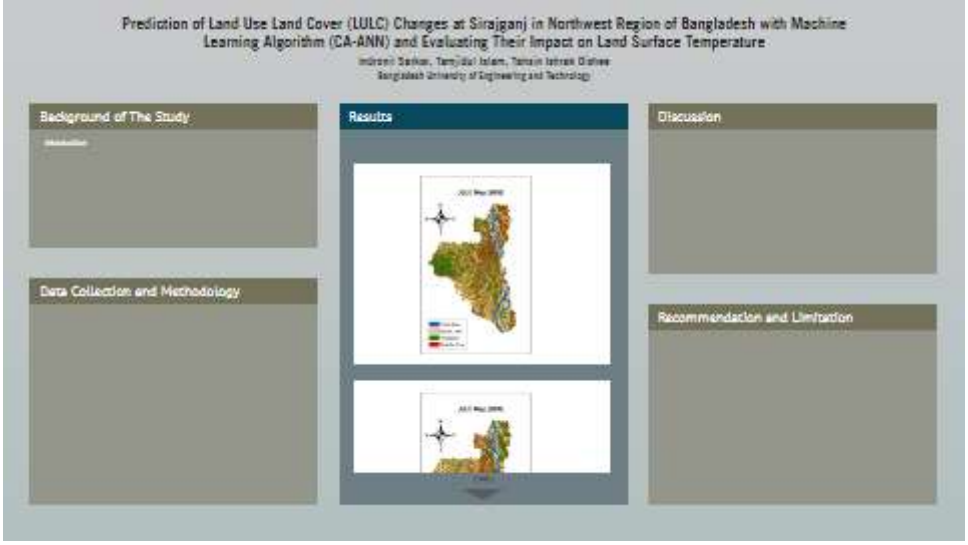
Prediction of Land Use Land Cover (LULC) Changes at Sirajganj in Northwest Region of Bangladesh with Machine Learning Algorithm (CA-ANN) and Evaluating Their Impact on Land Surface Temperature



Indronil Sarkar, Tamjidul Islam, Tahsin Ishrak Oishee

Bangladesh University of Engineering and Technology

PRESENTED AT:

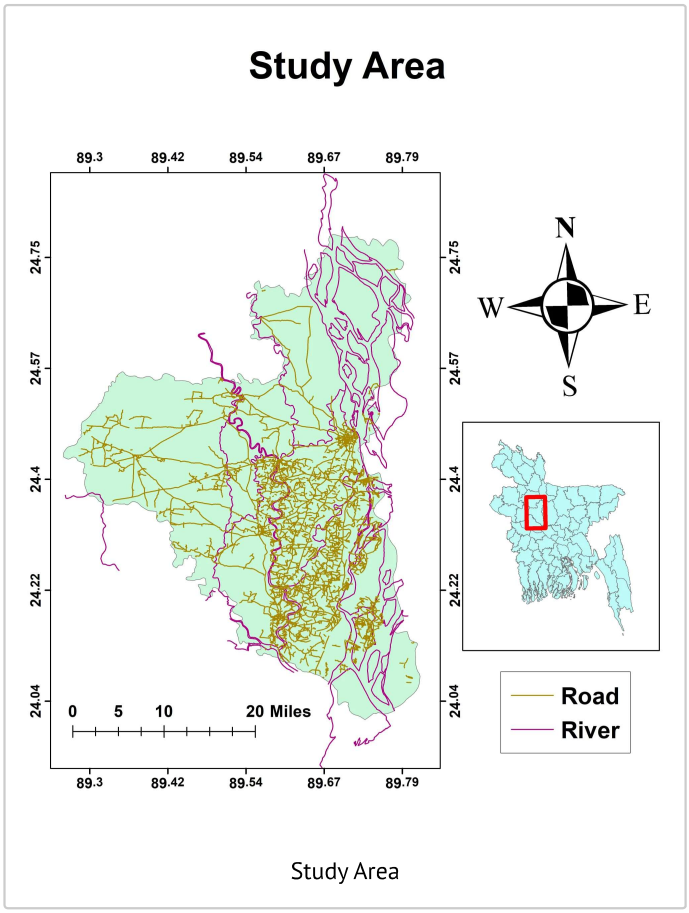
AGU23 WIDE. OPEN. SCIENCE.

BACKGROUND OF THE STUDY

Introduction:

- Rapid Urban Growth
- Increasing Trend of Land Surface Temperature
- Prediction of Land Use Land Cover
- Sirajganj: A Significant District at the Northwest region of Bangladesh
- Area: 2,498 Km^2

Study Area:



Study Area

Literature Review:

Changes in land use and land cover (LULC) are the primary human-caused environmental disturbance, leading to a range of microclimatic changes. For the sustainable management of natural resources, it is essential to comprehend these minute changes. Sustainable urban planning greatly depends on the quantitative and qualitative analysis of temporal variations in land use. These days, machine learning classifiers—which use a variety of classification algorithms—are being used more and more to improve the accuracy of image analysis. Cellular Automation (CA), Markov Chain Analysis (MCA), and Cellular Automata-Markov Models (CA-Markov) are popular models based on regression analysis.

Several models are often combined to maximize their benefits because CA models are not very accurate at simulating urban expansion. A lot of people use artificial neural networks (ANNs) to model intricate urban patterns and non-linear interactions between various components. Extensive reviews of the literature suggest that the combination of ANN and CA models yields superior LULC prediction performance. Four regression-based models are included in recently developed tools such as the MOLUSCE (Modulus of Land Use Change Evaluation) plugin for evaluating LULC changes and projections.

The Earth's systems' biological, physical, and chemical processes are all highly dependent on the land surface temperature (LST). Anthropogenic climate change is a serious concern because it will increase the frequency of heatwaves in the future. To comprehend the connection between LST and vegetation, a great deal of research

has been done on the NDVI (Normalized Difference Vegetation Index).

Long-term mitigation of climate change and environmental management depend on the monitoring of Land Use Land Cover (LULC) changing patterns and land surface temperature (LST) simulation. LST can offer vital information on the ecosystem and physical superficial properties in a variety of scenarios. Bangladesh, a nation that is rapidly urbanizing, ought to draw attention to how urbanization affects LULC. The landscape of Sirajganj, a city rising in socioeconomic standing, is changing quickly. In this area, there haven't been many studies to understand the relationship between LULC and LST, but none that stand out.

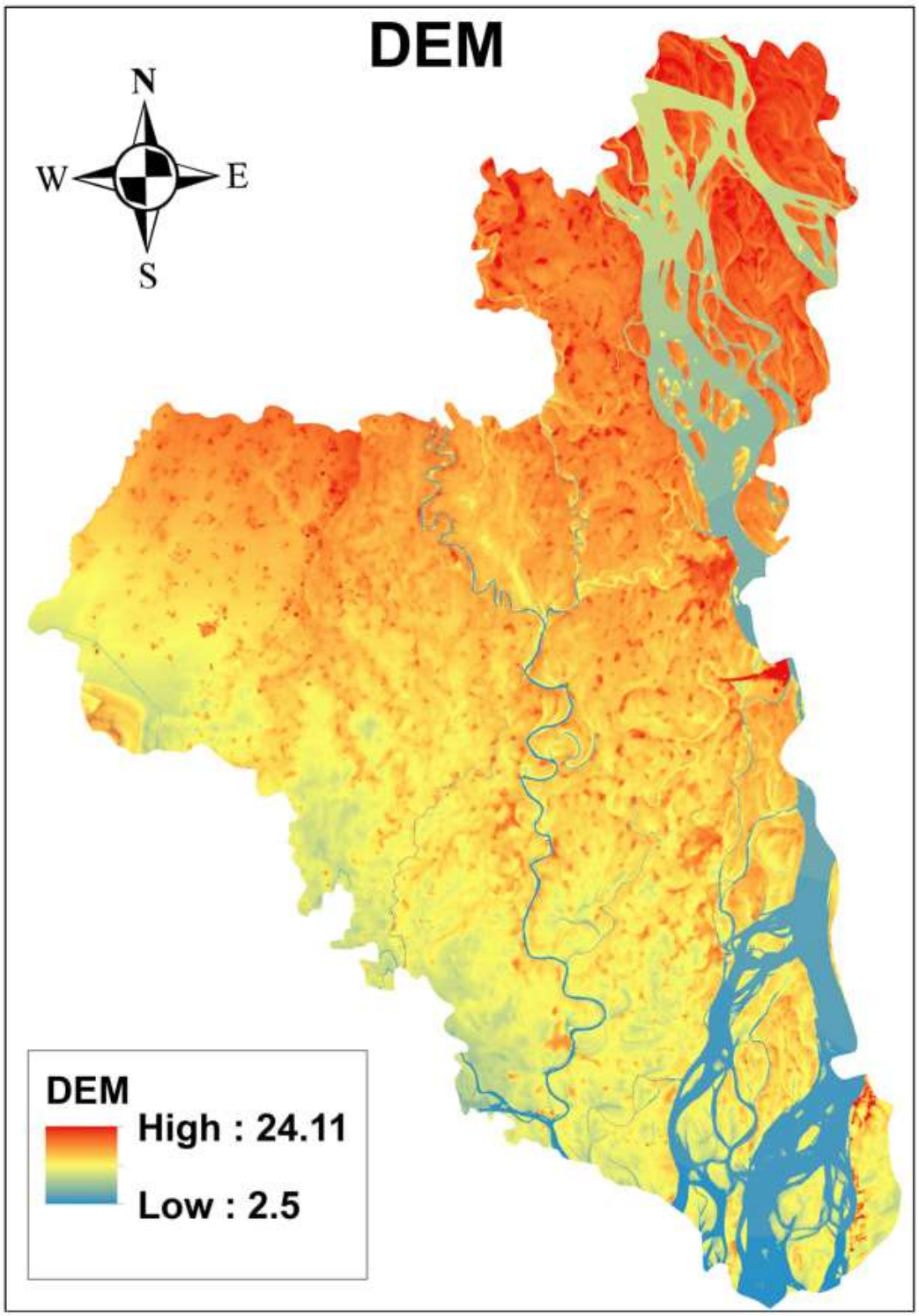
DATA COLLECTION AND METHODOLOGY

Required Data:

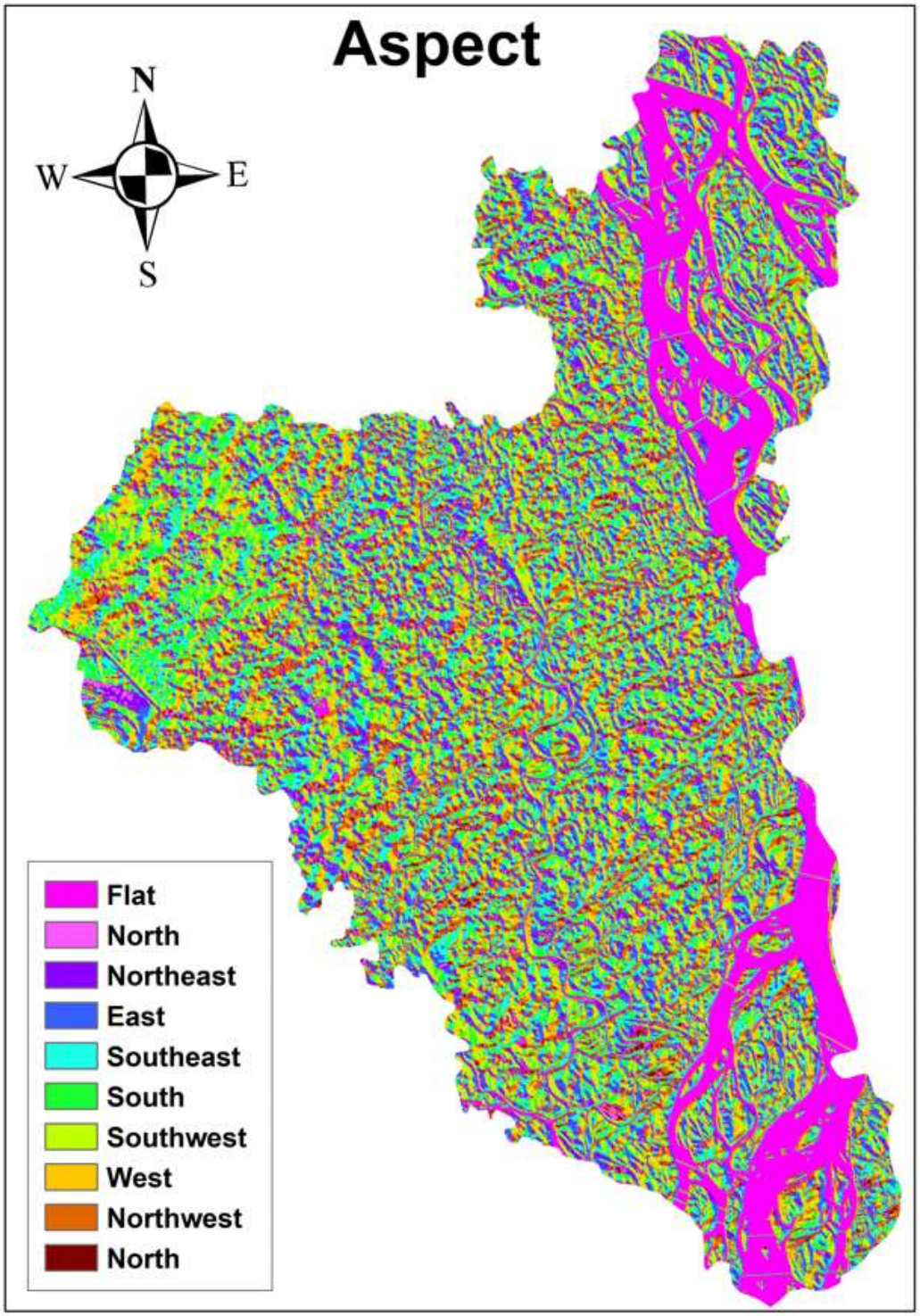
Data Type	Data Source	Data Resolution	Time Period
Landsat 5 and Landsat 8 satellite image	USGS	30m * 30m	2002, 2009, 2016, 2023
DEM	Copernicus 30	30m * 30m	2014
Road network	Google Earth	-	2020

Required Data

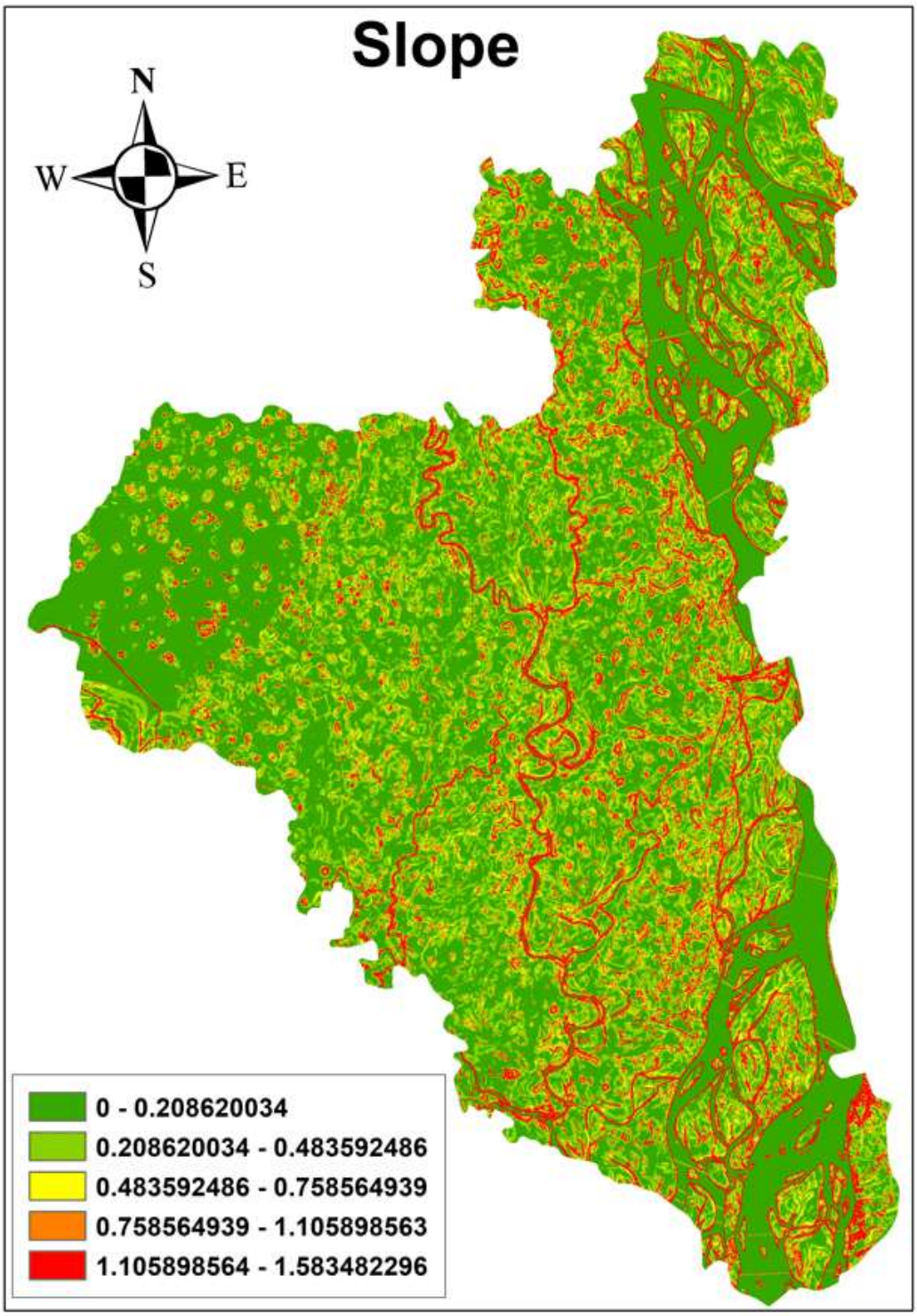
Data:



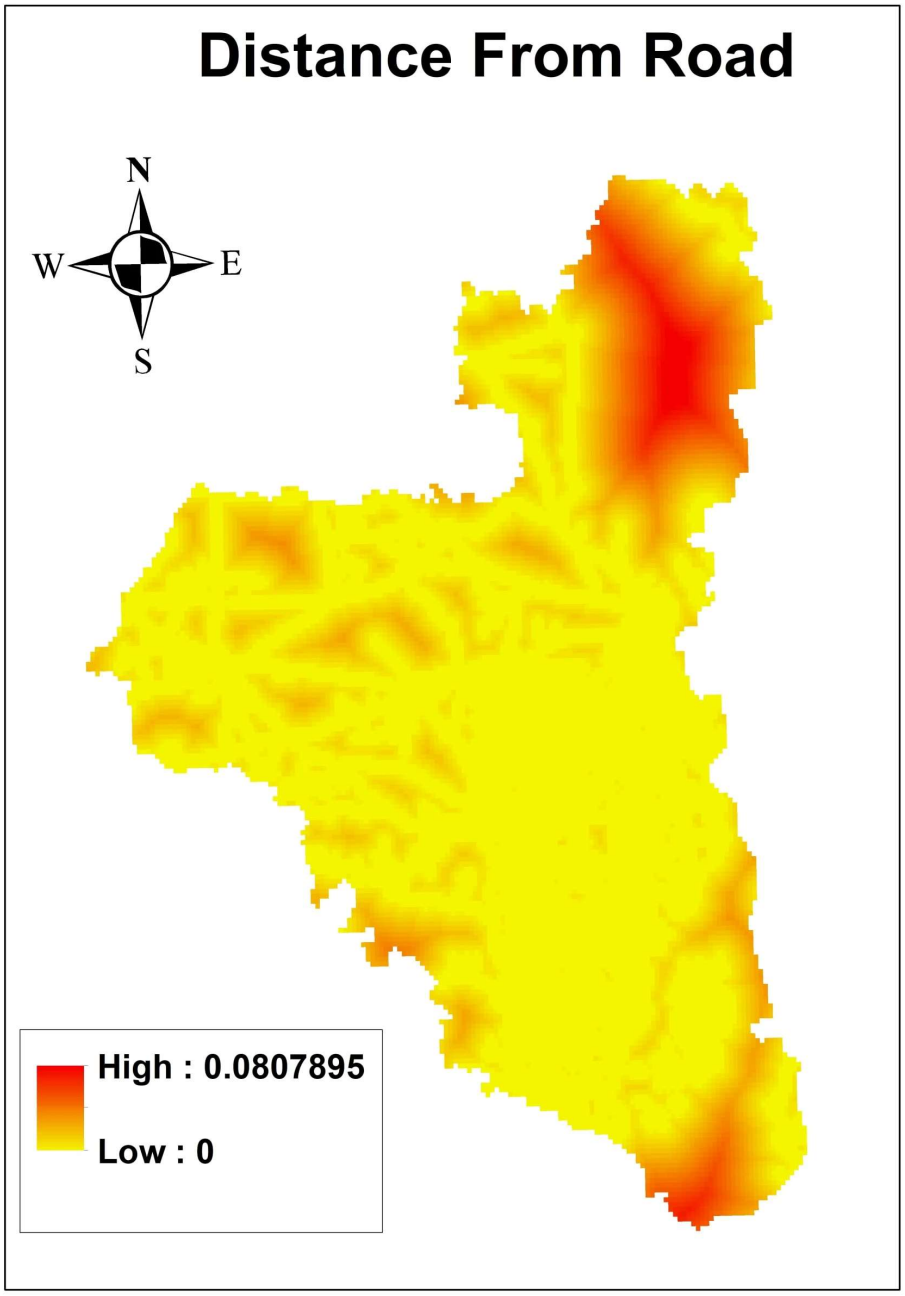
DEM


Aspect
N
W
E
S
Flat
North
Northeast
East
Southeast
South
Southwest
West
Northwest
North

Aspect

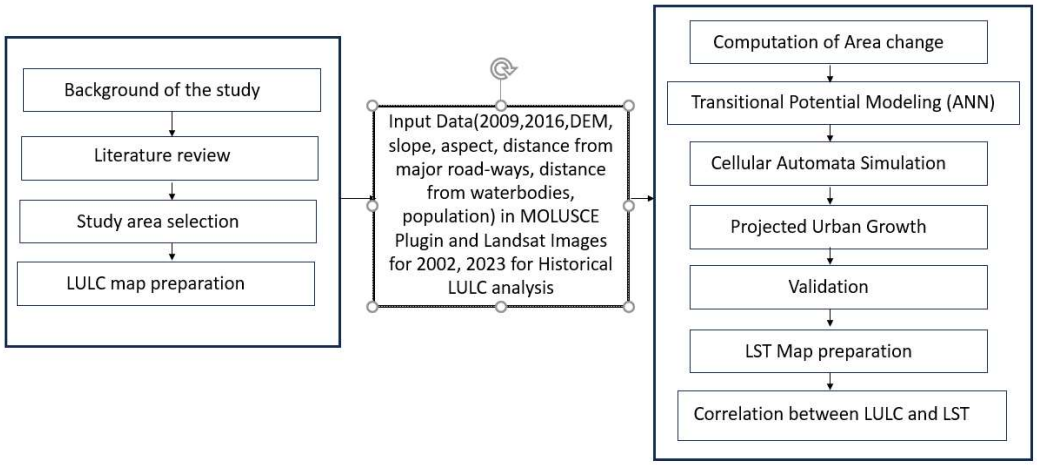

Slope
N
W
E
S
0 - 0.208620034
0.208620034 - 0.483592486
0.483592486 - 0.758564939
0.758564939 - 1.105898563
1.105898564 - 1.583482296

Slope



Distance From Road

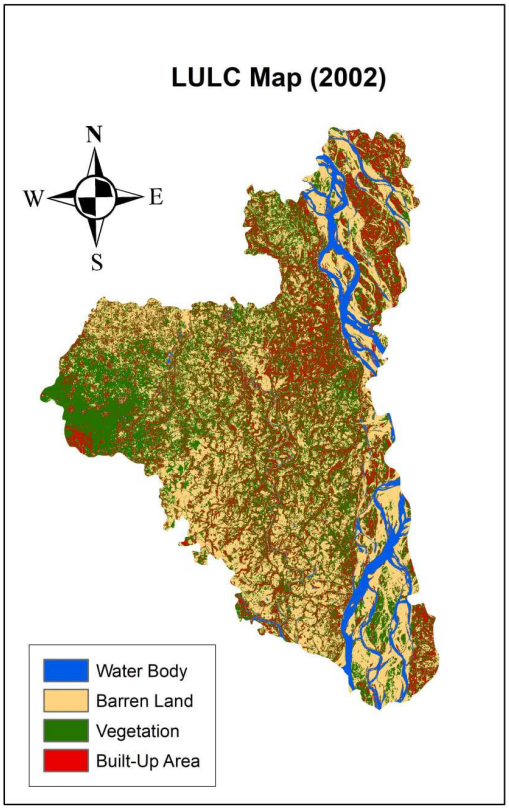
Flow-Chart of This Study:

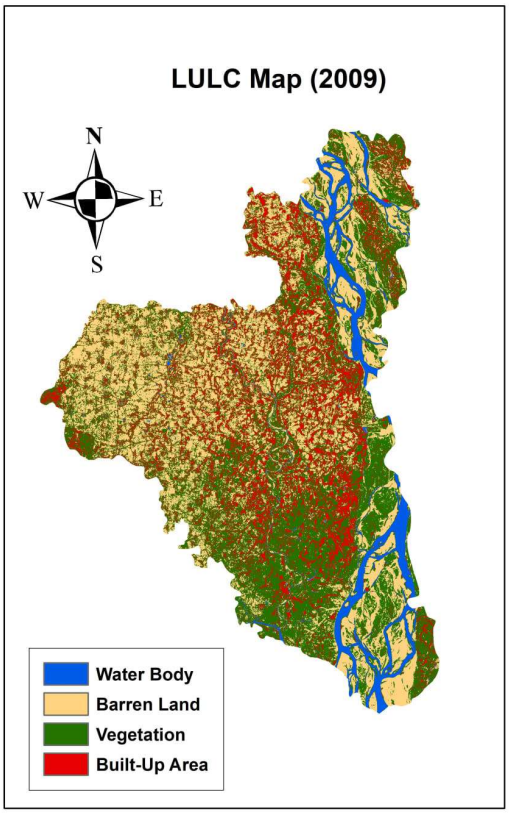

Background of the study
Literature review
Study area selection
LULC map preparation
Input Data(2009,2016,DEM, slope, aspect, distance from major road-ways, distance from waterbodies, population) in MOLUSCE Plugin and Landsat Images for 2002, 2023 for Historical LULC analysis
Computation of Area change
Transitional Potential Modeling (ANN)
Cellular Automata Simulation
Projected Urban Growth
Validation
LST Map preparation
Correlation between LULC and LST

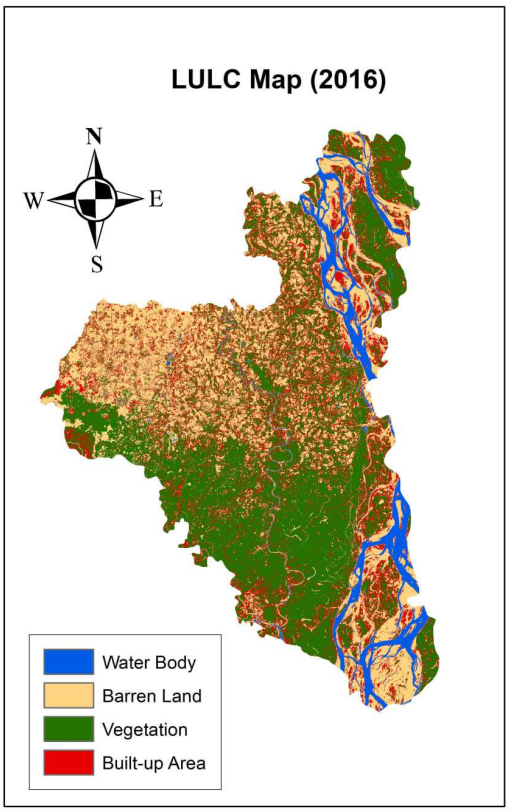
Flow Chart

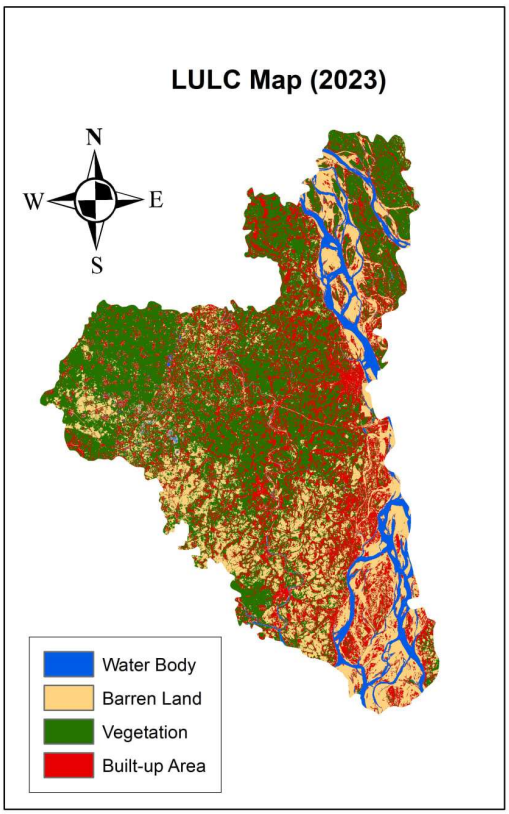
RESULTS

Historical LULC Classification:

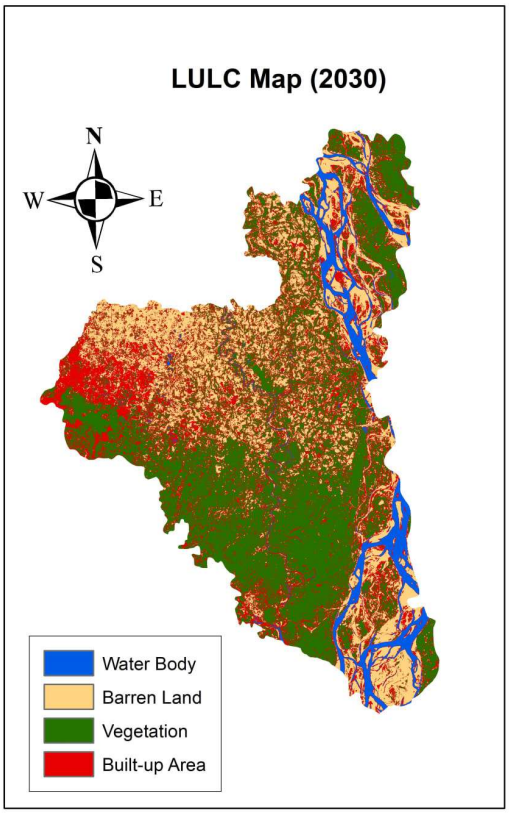


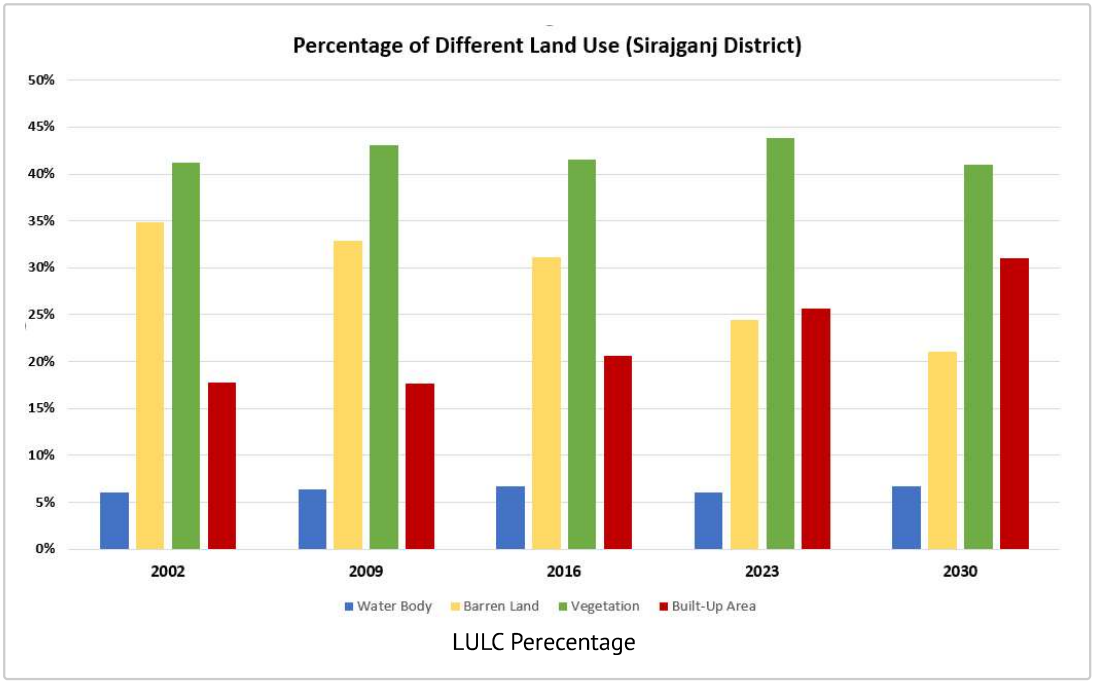

LULC Map (2009)
N
W
E
S
Water Body
Barren Land
Vegetation
Built-Up Area


LULC Map (2016)
N
W
E
S
Water Body
Barren Land
Vegetation
Built-up Area

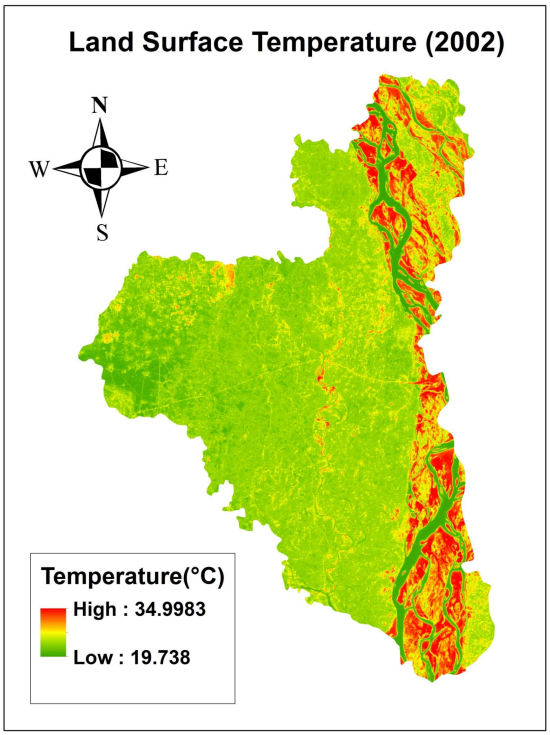


Prediction of LULC for 2030:

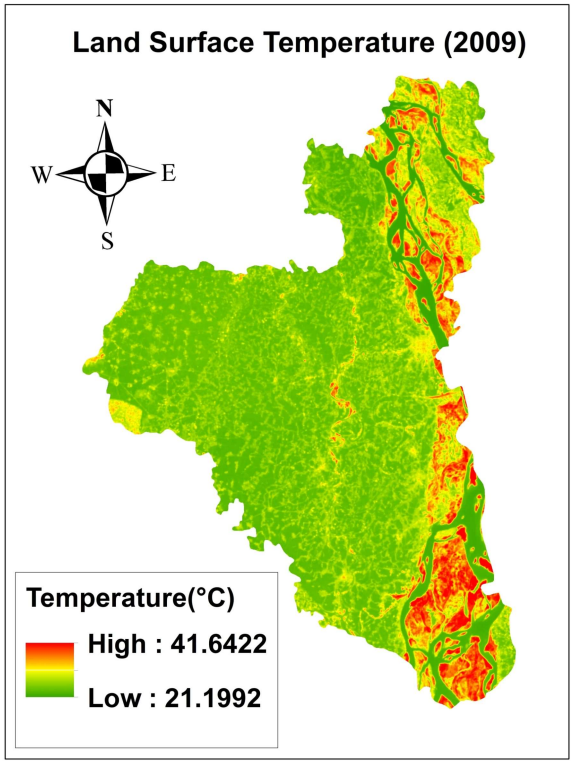




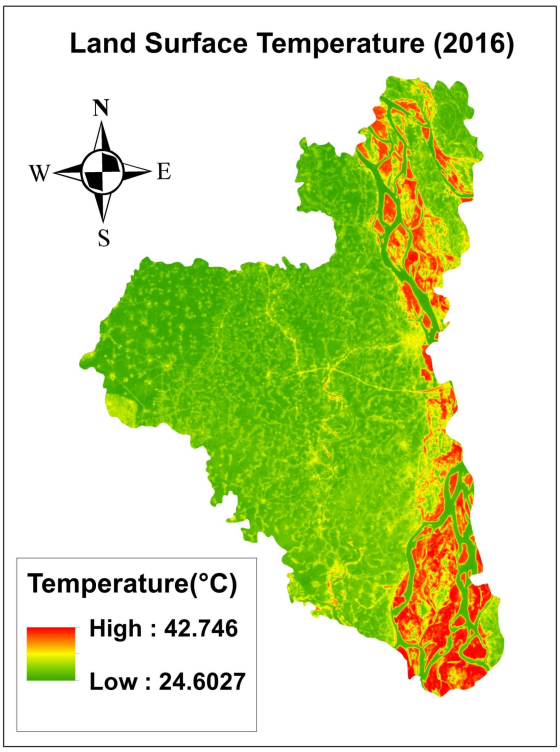
LULC Perecentage



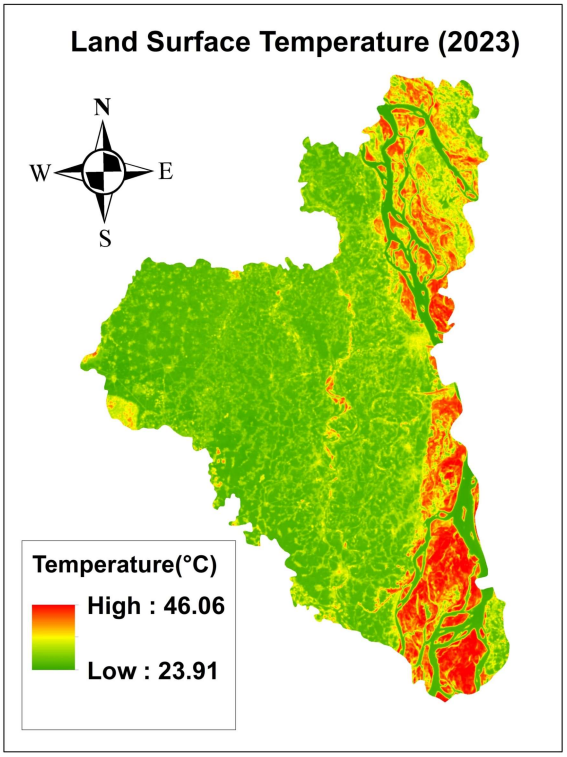
Land Surface Temperature (2002)



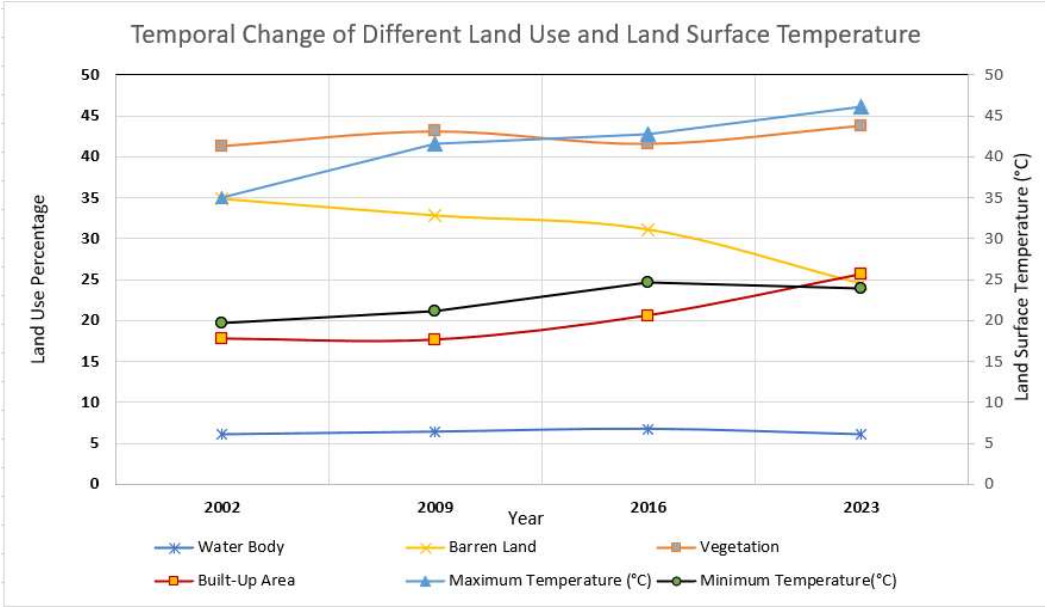
Land Surface Temperature (2009)



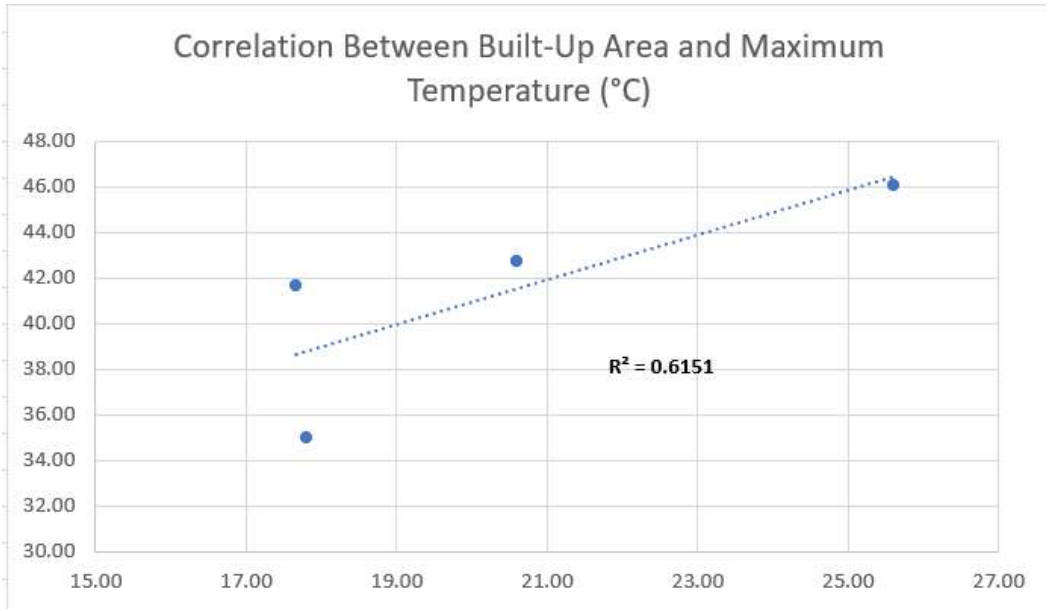
Land Surface Temperature (2016)



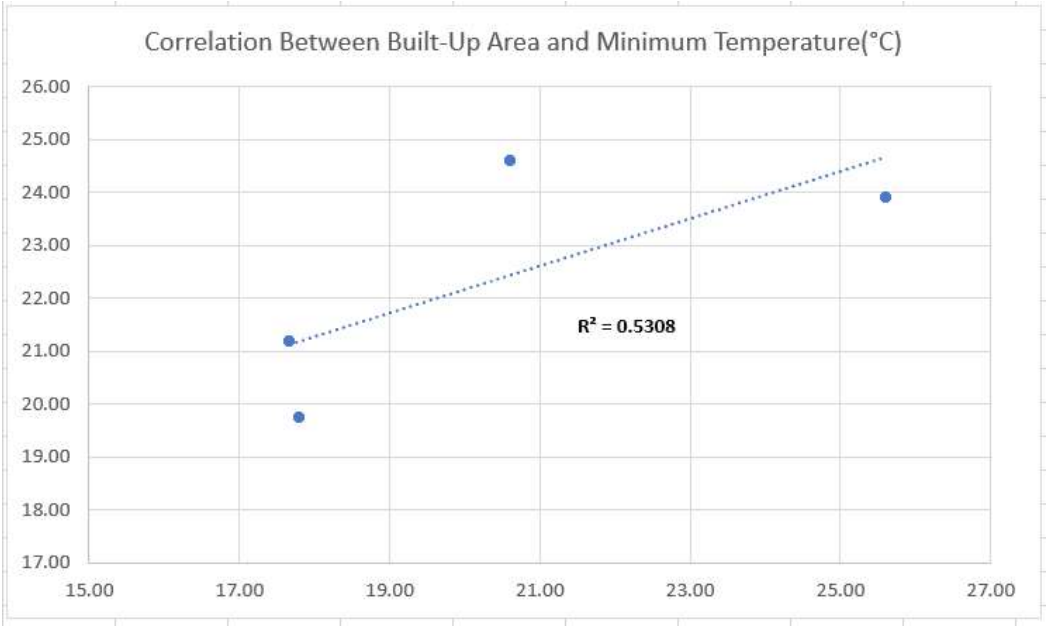
Land Surface Temperature (2023)



Temporal Change of Different Land Use and Land Surface Temperature



Correlation Between Built-Up Area and Maximum Temperature (°C)



Correlation Between Built-Up Area and Minimum Temperature(°C)

DISCUSSION

Discussion on LULC Results:

Historical LULC Analysis:

- From Historical LULC Analysis Water Body Remains the Same
- Barren Land Showed Decreasing Trend
- Built-Up Area Percentage has been increased
- Vegetation Area showed undefined pattern throughout the Histroical Period.

Predicted LULC Analysis:

- Water Body Remained Constant in 2030
- Built-Up Area Percentage has been increased rapidly from 26% to 31% between 2023 and 2030
- Barren Land followed the decreasing Pattern like Historical Period.

Discussion on LST Results:

- Maximum Land Surface Temperature showed an increasing trend from 2002 to 2023.
- Minimum Land Surface Temperature also showed an inctreasing trend but it gets reduced in 2023.

Discussion on the Correlation between LULC (Built-Up Area) and LST Results:

- Maximum Surface Temperature and Built-up Area shares strong positive colinearity among Each other, Which shows that with rapid increase of Urbanisation Maximum Temperature increases.

RECOMMENDATION AND LIMITATION

Recommendation:

- For Land Surface Temperature analysis, We have only considered the Summer Season Period. Winter season can also be considered for further studies.

- High Resolution DEM can be used for Better LULC prediction.

Limitation:

- Higher Resolution DEM was not Incorporated in Our Study.

AUTHOR INFO

Indronil Sarkar:

Indronil Sarkar Indronil Sarkar is a graduate student from the Bangladesh University of Engineering Technology. He is currently working as a research assistant at the Institute of Water and Flood Management. His work involves the use of software like SWAT, HEC-RAS, and GIS. He is keen to do work on hydrology, drought, water quality, river morphology, land use, and land cover change. He is also interested in exploring the application of machine learning to predict different hydraulic and hydrodynamic parameters under different conditions. He is a Hydrologic and Hydrodynamic Model User and Researcher. He is currently doing the prediction of drought indicators using an ANN model.

Indronil Sarkar (He/Him)

Research Assistant

Institute of Water and Flood Management (IWFM),

Bangladesh University of Engineering and Technology(BUET),

Dhaka-1000, Bangladesh.

E-mail: indronil.sarkar16@gmail.com , indrorahul7777@gmail.com

LinkedIn : www.linkedin.com/in/indronil-sarkar-686aa81b4 (https://LinkedIn : www.linkedin.com/in/indronil-sarkar-686aa81b4)

Tamjidul Islam:

Hello, I am Tamjidul Islam Illin, a final-year undergraduate student studying Water Resources Engineering. I am interested in solving real-world problems and understanding the impact of climate change on our environment. I am really excited to present our work at this amazing AGU platform.

Tahsin Ishrak Oishee:

Tahsin Ishrak Oishee
BSc, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology,
Email: Oishee163@gmail.com
Phone: 01869977568

TRANSCRIPT

ABSTRACT

Sirajganj, a major district in north-western Bangladesh, is the gateway to North Bengal and is undergoing rapid urbanization and infrastructure development. The district's proximity to the Jamuna River leads to dynamic channel bars on the eastern side due to uncertain river flow. For all these factors, land use and land cover change analysis and prediction become very important. In this study, historical land use and land cover changes have been estimated for 2002, 2009, 2016, and 2023. This study also includes the prediction of LULC classification for 2030. Moreover, the impact of LULC changes on land surface temperature has also been introduced in this study. For historical LULC change analysis, Landsat 5, 7, and 8 satellite images were collected, and the Support Vector Machine Algorithm was applied to classify the study area into 4 categories, such as water bodies, barren land, vegetation, and built-up areas. For LULC prediction, cellular automata (CA) and artificial neural network (ANN) algorithms are used, and the predicted land use map was generated for 2030. Satellite images, DEM (Digital Elevation Model), and a national road network map have been collected and used as input parameters for the CA-ANN model. For the estimation of LST, Landsat images are collected, and relevant equations are applied. According to the results of LULC change, Built-up areas have increased by approximately 7.82% between 2002 and 2023. On the other hand, Barren lands have decreased by 10.39%. Water bodies have held an approximately constant area percentage of 6% throughout these years. The area percentage of vegetation cover has increased by 2.52%, with some fluctuations from 2002 to 2023. From the results of LULC predictions, built-up areas are showing an increasing trend and barren lands are showing a decreasing trend in 2030. More than 80% in terms of kappa, a significant degree of estimating was found in the accuracy rating of all the maps. The impact of LULC can be easily observed on LST; a rapid spatiotemporal change in LST occurred due to LULC change. For example, a dynamic shift from high-temperature zones to medium-temperature zones occurred due to the replacement of barren land with built-up areas. This study will help the local authority take the necessary steps to protect natural resources from the impact of climate change.

REFERENCES

Full article: Prediction of land use changes at a metropolitan city using integrated cellular automata: Past and future. (n.d.). Retrieved January 22, 2024, from https://www.tandfonline.com/doi/full/10.1080/24749508.2022.2132010

Rahman, F., & Rahman, Md. T. U. (2023). Use of cellular automata-based artificial neural networks for detection and prediction of land use changes in North-Western Dhaka City. Environmental Science and Pollution Research, 30(1), 1428–1450. https://doi.org/10.1007/s11356-022-22079-9

Redowan, M., Phinn, S. R., Roelfsema, C. M., & Aziz, A. A. (2022). Modeling forest cover dynamics in Bangladesh using multilayer perceptron neural network with Markov chain. Journal of Applied Remote Sensing, 16(3), 034502. https://doi.org/10.1117/1.JRS.16.034502

Singh, B., Venkatramanan, V., & Deshmukh, B. (2022). Monitoring of land use land cover dynamics and prediction of urban growth using Land Change Modeler in Delhi and its environs, India. Environmental Science and Pollution Research, 29(47), 71534–71554. https://doi.org/10.1007/s11356-022-20900-z

Sustainability | Free Full-Text | Prediction of Land Use and Land Cover Changes for North Sumatra, Indonesia, Using an Artificial-Neural-Network-Based Cellular Automaton. (n.d.). Retrieved January 22, 2024, from https://www.mdpi.com/2071-1050/11/11/3024

Zhang, P., Gong, M., Su, L., Liu, J., & Li, Z. (2016). Change detection based on deep feature representation and mapping transformation for multi-spatial-resolution remote sensing images. ISPRS Journal of Photogrammetry and Remote Sensing, 116, 24–41. https://doi.org/10.1016/j.isprsjprs.2016.02.013

Driving Factors for Sustainable Development in Gazipur Bangladesh. (n.d.). Retrieved January 22, 2024, from https://www.mdpi.com/2073-4433/12/10/1353

Imran, H. M., Hossain, A., Islam, A. K. M. S., Rahman, A., Bhuiyan, M. A. E., Paul, S., & Alam, A. (2021). Impact of Land Cover Changes on Land Surface Temperature and Human Thermal Comfort in Dhaka City of Bangladesh. Earth Systems and Environment, 5(3), 667–693. https://doi.org/10.1007/s41748-021-00243-4

Kamaraj, M., & Rangarajan, S. (2022). Predicting the future land use and land cover changes for Bhavani basin, Tamil Nadu, India, using QGIS MOLUSCE plugin. Environmental Science and Pollution Research, 29(57), 86337–86348. https://doi.org/10.1007/s11356-021-17904-6