pro is desktop GIS software developed by Esri, which replaces their ArcMap software generation. The product was announced as part of Esri's ArcGIS 10.3 release, ArcGIS Pro is notable in having a 64-bit architecture, combined 2-D, 3-D support, ArcGIS Online integration and Python 3 support.

4. Problem Statement:

Land Surface Temperature (LST) is a critical environmental parameter that affects various processes and activities on the Earth's surface. Monitoring and understanding LST changes over time can provide valuable insights into climate patterns, urban heat island effects, land cover dynamics, and the overall health of ecosystems. Geographical

Information Systems (GIS) and Remote Sensing (RS) techniques are powerful tools for analyzing and visualizing LST data and can help in identifying and assessing temporal trends and spatial patterns of LST change in a particular area.

Geographical Information Systems (GIS) and Remote Sensing (RS) technologies are widely used for analyzing and visualizing spatial data, including LST data. GIS integrates spatial data with attribute data, allowing for comprehensive analysis and visualization of LST patterns across a specific geographic area. RS techniques involve the use of satellite imagery or aerial photographs to collect information about the Earth's surface without physical contact.

To study and analyze Land Surface Temperature change in recent years for particular area using GIS and RS.

5. Objectives

- To study domain of Remote Sensing and GIS.
- To study and process remote sensed data in the form of satellite images.
- To study ArcGIS Pro software for data processing.
- To build and implement spatial model for automation of manual processes.
- To analyze the result.
- To predict the future trend from the result data.

6. Methodology

- Software Specifications
- ISRO Bhuvan / USGS IoT Gecko
- Erdas Imagine
- ArcGis 10.3

Techniques and Algorithms:

1. The proposed work is to estimate LST of study area, i.e., Sangli district by using TIR band independently using Mono Window Algorithm. GIS software used for the assessment of LST from LANDSAT 8 data was ArcGIS10.3

2. Mono Window algorithm comprises 6 steps process in the estimation of the LST of the study area. These steps are specifically used for processing the LANDSAT 8 band data only. LST assessment requires brightness temperature, Land surface emissivity and NDVI values.
   Mono Window Algorithm uses the TIR band for the estimation of LST. i.e., 10 and 11 of LANDSAT 8 Thermal Infra-Red sensor.

3. The processing steps involved in Mono-Window Algorithm for estimating LST are as follow.

Step 1:

Translation of satellite image Digital Number (DN) into spectral radiance called Top of Atmosphere (TOA)

$$L_\lambda = M_L * Q_{cal} + A_L - O_i$$

Lλ - Spectral radiance of TOA (mW /sr mm2)

ML - Multiplicative rescaling value

AL - Additive rescaling factor of specific band

Qcal – Digital Number (i.e., Quantized and calibrated pixel values)

Oi - Adjustment factor

Step 2:

Conversion of Top of Atmosphere (TOA) radiance into brightness temperature (BT) using TOA and thermal conversion constants K1 and K2

$$B_T = \frac{K_2}{ln\left[\left(\frac{K_1}{L_\lambda}\right)+1\right]} - 273.15$$

BT - Brightness Temperature in 0Celsius

Lλ - Top of Atmospheric spectral radiance (Band 10 or Band 11)

K1 and K2 – Thermal Sensor constants used for conversion

Step 3:

Calculation of NDVI. The NDVI value varies between -1 to +1.

NDVI for each pixel is calculated using the NIR and Red band.

Step 4:

Vegetation proportion (Pv) is calculated by using equation number 4, where NDVI is obtained from step 3.

$$P_V = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2$$

After the estimation of NDVI values of study area, then consider from that NDVI image lowest and highest values of the NDVI image

Step 5:

Land Surface Emissivity (ε) anticipated through the use of the NDVI threshold method.

$\varepsilon = \varepsilon s\ (1 - Pv) + \varepsilon v Pv + d\varepsilon$ (5)

Where,

εv denotes Emissivity parameter of Vegetation

εs denotes Emissivity parameter of soil

Pv – Vegetation proportion

Step 6:

Last step for calculation of LST

$$LST = \frac{B_T}{\left\{1 + \left[\left(\frac{\lambda B_T}{\rho}\right) \ln\ln(\square_\square)\right]\right\}}\ ^\circ C$$

λ = 10.8 µm i.e. Emitted radiance wavelength

ελ - land surface emissivity and

$$\rho = h\frac{c}{\sigma} = 14388\ \mu m\ K$$

Where,

c – Light Velocity = 3×108 m/s

σ – Boltzmann's Constant = 138 ×10− 25 J/K and constant

h - Planck's Constant = 662.6 ×10− 36 Js.

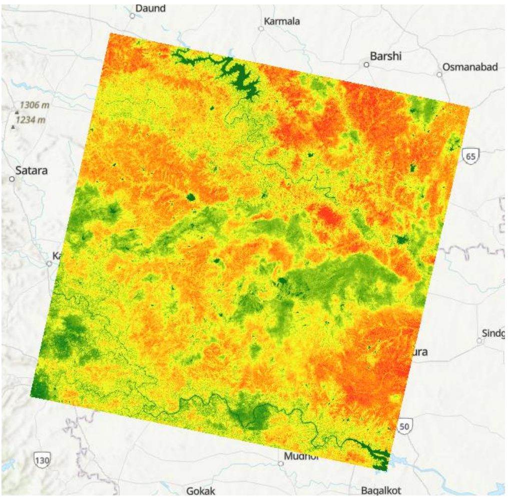


Fig 2. LST

4. After retrieving land surface temperature from multiple spectral bands and multiple sensors, it is used to validate with in-suite data obtained from AWS station
5. The LST estimated by using remote sensing and GIS is compared with in-suite AWS stations temperature data and difference of two temperatures is calculated.
6. After calculating and validating the LST, LST maps are generated

Spatial Model:

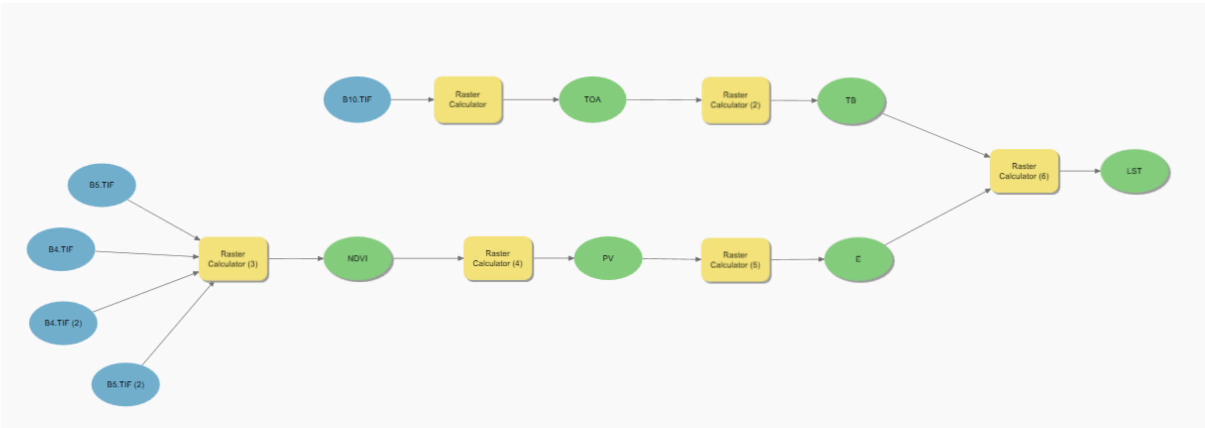


Fig 3. Spatial Model

Block Diagram

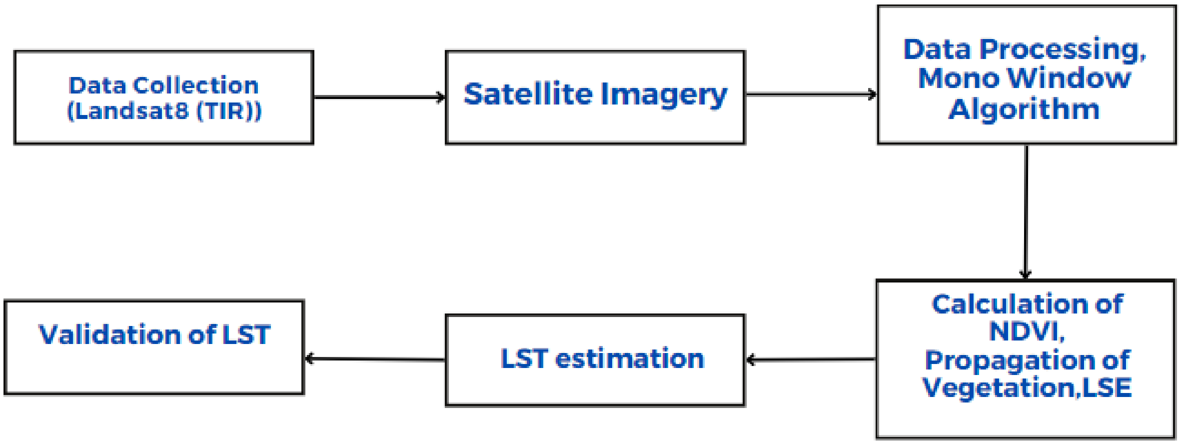


Fig 4. Block Diagram for calculation of LST

Output:

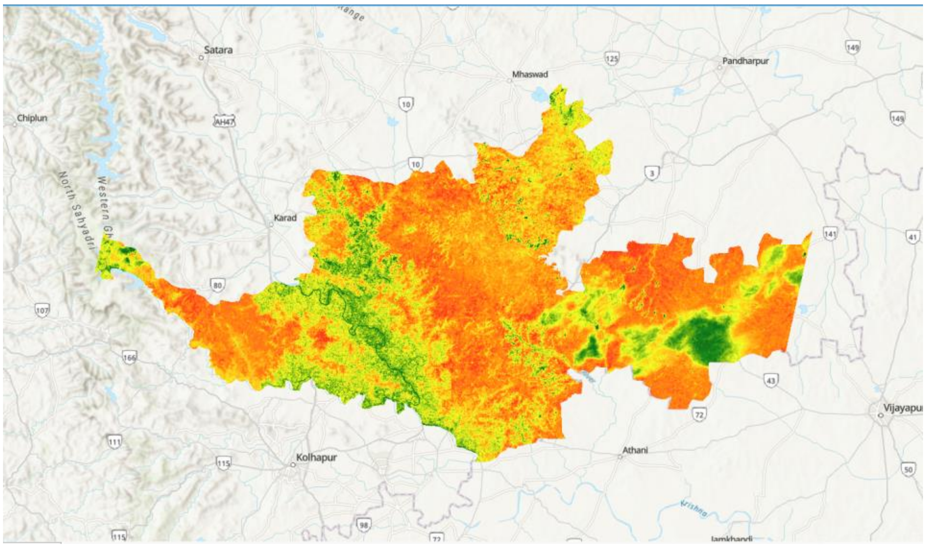
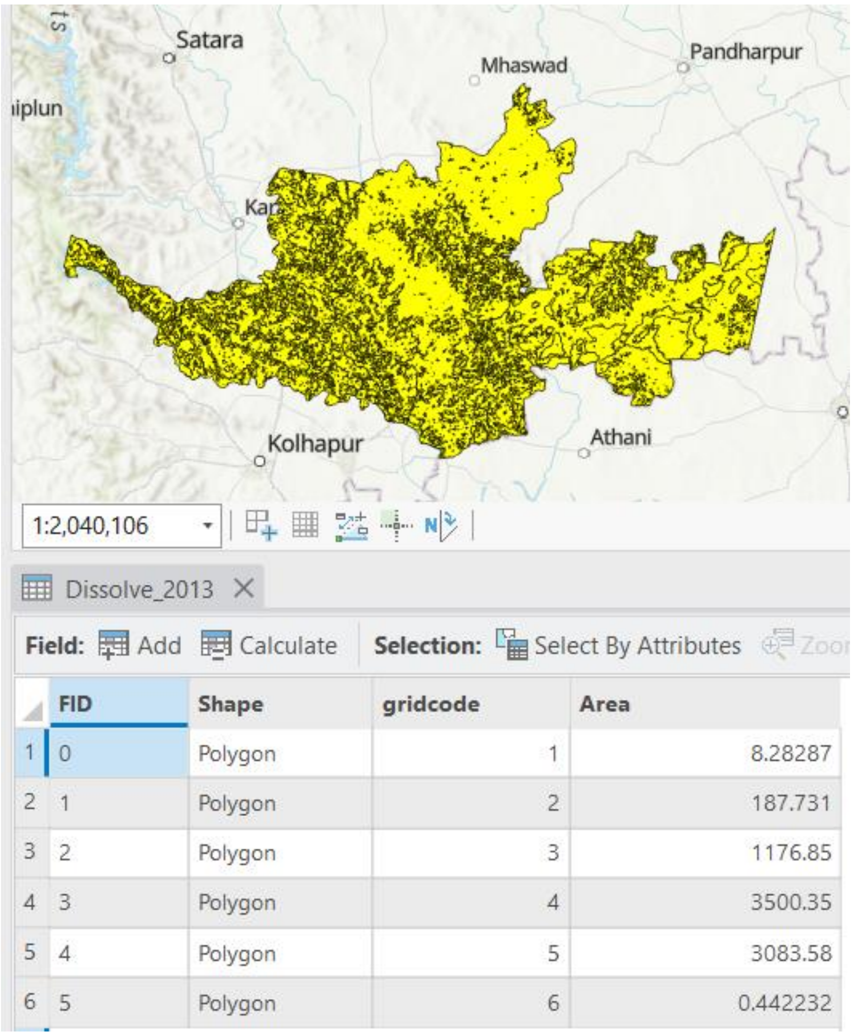


Fig. 5 Talukawise LST of Sangli District



	FID	Shape	gridcode	Area
1	0	Polygon	1	8.28287
2	1	Polygon	2	187.731
3	2	Polygon	3	1176.85
4	3	Polygon	4	3500.35
5	4	Polygon	5	3083.58
6	5	Polygon	6	0.442232

Fig. 6 Calculated Area for each class of 2013

7. Analysis

Classes:

Class 1: <=20

Class 2: 20 - 30

Class 3: 30 - 35

Class 4: 35 - 40

Class 5: 40 - 45

Class 6: >45

Table 1: Temperature classes and their respective areas for years studied

Grid Code	Temperature (in deg. cel.)	Area (In sq. km.)				
		April 2013	April 2014	April 2018	April 2020	March 2023
1	<20	8.28287			3.516985	0.036463
2	20-30	187.731	8.886167	6.158569	256.6472	285.9095
3	30-35	1176.85	128.0953	48.87252	3087.933	4218.829
4	35-40	3500.35	1032.788	543.786	3743.072	3371.364
5	40-45	3083.58	2795.889	1953.553	807.8043	9.177532
6	>45	0.442232	3937.784	5330.177	0.059817	0.002418
	Total	7,957.24	7,903.44	7,882.55	7,899.03	7,885.32

Table 2: Taluka wise April 2013 Data

Taluka	**April 2013 Temperature (In Degree Celsius)**		
	Min	**Max**	**Mean**
Sangli	**26.38**	**44.42**	**37.90**
Shirala	**25.13**	**46.86**	**36.30**
Islampur	**25.72**	**43.43**	**35.59**
Vita	**24.99**	**44.11**	**39.63**
Kavathe-Mahakal	**25.59**	**44.04**	**38.57**
Tasgaon	**26.55**	**44.30**	**38.90**
Atpadi	**26.87**	**44.32**	**41.43**
Jath	**25.04**	**44.71**	**37.14**

Table 3: Taluka wise April 2020 Data

Taluka	April 2020 Temperature (In Degree Celsius)		
	Min	Max	Mean
Sangli	26.17	44.30	37.20
Shirala		47.56	
Islampur	25.94		32.69
Vita	25.00	44.65	36.30
Kavathe-Mahakal	25.72	45.44	37.84
Tasgaon	25.42	44.41	36.60
Atpadi	25.29	44.71	36.33
Jath	5.41	43.87	34.28

Table 4: Taluka wise March 2023 Data

Taluka	April 2019 Temperature (In Degree Celsius)		
	Min	Max	Mean
Sangli	23.62	40.77	40.82
Shirala		40.58	
Islampur	24.19		32.18
Vita	19.54	40.95	33.43
Kavathe-Mahakal	22.94	44.97	34.37
Tasgaon	22.80	40.23	33.29
Atpadi	23.23	40.93	34.97
Jath	23.29	41.34	36.32

Table 5: Taluka wise April 2019 Data

Taluka	Mean Temperature (In Degree Celsius)				
	April 2013	April 2017	April 2019	April 2020	March 2023
Sangli	37.90	38.87	40.82	37.20	33.71
Shirala	36.30				
Islampur	35.59	37.93	38.42	32.69	32.18
Vita	39.63	41.44	41.56	36.30	33.43
Kavathe-Mahakal	38.57	42.47	43.15	37.84	34.37
Tasgaon	38.90	40.41	41.21	36.60	33.29
Atpadi	41.43	45.32	43.68	36.33	34.97
Jath	37.14	45.37	44.04	34.28	36.32

Table 6: Taluka wise Mean Temperature Data for given Years

Taluka	March 2023 Temperature (In Degree Celsius)		
	Min	Max	Mean
Sangli	23.62	40.77	33.71
Shirala			
Islampur	24.19	40.58	32.18
Vita	19.54	40.95	33.43
Kavathe-Mahakal	22.94	44.97	34.37
Tasgaon	22.80	40.23	33.29
Atpadi	23.23	40.93	34.97
Jath	23.29	41.34	36.32

8. Results

The land surface temperature study was conducted to investigate the temporal and spatial variations of land surface temperature (LST) across a specific region over a period of five years. The study utilized satellite imagery and advanced remote sensing techniques to collect LST data.

The results indicate a clear seasonal pattern in land surface temperature, with higher temperatures observed during the summer months and lower temperatures during the winter months. Spatially, the study found variations in LST across different land cover types, with urban areas exhibiting higher temperatures compared to rural and vegetated areas.

Furthermore, the analysis revealed an increasing trend in land surface temperature over the study period, indicating a potential long-term warming effect. This trend was found to be consistent across the entire region, suggesting a regional-scale influence on land surface temperature.

9. Conclusion

The land surface temperature study provides valuable insights into the spatiotemporal dynamics of land surface temperature in the study area. The findings highlight the influence of seasonal variations, land cover types, and potential long-term warming trends on land surface temperature.

The observed higher temperatures in urban areas compared to rural and vegetated areas emphasize the urban heat island effect, indicating the need for appropriate urban planning and mitigation strategies to address the heat-related challenges faced by densely populated regions.

The increasing trend in land surface temperature suggests a potential climate change impact on the study area. These findings emphasize the importance of monitoring and managing land surface temperature as a crucial component of climate change adaptation and mitigation strategies.

The results of this study contribute to a better understanding of land surface temperature dynamics, which can be utilized for various applications such as urban planning, environmental management, and climate modeling. However, further research is recommended to explore the underlying factors driving the observed trends and to assess the potential impacts on ecosystems, human health, and socio-economic systems in the region.

10.References

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