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Characteristics Of Urban Heat Island Of Shillong City Agglomeration

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The most intricate type of microclimates are found in urban areas , that is why geographers and meteorologists have focused so much attention on them. The purpose of the study is to measure changes in microclimate that occur over time and apace as a result of high traffic pedestrian activity. Shillong urban agglomeration experience a high traffic congestion which is generated heat . Therefore , it's possible that certain urban microclimate studies understand the impact of urbanization .Furthermore aggravating the effects of naturally occurring that waves periods of very hot and frequent humid weather are heat islands. The UHI effect and relate issues are caused by a rise in the landsat temperature increase air pollution , fewer local nights and greater daytime temperature are caused by urban heat islands. The UHI effect is a serious issues and contributing factor to climate change as a urbanization spread throughout the nation on a daily basis. Consequently its critical to locate the cities comfort zones and other spatial hot spots. An increase the temperature the UHI effect and relate issues are caused by a rise in the landsat temperature increase air pollution, local nights and greater daytime temperature are caused by urban heat islands. Microclimate variations both winter and summer season temperature data is collected from several ground station .The summer and winter average daily temperature measurements of points is chosen for additional evaluation . In order to better access the microclimate difference between condition of pedestrian activities verses heavy traffic congestion.The majority of research found that variation in land use changes result in UHI values among cities .It is shown that increasing tendency most resulted from expansion into populated regions decline and green space .Additionally several research revealed that in many locations across the world uhi intensity is highest winter in nights lower on summer afternoon . The majority of research that found that variation in urban issues between cities .

Keywords : Urbanization, land surface temperature ,urban heat islands effects hot spots.

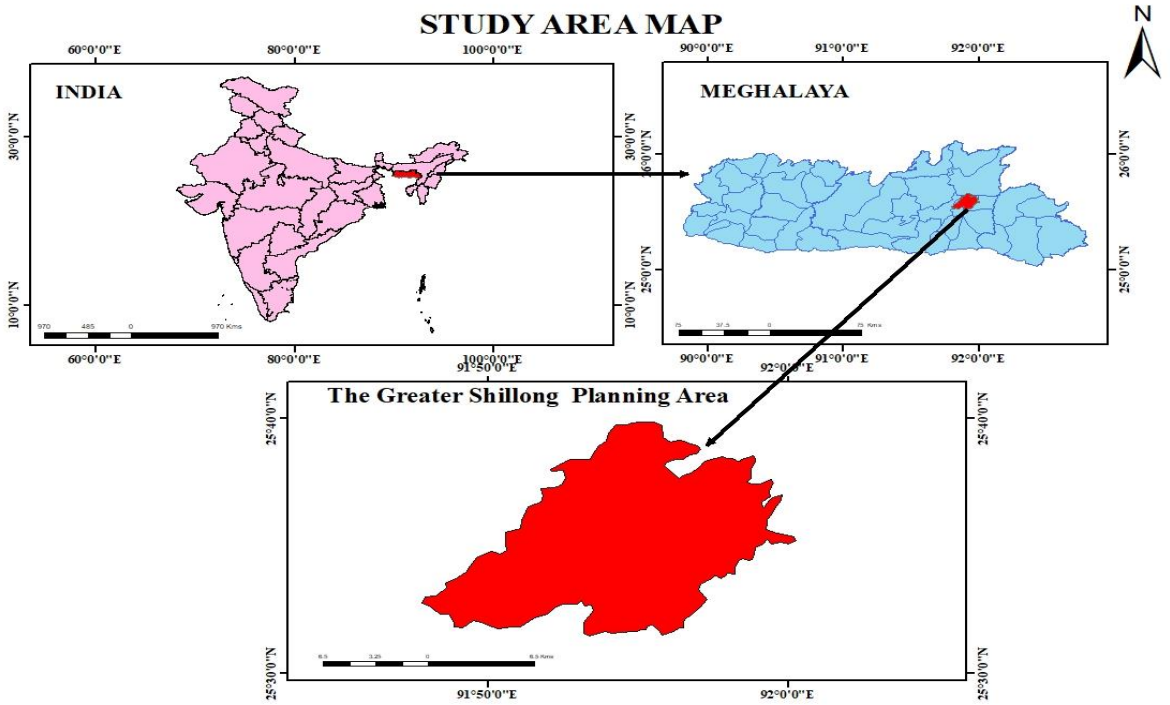
Introduction :

Urban microclimates are the most complex forms of microclimates one of the most studied and researched topics by geographers and meteorologists. One of the most significant aspects of urban microclimates is elevated air temperature within urban areas as compered within surrounding rural areas , which is known as the urban heat islands effects. A typical urban environment has limited vegetation is set amongst high rise buildings and transport infrastructure. Urban environments are characterized by growing energy consumption and escalating anthropogenic heat from air conditioners and vehicles as well as increasing disposal of industrial wastes and emission of toxic contaminants .Urban areas are *usually covered by street design is known to have an impact on the urban* microclimates. It is widely known that anthropogenic heat caused by human activities and people themselves are caused by

human activities and people themselves are major contributor to microclimate variation. Urban areas are usually covered by streets and street design is known to have an impact urban microclimate. This paper aimed to quantify temporal and spatial micro climate variations caused by heavy traffic and pedestrian activities were varied under the same street geometry . To examine the temperature variations at street level , a field monitoring study was conducted five representative locations characteristically different settings .

Study Area :

Shillong is located at 25 °46'N latitude and 91°48' E longitude , with the highest elevation of 6433 feet (1961 meters) above the mean sea level.Shillong urban agglomeration includes municipality, cantonment , and all areas under Mawlai C& RD Block including Census town , Mawpat C & RD Block from umshyrpri Bridge upto 7th Mile, Upper Shillong including , Mandanrting , Mawblei , Laitkor, Nongkseh, Umlyngka, Lawsohtun, Mawdiangdiang, Diengiong , Siejiong, (Govt of Meghalaya , Shillong Master plan 2035).



Objective :

1. To investigate the land surface temperature of the study area.
2. To analyze the temporal and spatial characteristics of urban heat island of the study area.
3. To analyze the cause and consequences of urban heat island of the study area .

Data source and Methodology :

Data	Dataset	Data sources
Satellite Imageries	Landsat 5,8 MODIS	USGS Bhuvan Geo portal
Temperature Data	Microclimate variations in both season (summer and winter) temperature data will be collected from several ground station	Various ground station
	Temperature data from individual roof top through appropriate sample survey so as understand the range of temperature at various locations	Infrared thermometer

For the present work the following methods are :

Research Methodology for objective 1 : The change in land surface temperature will be investigated from the download imageries from USGS website and there after following calculation will be used :

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

Where , LST = Land Surface temperature (Celcius)

W= Wavelength of emitted radiation

BT= Top of atmosphere brightness temperature (C).

E= Land surface emissivity (LSE) .

Research Methodology for objective 2 : To analyze the temporal and spatial characteristics of urban heat of the study area .

A. **Primary Data :** Derived map objective 1 (LST) Land use and land cover map of the study area.

. MODIS land cover type product (MCD12Q1) will be used to demarcate the urban area of Shillong urban agglomeration , with a suitable rural area buffer .

. The pre processing of MOD11A2 will be done to bring the entire data into the same format and the same resolution .

UHI index= _____LSTi - LSTmin_____

LST max- LST min

B. Secondary Data : Scientific research journal , government report etc.

Research Methdology for objective 3 :

A. Primary Data :

Temperature data collected from infrared thermometer, Survey and Interview .Infrared thermometer will be used in the field combined with temperatures from ground stations to measure temperature of the study area using appropriate sample survey method so as to understand the levels of temperature emissionvity.

Interviews will be conducted from various stakeholders , govornments ngo

Secondary Data : Scientific research journal , govornments etc.

Results and Discussion :

Analysis the land use dynamically by ALUCR model :

Major changed in LULC area caused as a result of the comprehensive human settlement and social forestry over the hill slope .

Landsat 5 LANDSAT 8

January 1991 Landsat map

Land use map Land use change map Settlement (SVM)

Settlement Settlement expansion map NDVI Map

NDVI Map NDVI Change Map Land surface temperature map

Land surface Temperature map Change land surface temperature map

Impact build up area expansion on land surface temperature map distribution

Accuracy Assesment :

The LULC classification for urban growth is sensitive to accuracy assessments. A method was defined to assess the accuracy of the LULC classification ,utilizing 200 stratified random samples for each LULC map . The result show overall accuracy was 85 % for 1993 ,86 % for 2003, 90 % for 2013 , 89 % for 2023.

To ensure compatability between the classification and reference data, kappa coefficients should greater than 0.75 . The USGS recommends the use of Landsat satellite images for LULC mapping if the accuracy level was 85 % for 1993 , 86 % for 2003 , 90 % for 2013.

Transition of LULC Characteristics over the years :

To understand the changing patterns of LULC classes , we analyzed the net changes in various LULC classes that transitioned into settlement areas from 1993 to 2023 . The settlement area is the most stable land use class, suggesting that likelihood that settlement areas being transformed into different land use classes is minimal . Additionally forested areas are maintaining some level of stability , likely due to recent plantation initiatives undertaken by the government.

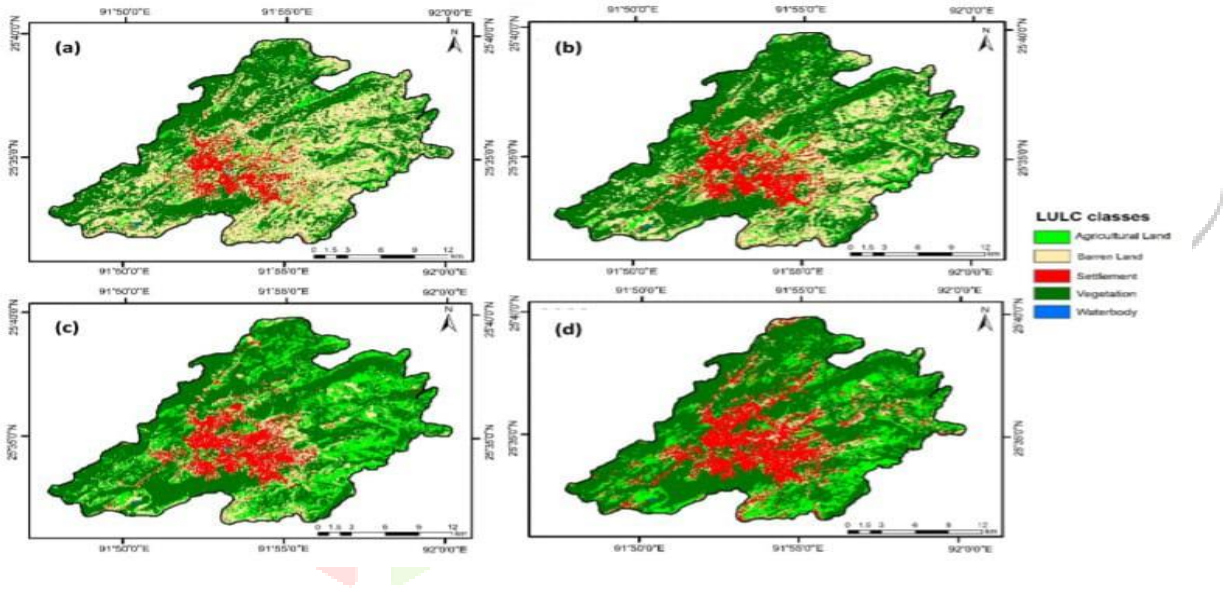


Figure 1 : Land use and land cover transition across different years

a. 1993 , b. 2003 , c, 2013 d. 2023

Table 1. The area of different LULC classes (in square kilometers , Km2) was measured after classifying satellite images across different years .

LULC Class	1993		2003		2013		2023	
	Area km 2	Area (%)	Area km	Area (%)	Area (km2)	Area (%)	Area (km2)	Area (%)
Agricultural land	12.37	7.24	14.13	8.27	24.36	14.26	32.08	18.79
Barren land	69.87	40.87	49.63	29.03	34.49	21.36	11.65	6.82
Settlement	10.94	6.40	15.34	8.97	17.92	10.49	29.63	17.36
Vegetation	77.67	45.43	91.69	53.64	91.78	53.73	97.22	56.95
waterbody	0.10	0.06	0.15	0.09	0.27	0.16	0.13	0.08

Changes in LST between 1993 and 2023 :

The LST temperature values have been divided into five catagories. These catagories were used to estimated the area covered by each temperature range.The results indicate a notable increase in surface temperatures between 1993 and 2023.

℃Figure : The changes in land surface temperature during different years

a. 1993 , b. 2003, c. 2013 d. 2023

Table 4 . Land surface temperature (LST) was determined by classifying satellite images across different years .

Years	Minimum (℃)	Maximum (℃)	Mean (℃)
1993	5.46	26.28	13.85
2003	9.03	33.52	18.04
2013	11.09	31.62	19.03
2023	11.76	29.68	19.24

During the study period , a noticeable shift from lower temperature to higher temperature was observed . In 1993, temperature below 12℃ accounted for 27.95 % of the total area.

Variation in Land surface temperature across different LULC classes over the years :

Urbanization is one of the most dynamic forces driving changes in LULC characteristics and has a significant impact on the environment. Build up
(settlement) areas have the highest average temperatures along with barren land, agricultural land etc.

A significant rise in LST is associated with the development of the buildings and urban infrastructure. Conversely the smallest rise in LST is observed in areas with vegetative cover. The difference is primarily attributed to the high evapotranspiration from vegetation , which is cooling effect .

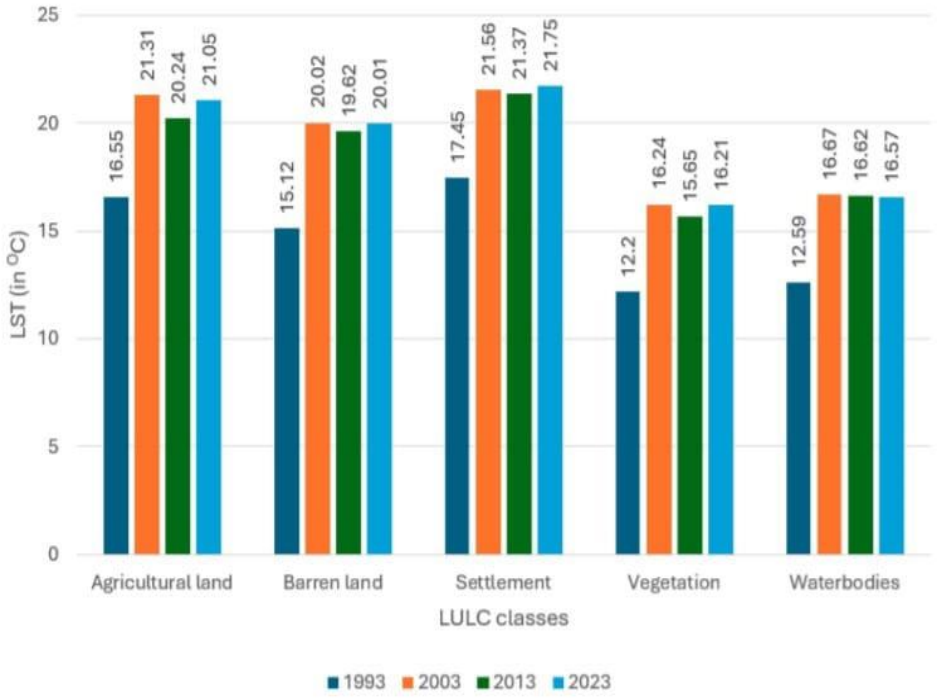


Figure 2 . The bar chart shows the relationship between LULC and LST using different years .

A significant rise in LST is associated with the development of the buildings and urban infrastructure. Conversely the smallest rise in LST is observed in areas with vegetative cover. This difference is primarily attributed to the high evapotranspiration from vegetation , which has a cooling effect. Existing research has demonstrated that green cover trends to lower temperature by absorbing reflecting solar radiation regulating latent sensible heat exchange.

Modelling and prediction of future land use :

This stimulation based on a historical LULC data and transition matrices specific to the study area. To validate the stimulation model , classified LULC maps of the study area for the years 2013 and 2023 were used a generate a probability matrix , transition area matrix , and series a conditional probability images. These datasets facilated the generation of predicted land use scenarios for 2030 and 2050 .

Comparison of predicted and classified areas of various LULC classes for the year 2023 .

LULC Class	Area Classified (km2)	Area predicted (km 2)	Accuracy %
Agricultural land	32.08	36.18	87.22
Barren l.and	11.65	23.95	5.58
Settlement	29.63	21.95	74.08
Vegetation	97.22	88.16	90.68
waterbody	0.13	0.25	7.69

To validate the accuracy of the prediction , the CA markhov model was used to estimate the areas of different LULC classes for 2023. The prediction of vegetation was also highly accurate , with an accuracy of 90,68 % indicating that the model effectively captured the changes. Settlement areas with predicted an accuracy of 74.08% through the model understand the total area by 7.68 km2 . In contrast , the model performance for barren's land and waterbodies was largely inaccurate with

accuracies of 5.58 % and 7.69 % respectively , highlighting the challenges in accurately predicting small and dynamic land uses.

LULC class	Area Classified (km 2)	Area predicted (km 2)	Accuracy
Agricultural land	32.08	36.18	87.22
Barren land	11.65	23.95	5.58
settlement	29.63	21.95	74.08
Vegetation	97.22	88.16	90.68
waterbody	0.13	0.25	7.68

Since the transition sub-model focuses on settlements, we prioritized the accuracy of settlement predictions . The years 2003 and 2013 were used to predict changes in 2023. The results showed that the rate of change in settlements from 2003 to 2013 gradually increased , whereas from 2013 to 2023, where was an accelerate increase in settlements. Other parameters such as roads , elevation, and trend of transition from all classes converted into settlements were added to the transition model to confirm its reliability. The model was then used to predict LULC for 2030 and 2050.

Predicted LULC for 2030 and 2050 :

The predicted LULC maps indicate the urban areas will experience significant growth , with the total area increasing to 21.39 % in 2030 and further to 28.56 % in 2050 . This increase is likely if the current development trend continues without intervention, According to the LULC scenario, settlements will expand by 4.03 % by 2030 and 11.2 % by 2050 , accompanied by a decrease in vegetation , agricultural land , and barren land , These results highlight the potential impacts on ecosystem services , urban health , and thermal characteristics of deforestation and increase urbanization. If uncontrolled urban growth predicts , it will likely lead to considerable environmental, economic and health issues .

LULC Class	Area (km 2)	Area (%)	Area (km2)	Area (%)
Agricultural land	31.57	18.48	27.01	15.81
Barren land	8.21	4.81	6.59	3.86
Settlement	36.54	21.39	48.79	28.56
Vegetation	94.42	55.26	88.38	51.72
waterbody	0.12	0.07		0.06

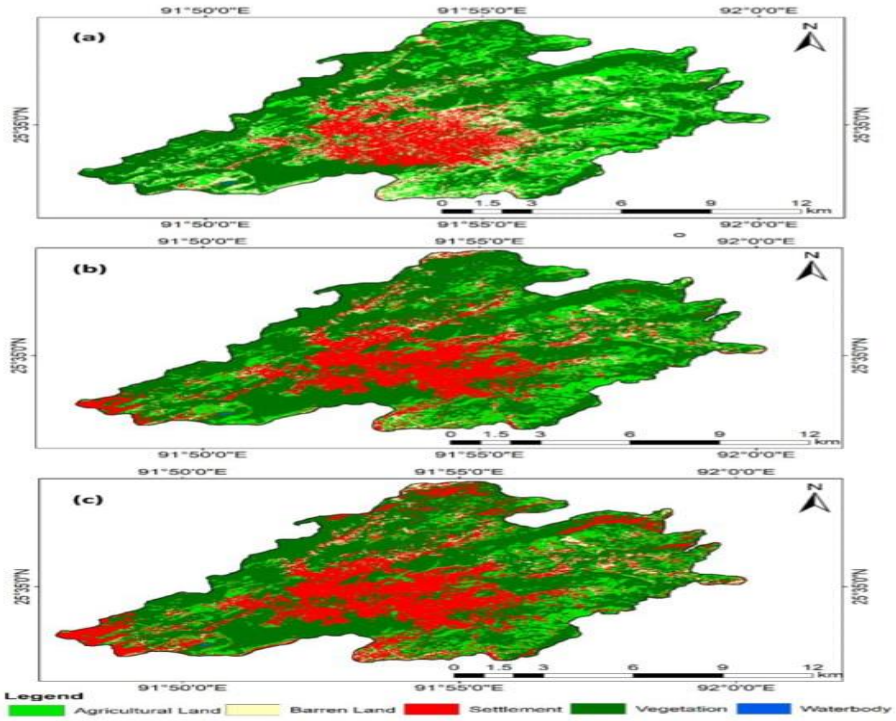


Figure 3. Predicted map of LULC for a. 2023 , b. 2030 , and c. 2050 .

Discussion :

Shillong has experienced rapid population growth due to its administrative and educational facilities .Despite this discussion other LULC catagories have remind relatively stable over the 30 years .The forest area , in particular has not undergone significant changes during the study period. Shillong is a tribal town , and stricts regulations prohibit indescriminant tree cutting , which has helped maintained a relatively constant forest area.
The rapid growth of build up areas negatively affect the natural cooling process influenced by factors such as decreased vegetation shading transpiration.

Shillong , a prominent hill station in the eastern Himalayas has experienced rapid population growth in recent years.This study offers valuable insights into the environmental consequences of urbanization in Shillong providing a foundation for future urban planning and climate adaption strategies in the region and others areas with similar geographical characteristics .

Conclusions :

This study examines how LULC change in Shillong city , India. The results showed that regions with natural cover, such as water bodies and vegetation had the lowest surface temperatures with mean values of 16.57℃ and 16.21℃ respectively , The integrated satellite data and Gis technology is crucial for obtaining spatial information and LULC characteristics necessary for effective land resource planning and management . This study demonstrate in analyzing landuse and land cover changes and predicting future scenerios.

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