

**Welcome**  
To the presentation on

**Simulating Land Cover Changes  
and their Impacts on Land Surface  
Temperature in Dhaka City,  
Bangladesh**

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# Background of the Research

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1. **Urban Heat Island (UHI)** is considered as one of the main causes of **urban micro-climate warming** [1].
  2. An environmental phenomenon where air and **Land Surface Temperatures (LST)** of **urban areas are higher than those of its surrounding areas** [2].
  3. UHI is associated with a number of local problems such as **biophysical hazards** (e.g. heat stress), **air pollution** and associated **public health problems** [3].
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## Background of the Research

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4. This research focuses on the **LST, an important contributor to the UHI effect.**
5. This is due to the fact that **UHI is related to the spatial distribution of LST** [4].
6. Multiple factors contribute to the generation of UHI (e.g. changes in land use such as **Urbanization**, loss of vegetation and water body etc.) [5].

# Objectives of the Research

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Based on the above discussion, this research has **two objectives**:

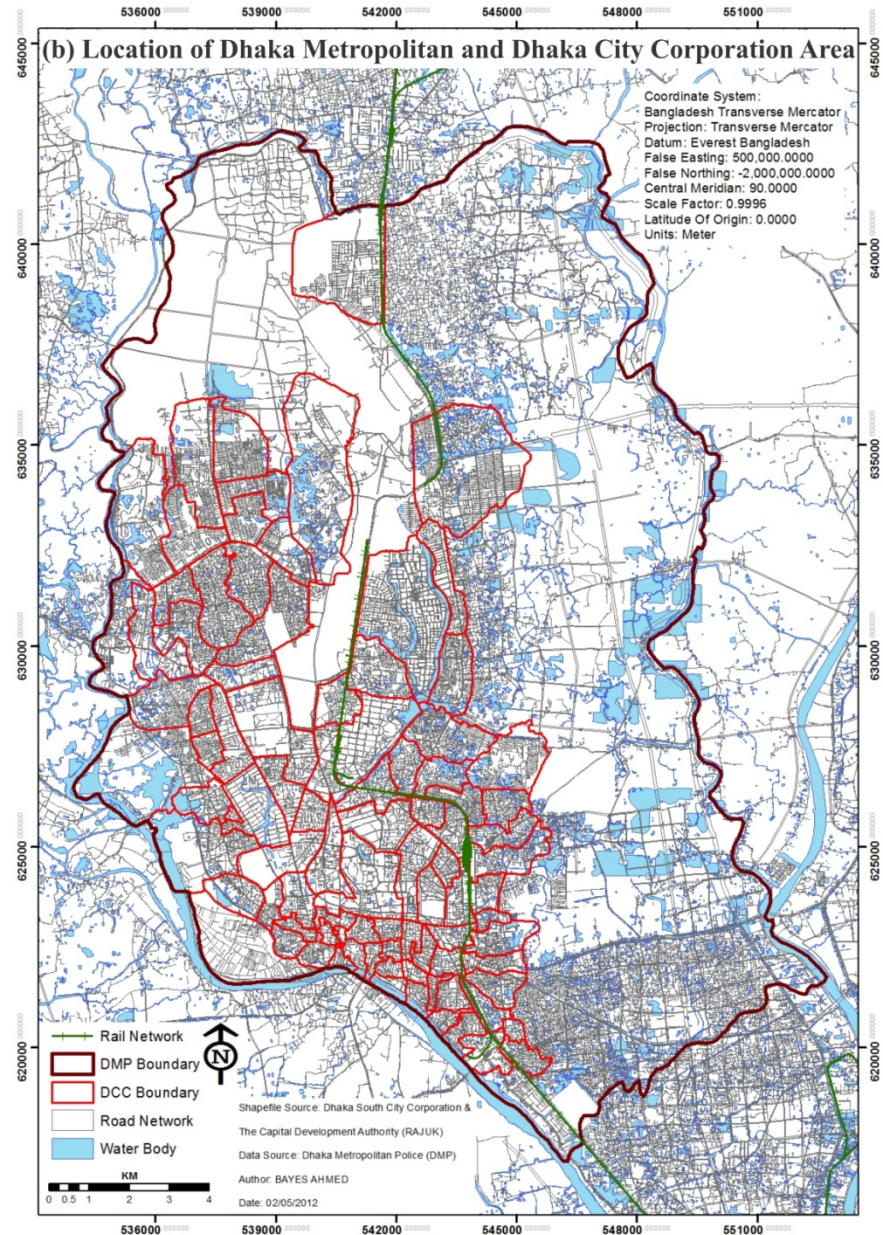
1. To identify the **patterns of land cover changes** (1989 to 2009) and also investigate **their impacts on LST**.
2. To **simulate land cover changes** for 2019 and 2029 and estimate **their impacts on LST** in respective periods.

# Study Area

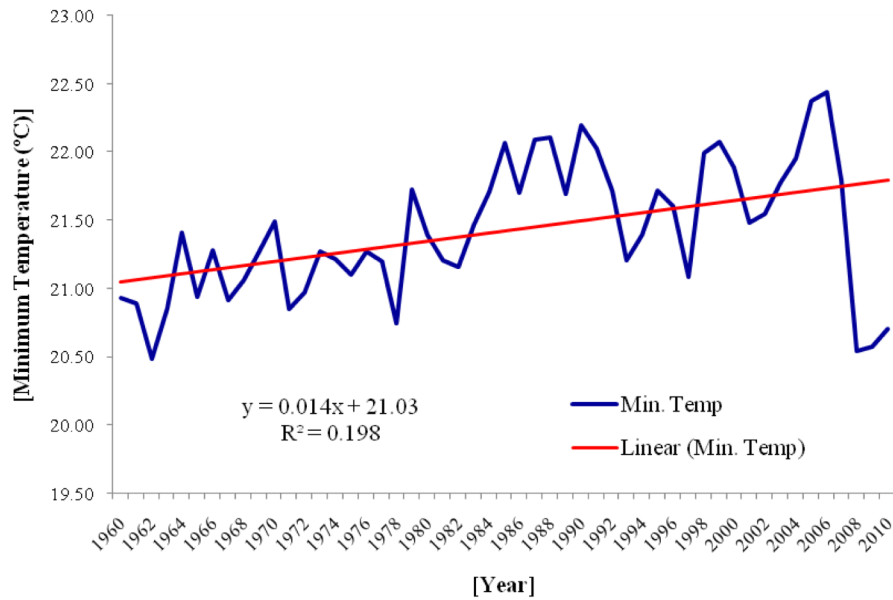
The **Capital of Bangladesh**

Population = **16 million**

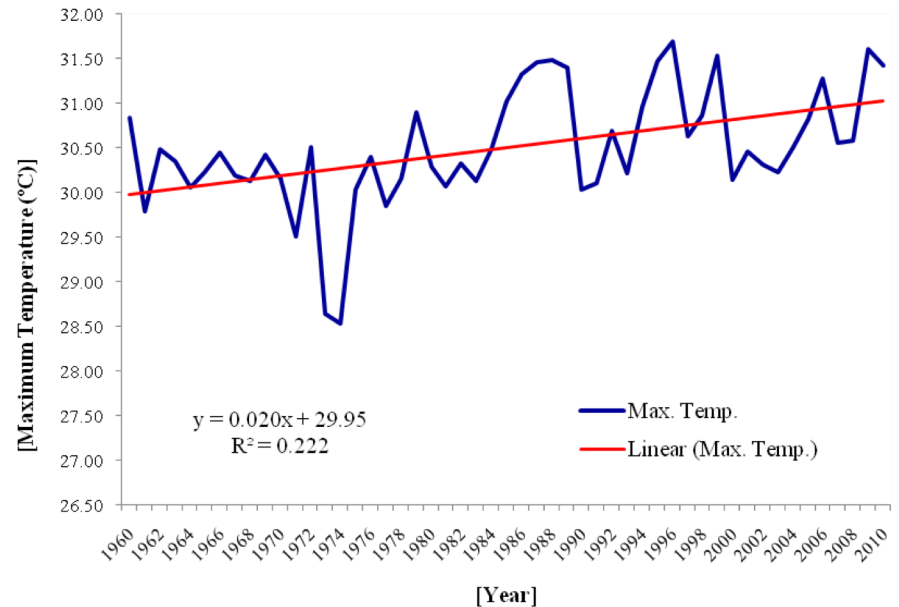
Area = **304.16 sq. Km.**



# Annual Mean Temperature (In-situ Data)



An **upward shift of temperature** has been noted in the past five decades



Date source: Bangladesh Meteorological Department, 2011.

# Landsat Satellite Images

Path 137 Row 44

Map Projection: UTM-46 N

Datum: WGS 84

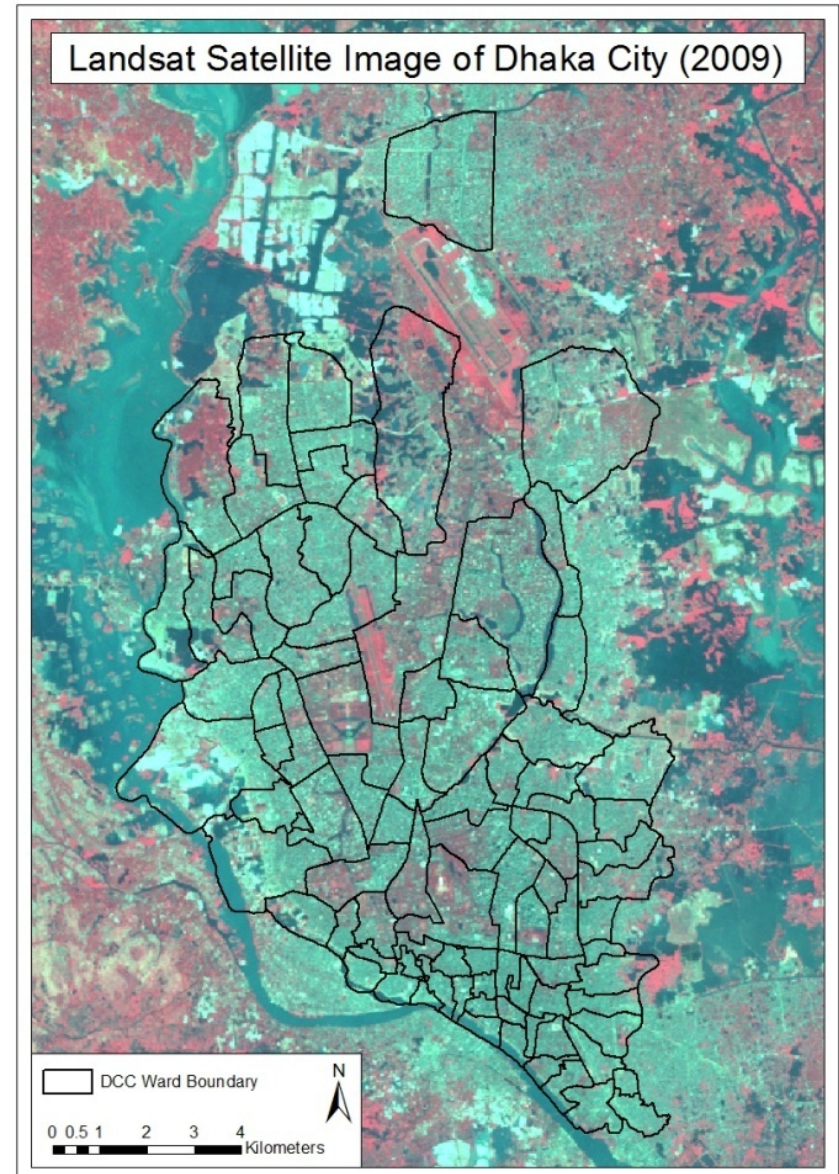
Pixel Size: 30 meters

7 Bands

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Year	Date Acquired (Day/Month/ Year)	Sensor
1989	13/02/1989	Landsat 4-5 Thematic Mapper (TM)
1999	24/11/1999	Landsat 7 Enhanced Thematic Mapper Plus (ETM+)
2009	26/10/2009	Landsat 4-5 Thematic Mapper (TM)

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# Image Classification

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Composite Image (RGB = 432)

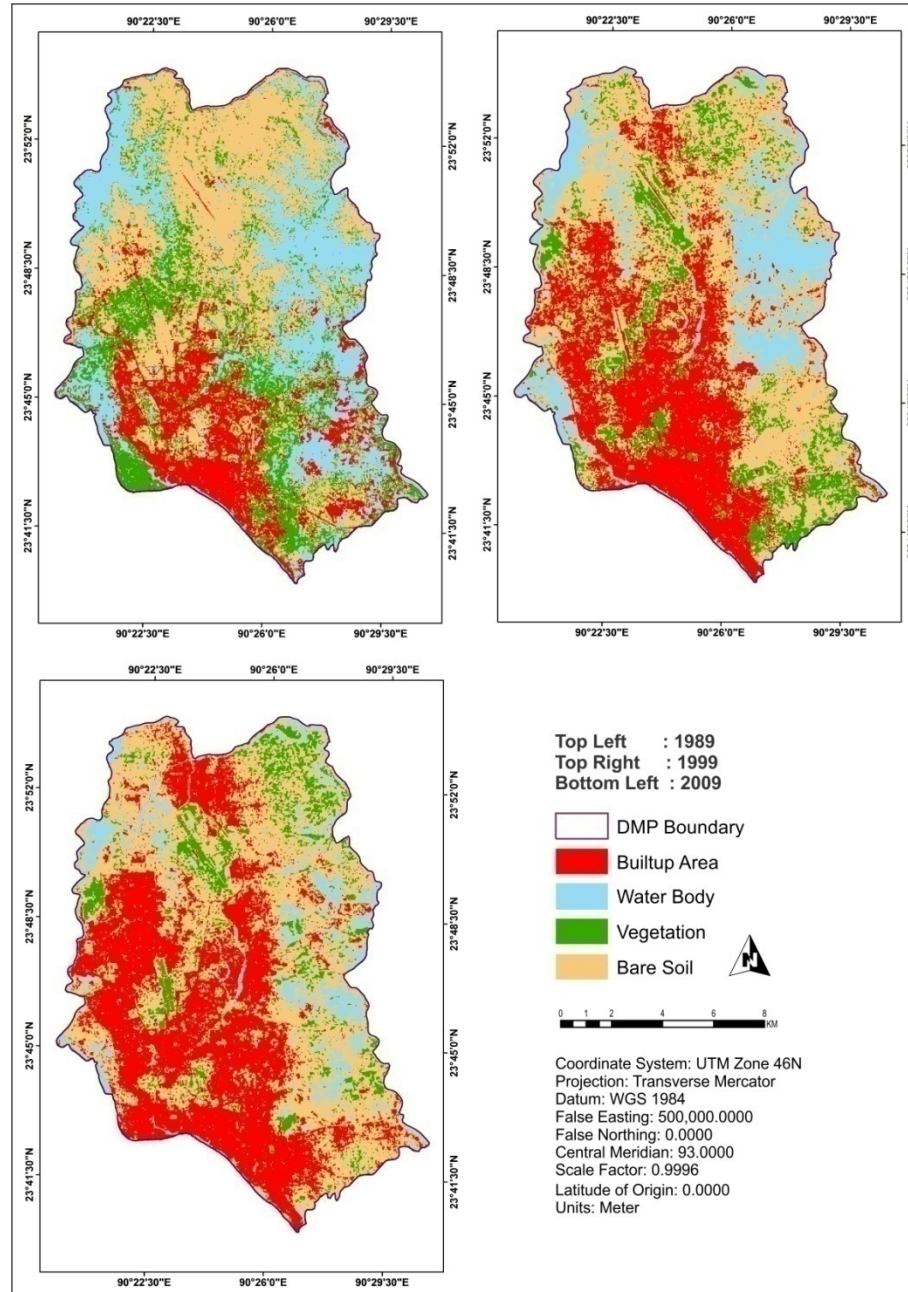
## Supervised Classification

Land Cover Type	Description
<b>Builtup Area</b>	Residential, Commercial and Industrial Areas
<b>Water Body</b>	River, Lakes, Ponds and Canals
<b>Vegetation</b>	Trees, Natural Vegetation, Parks and Playgrounds
<b>Bare Soil</b>	Open Space, Bare and Exposed Soils

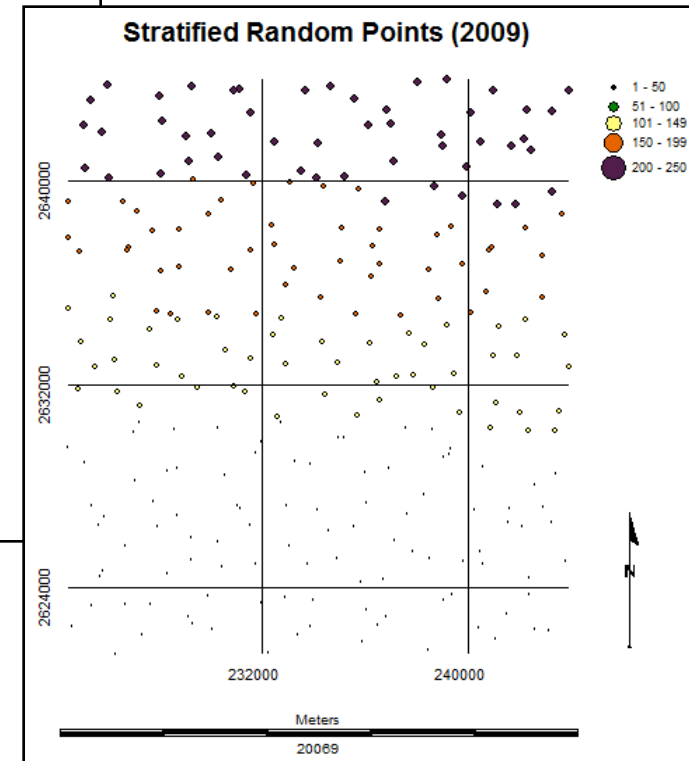
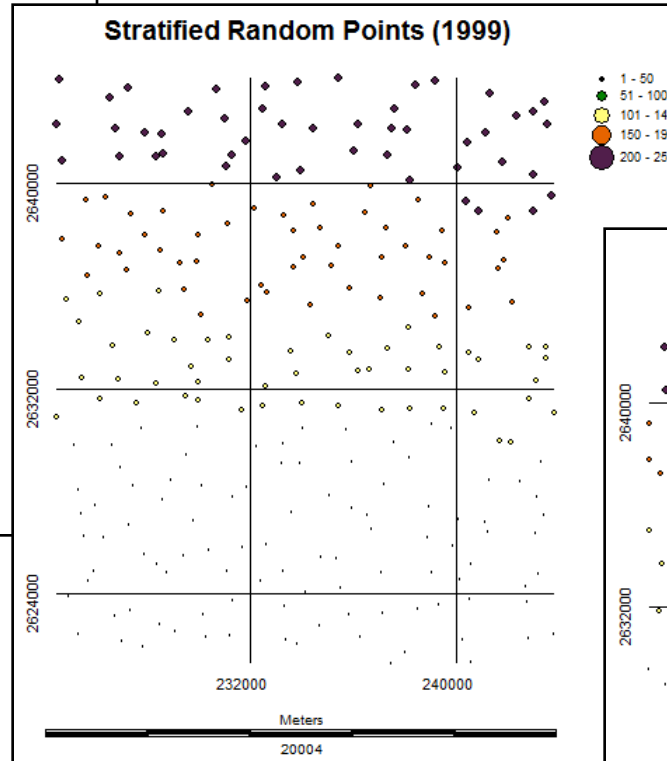
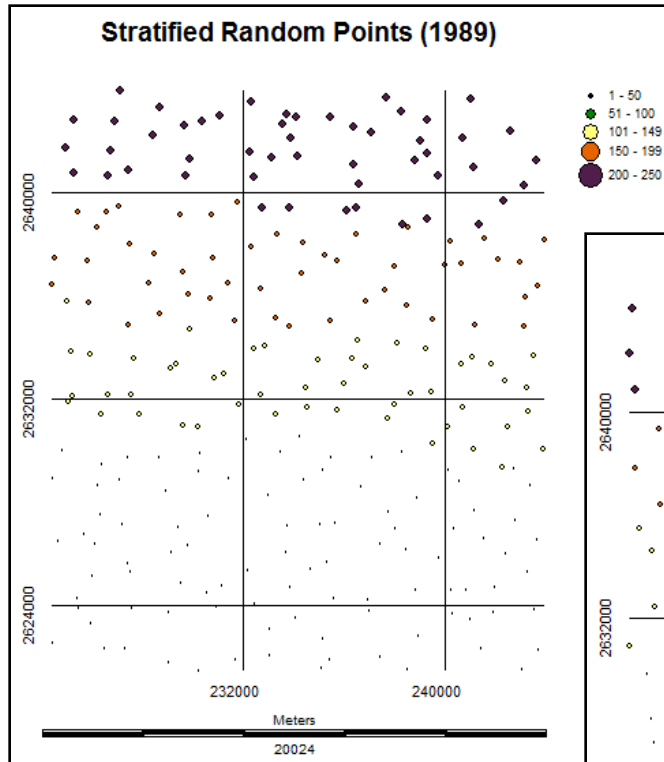
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# Base Maps



# Accuracy Assessment

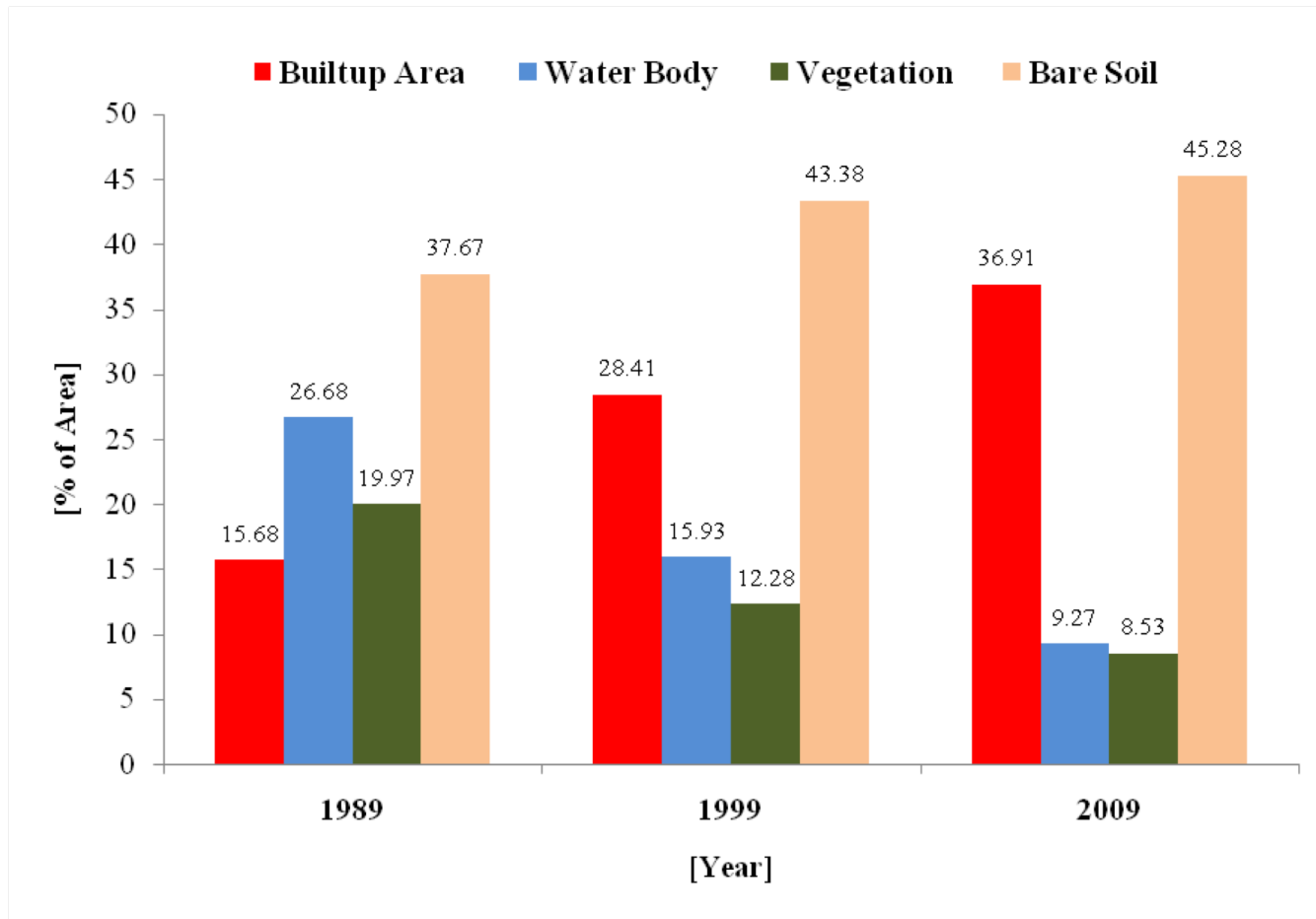


# Accuracy Assessment

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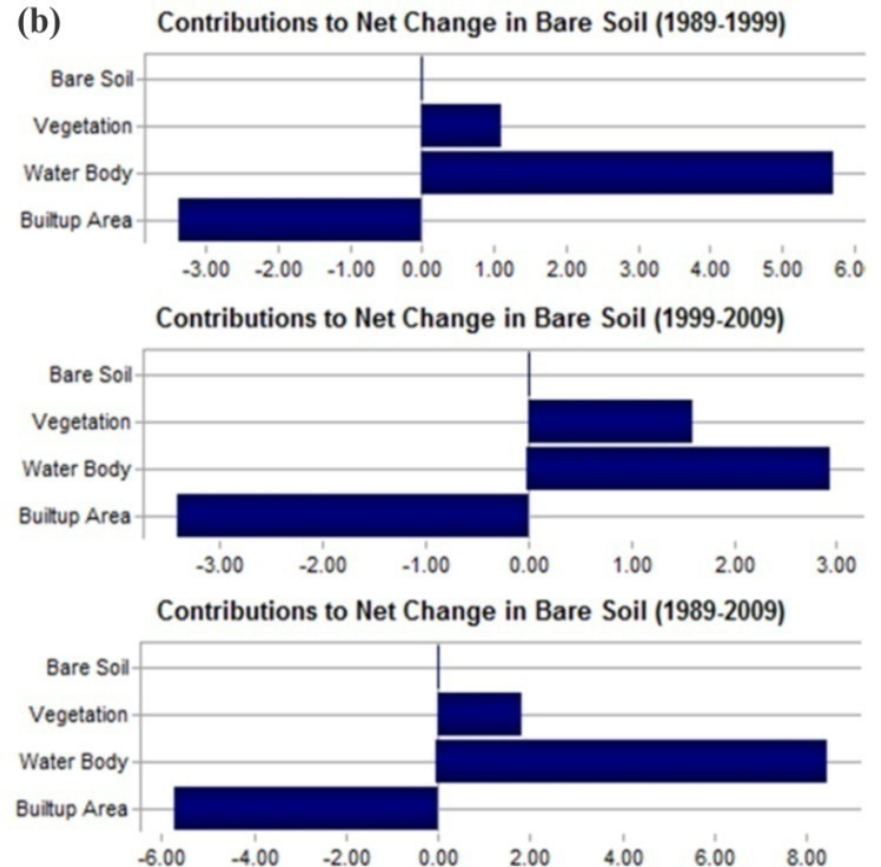
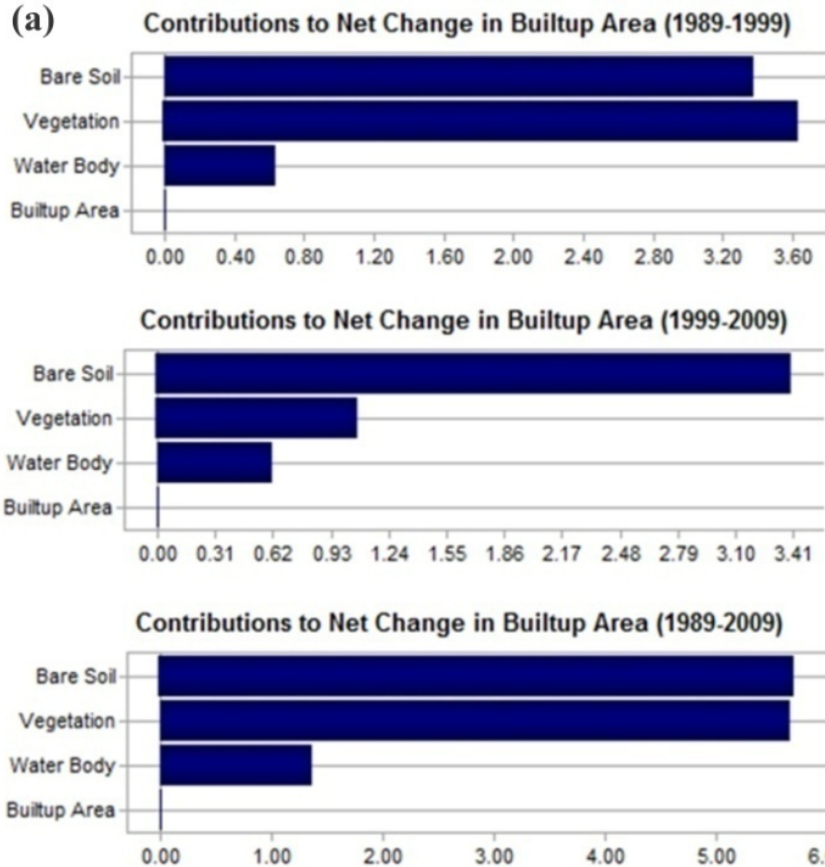
<b>Base Year</b>	<b>Overall Accuracy</b>	<b>Kappa Statistics</b>
<b>1989</b>	<b>86.48</b>	0.86
<b>1999</b>	<b>90.69</b>	0.91
<b>2009</b>	<b>94.13</b>	0.95

# Change Detection



**Built-up Area increased by 88.78% in the past 20 years**

# Change Detection



**Bare Soil** was the **main contributor in forming the built-up areas** followed by vegetation and water body

**Built-up area was not converted into bare soil type at all**

# Retrieval of LST from the Landsat Images (Band 6)

## **Landsat 4-5 Thematic Mapper (TM)**

$$R_{TM6} = \frac{V}{255} (R_{\max} - R_{\min}) + R_{\min}$$

$$T = \frac{K1}{\ln(K2 / (R_{TM6} / b) + 1)}$$

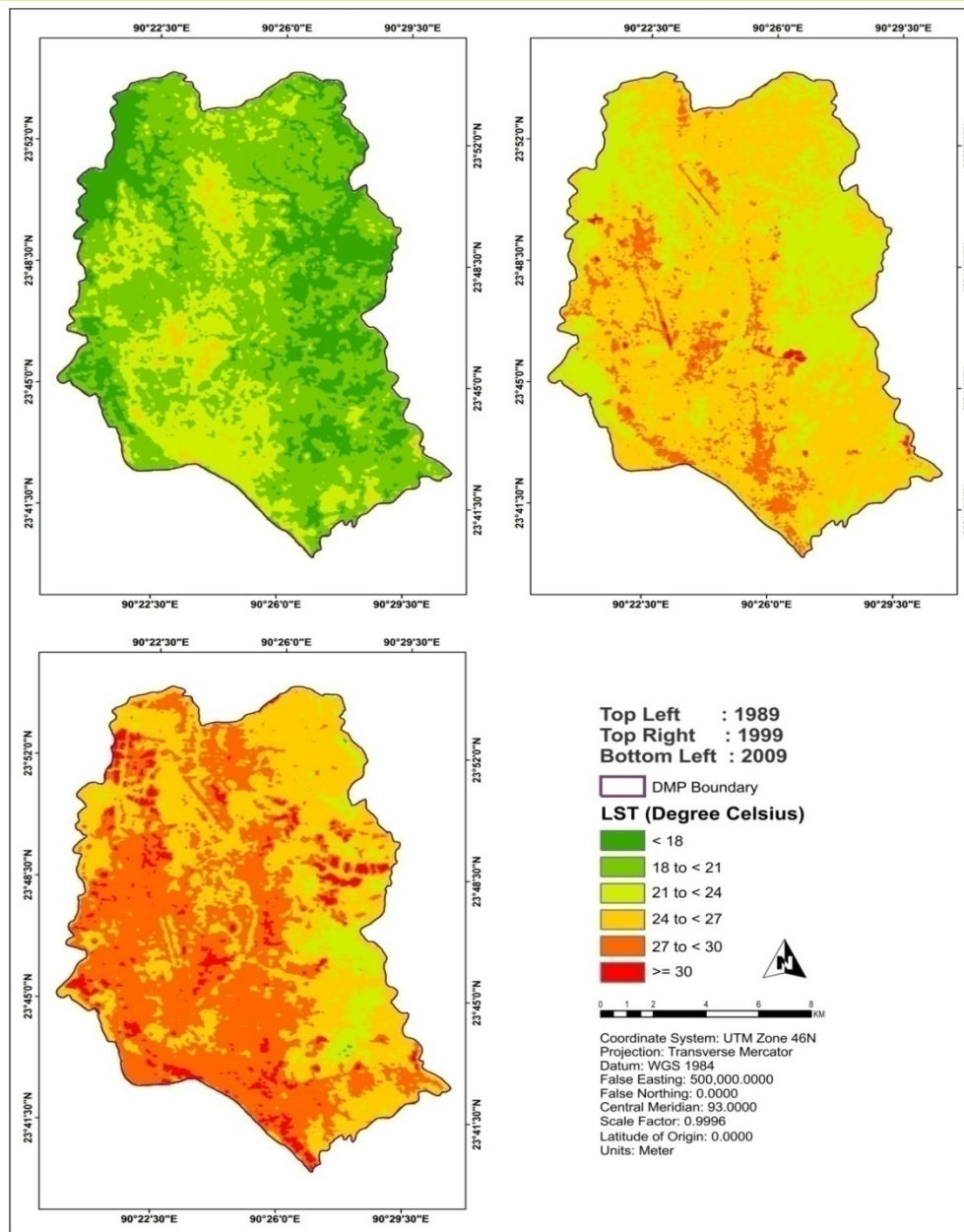
## **Landsat 7 Enhanced Thematic Mapper Plus (ETM+)**

$$Radiance = \frac{LMAX - LMIN}{QCALMAX - QCALMIN} \times (QCAL - QCALMIN) + LMIN$$

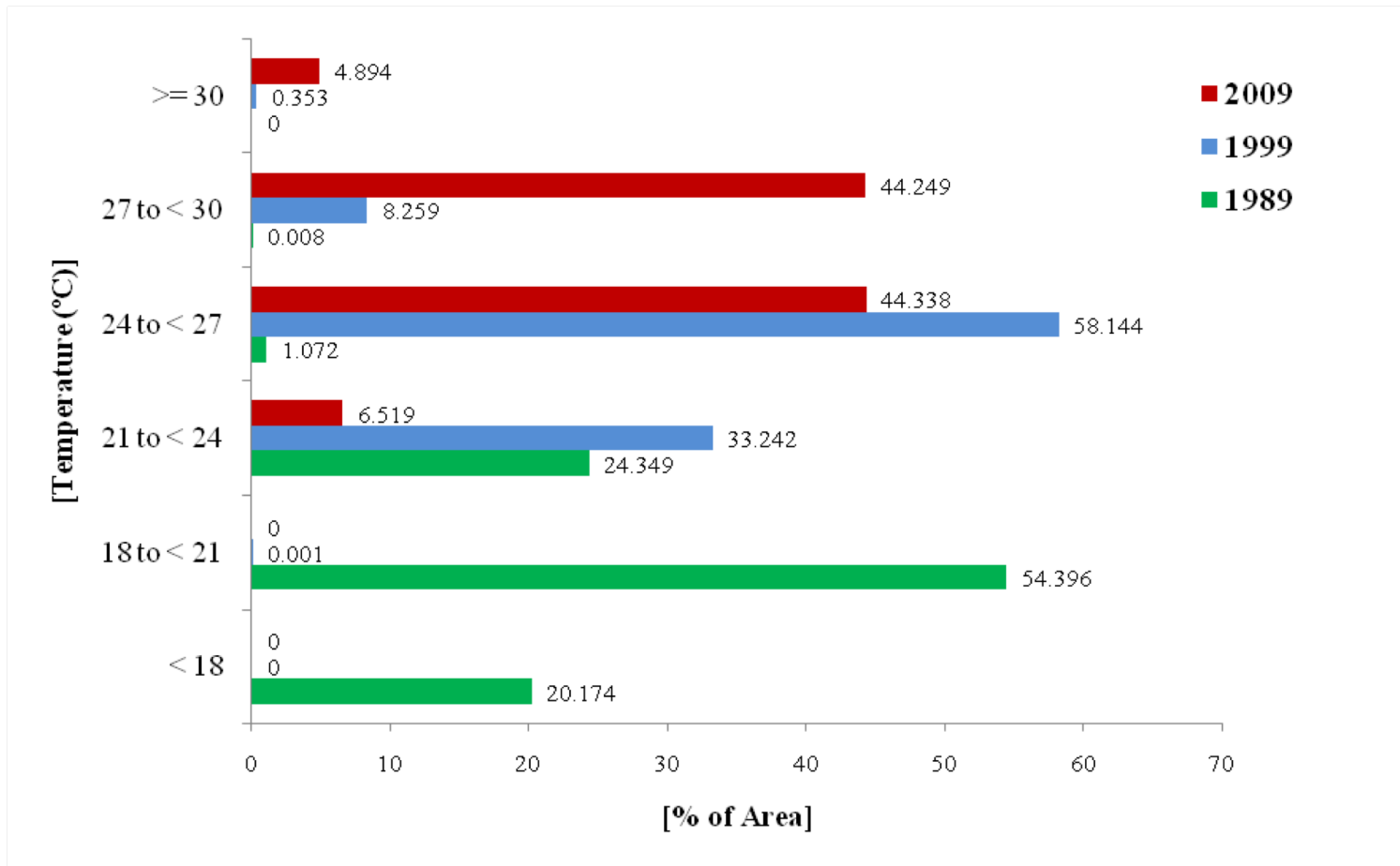
$$T = \frac{K2}{\ln(K1 / L_{\lambda} + 1)}$$

Source: Landsat 7 Science Data Users Handbook, 2010.

# Spatial Distribution of Land Surface Temperature (LST)



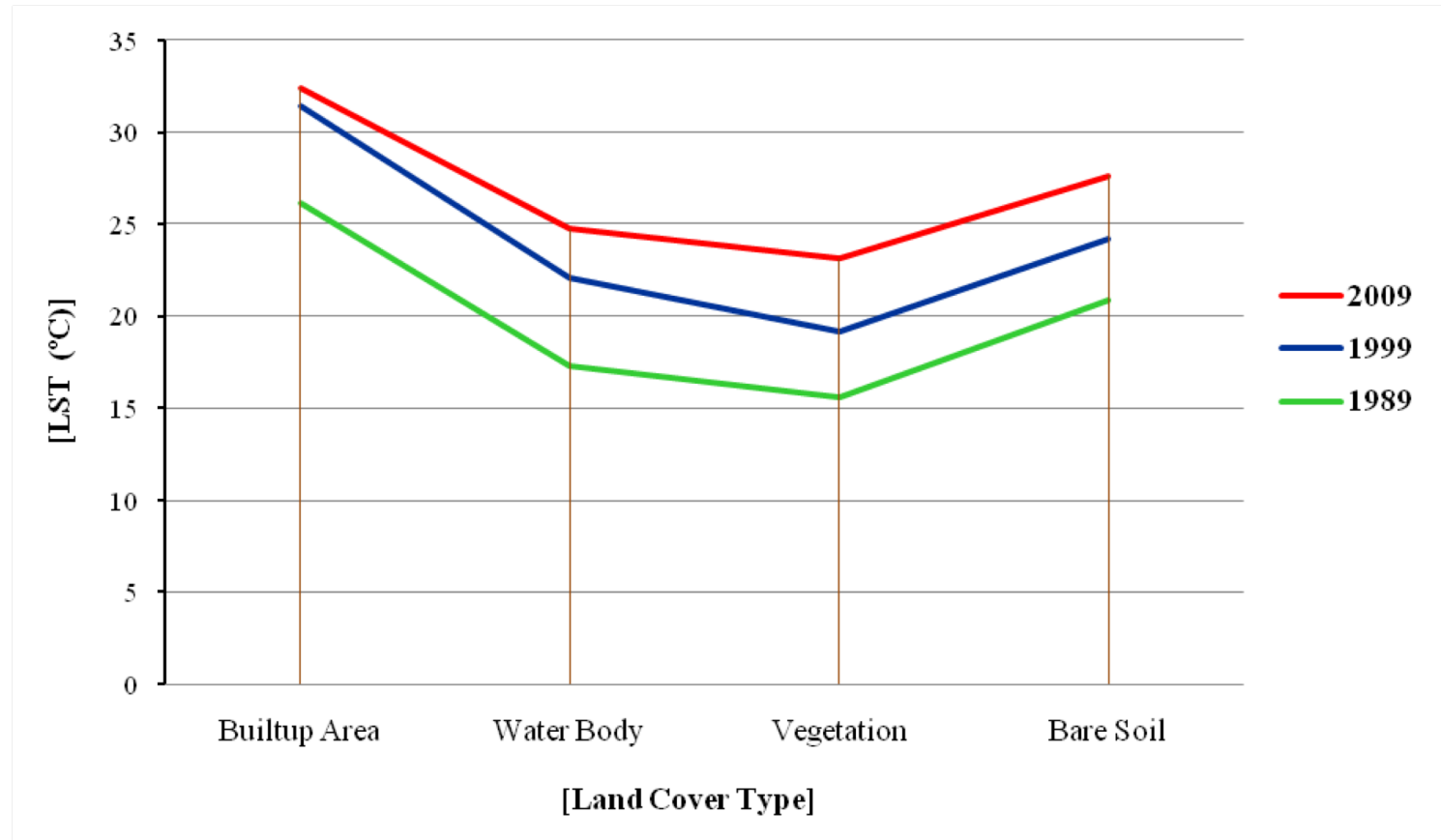
# Change in Land Surface Temperature (°C)



**Trend:** A larger portion of the DMP area is **moving towards the higher temperature zones.**



# Temperature Variations for Different Land Cover Types



**LST increased for all land cover types** over the periods

**Built-up Area exhibited the highest LST**, followed by bare soil, water body, and vegetation

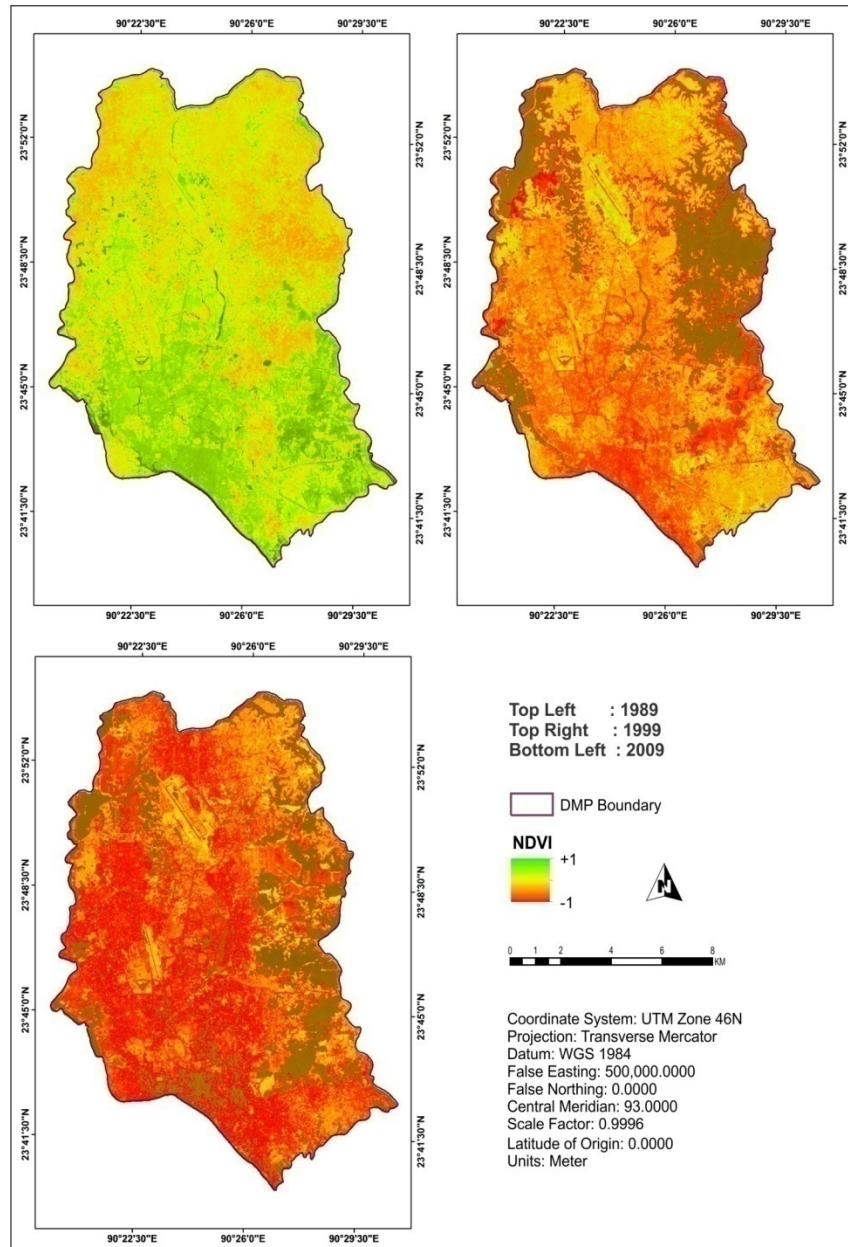
# Land Cover Indices

$$\text{NDVI} = \frac{b_4 - b_3}{b_4 + b_3}$$

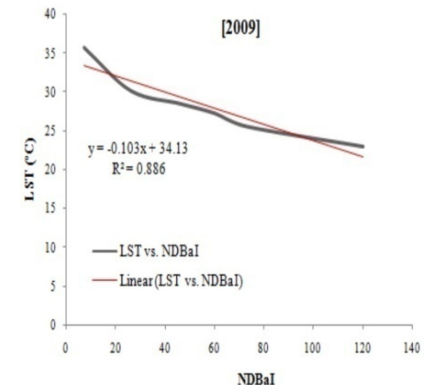
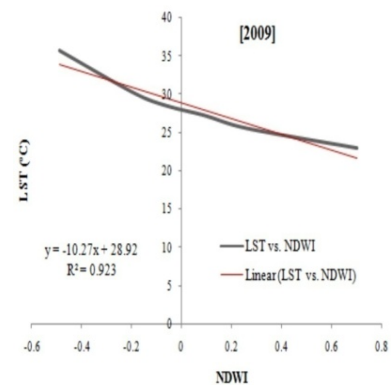
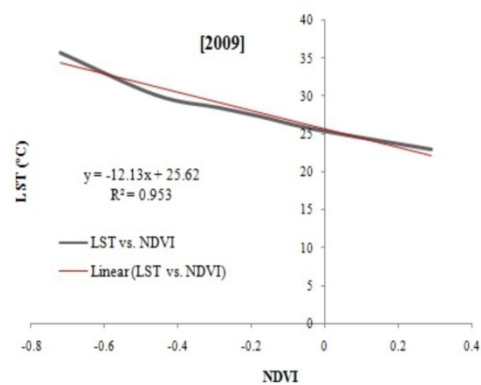
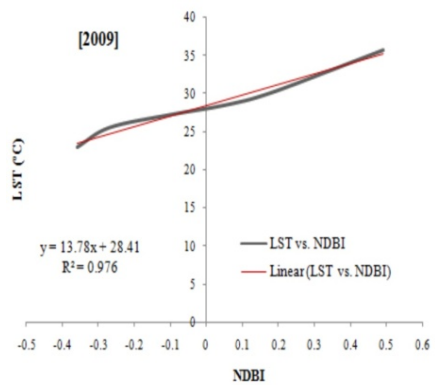
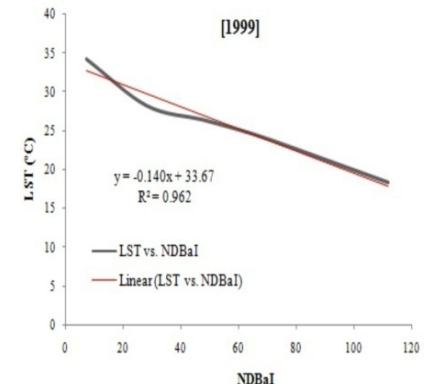
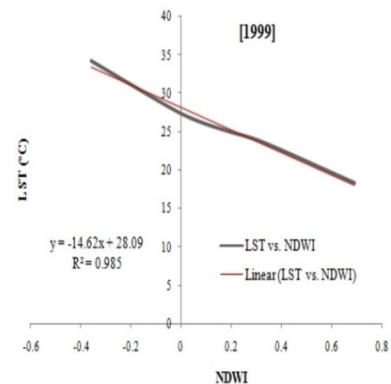
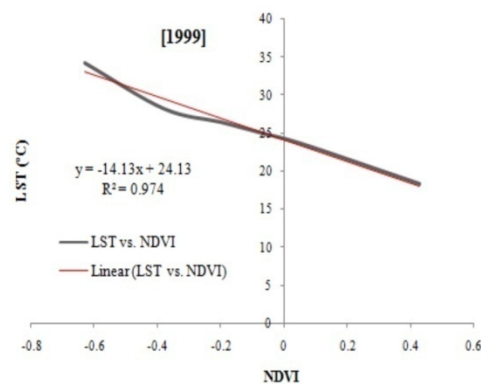
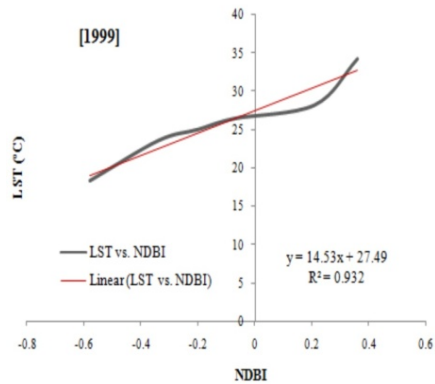
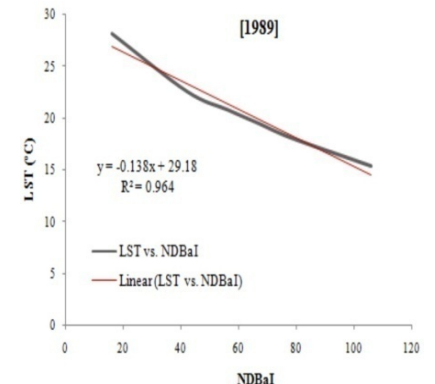
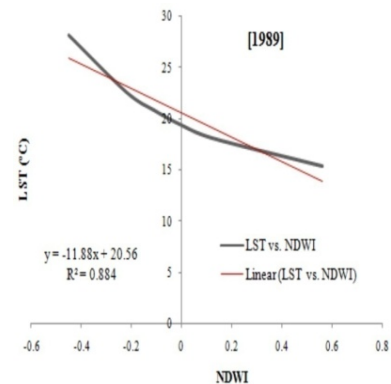
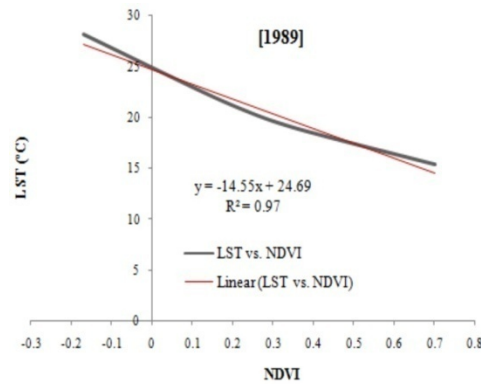
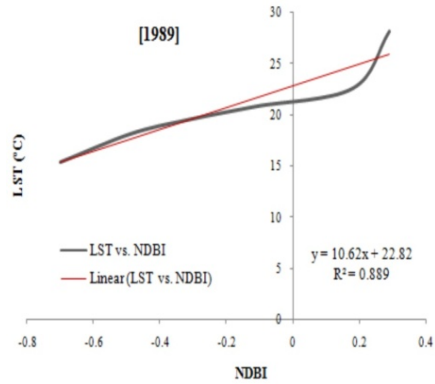
$$\text{NDWI} = \frac{b_4 - b_5}{b_4 + b_5}$$

$$\text{NDBI} = \frac{b_5 - b_4}{b_5 + b_4}$$

$$\text{NDBaI} = \frac{b_5 - b_6}{b_5 + b_6}$$



# Relationship between LST and Land Cover Indices



# Major Findings

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The major findings are as follows:

a) Builtup area and bare soil types are **increasing** over time.

b) The mean LST is **increasing** following a **trend**.

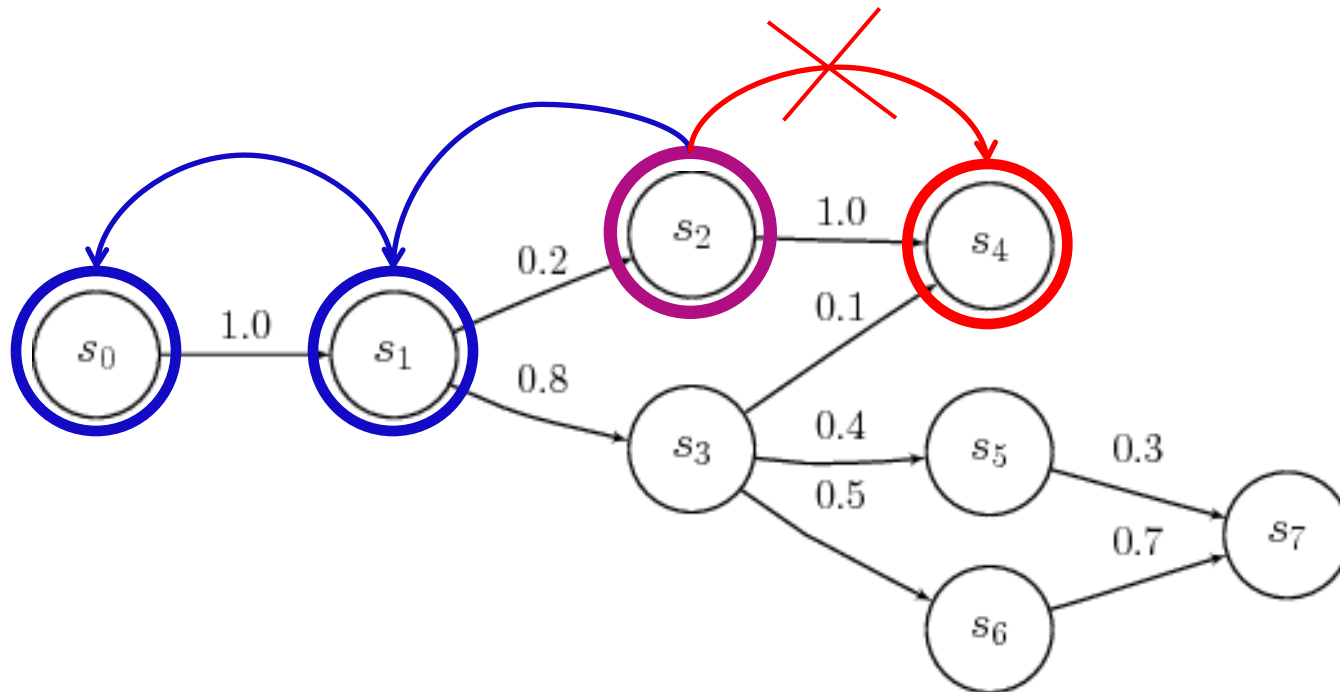
c) Builtup area type exhibits the **highest LST** followed by bare soil, water body and vegetation.

d) The **percentage of areas falling in high temperature zones** are increasing gradually.

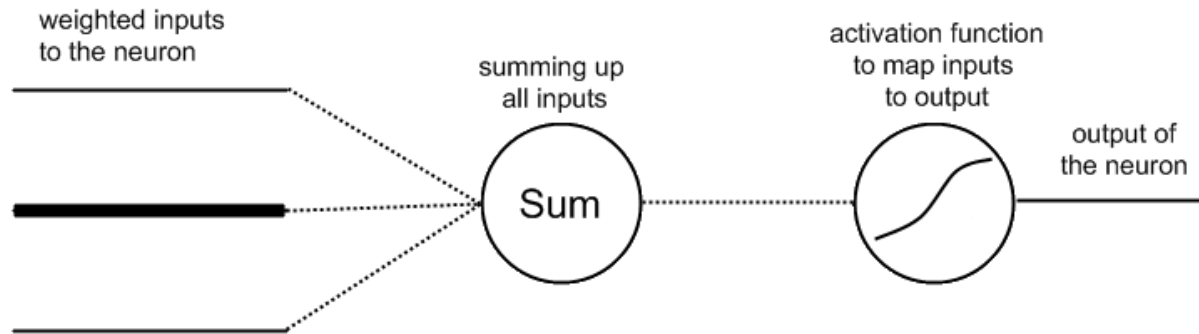
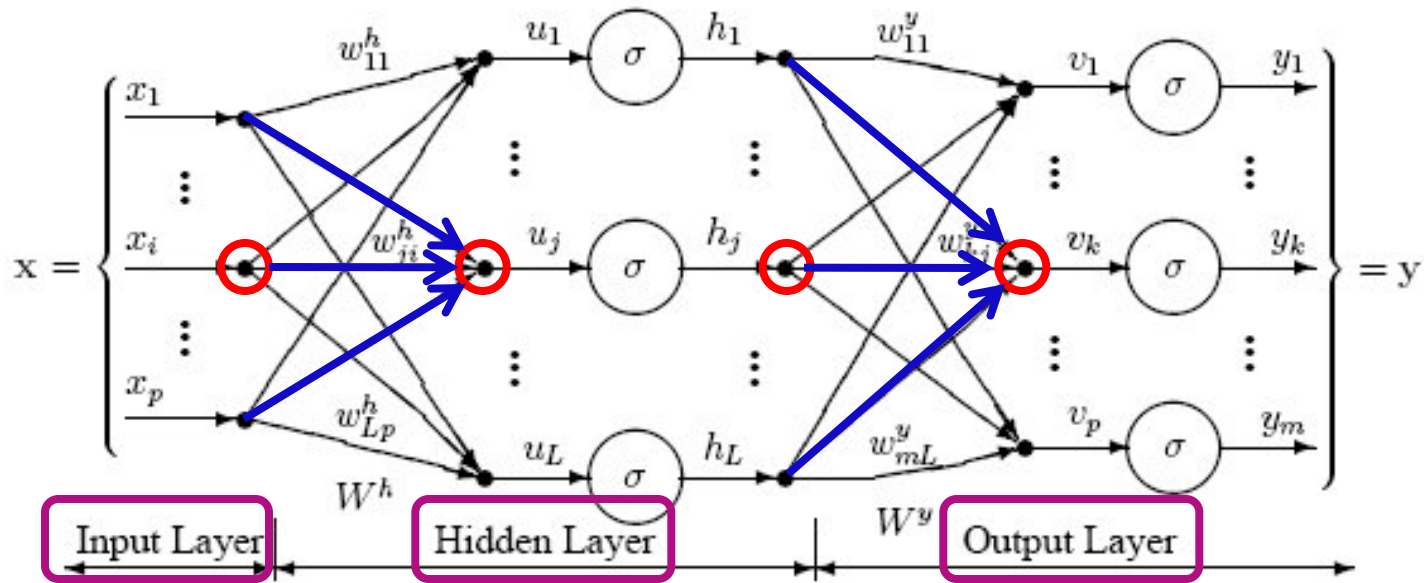
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# Markov Chain Analysis

A Markov chain is a discrete random process with the property that **the next state depends only on the immediately preceding state(s) [6]**

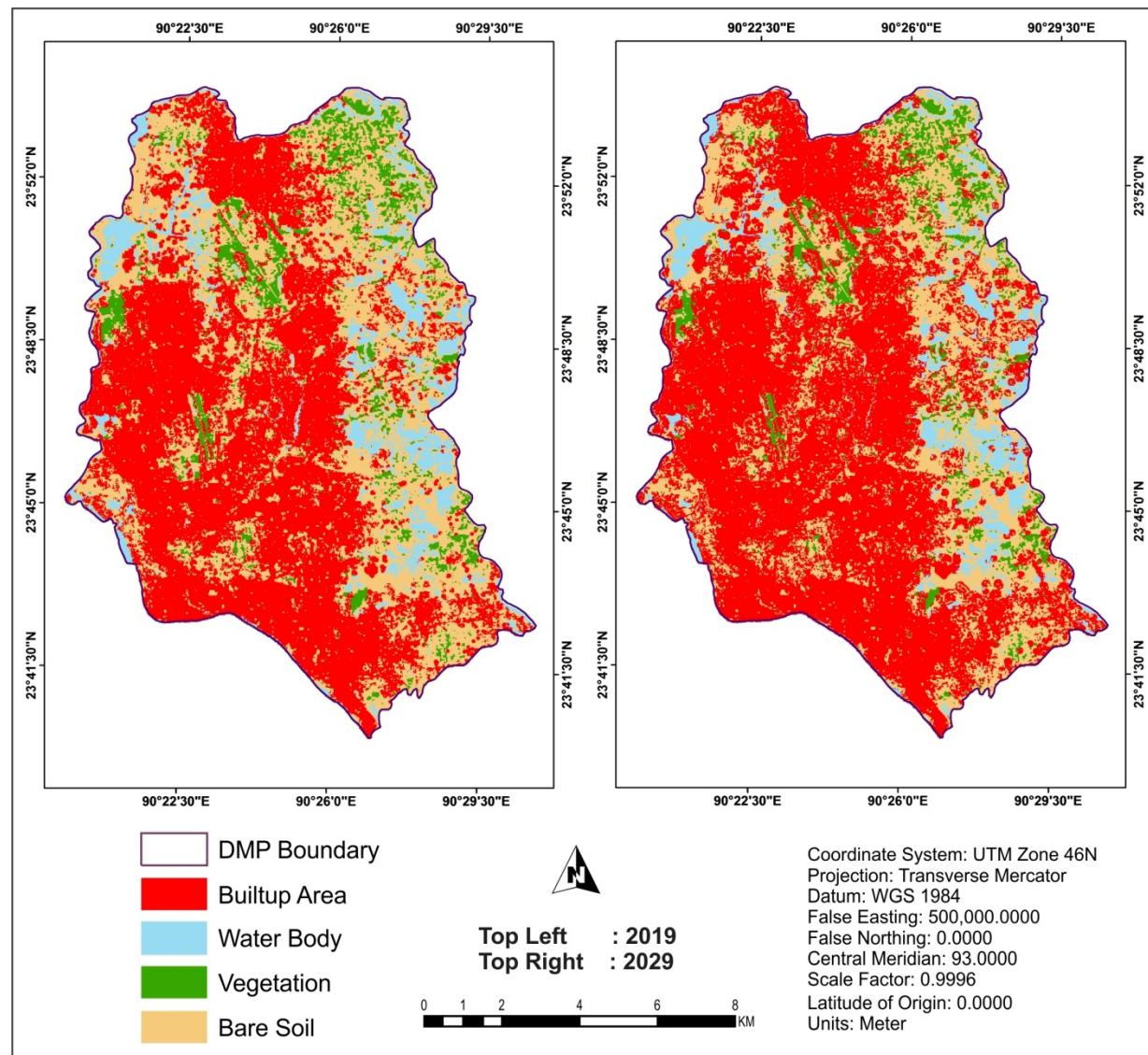


# Artificial Neural Network (MLP)



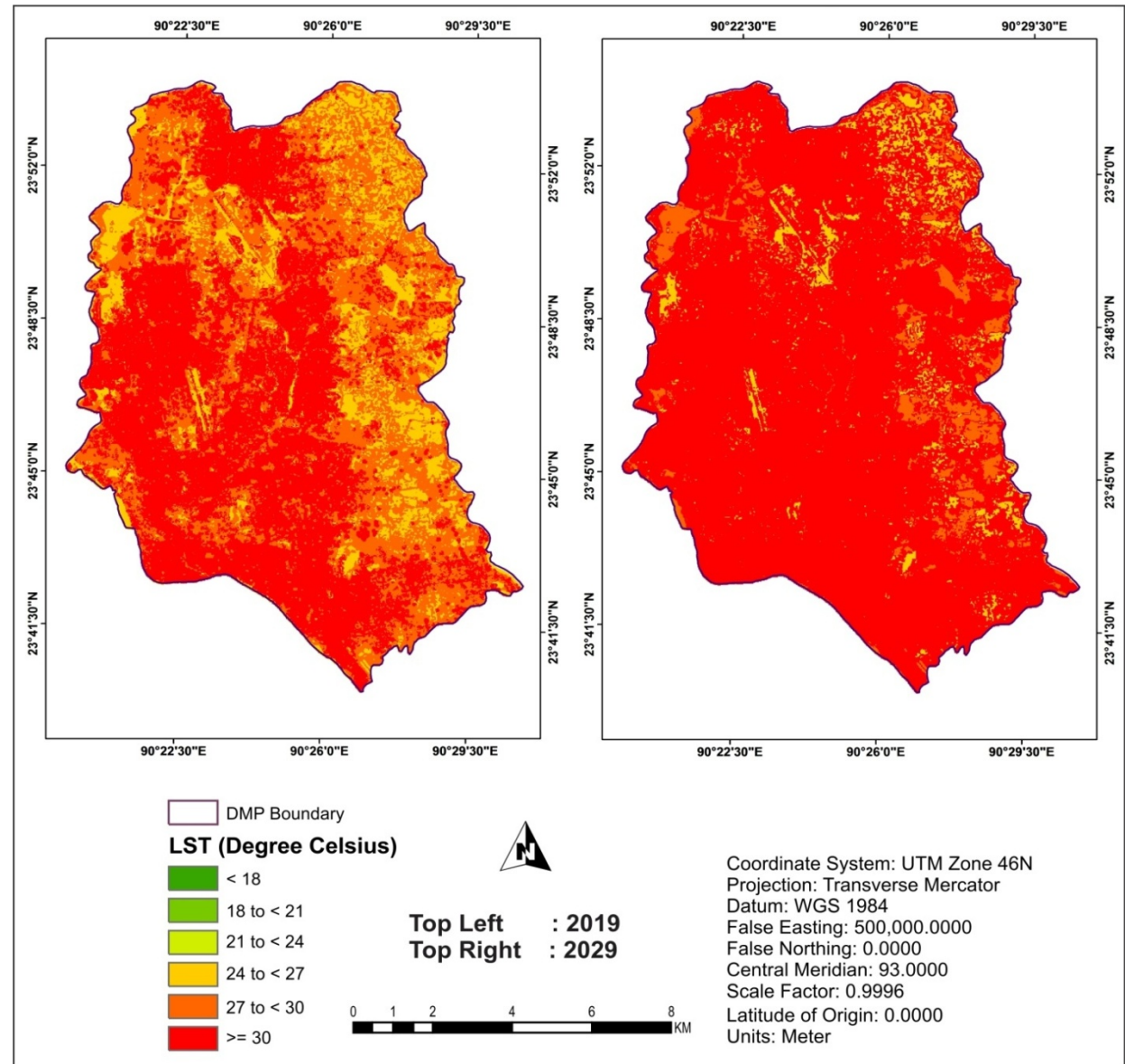
# Simulated Land Cover Dynamics (MLP\_Markov Model)

Approximately **49%** and **57%** of DMP area will be converted into **'Built-up Area'** land cover type in 2019 and 2029, respectively



# Simulating the Future LST Maps (2019 and 2029)

Approximately **56%** and **87%** of DMP area will fall in the **Highest Temperature Zone ( $\geq 30^{\circ}\text{C}$ )** in 2019 and 2029, respectively





## Future Research and Conclusion

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- Further research should seek to **validate the findings** reported in this research **using more authentic datasets**.
  - The **calculation of UHI** requires data from a **comparative geography** (e.g. rural vs. urban) which was not considered in this research.
  - **Growth management policies** (e.g. green belt) can be implemented that would contain the growth and consequently **help reducing UHI effect**.
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**Thank You All**  
**QUESTIONS?**



## References

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1. He, F.; Liu, J.Y.; Zhuang, D.F.; Zhang, W.; Liu, M.L. Assessing the effect of land use-land cover change on the change of urban heat island intensity. *J. Theor. Appl. Climatol.* 2007, 90, 217–226.
  2. Trenberth, K.E. Climatology (communication arising): Rural land-use change and climate. *Nature.* 2004, 427, 213.
  3. Patz, J.A.; Lendrum, D.C.; Holloway, T; Foley, J.A. Impact of regional climate change on human health. *Nature.* 2005, 438, 310–317.
  4. Liu, L.; Zhang, Y. Urban Heat Island Analysis Using the Landsat TM Data and ASTER Data: A Case Study in Hong Kong. *Remote Sens.* 2011, 3, 1535–1552.
  5. Kalnay, E.; Cai, M. Impact of urbanization and land-use change on climate. *Nature.* 2003, 423, 528–531.
  6. Ahmed, B.; Ahmed, R. Modeling Urban Land Cover Growth Dynamics Using Multi-Temporal Satellite Images: A Case Study of Dhaka, Bangladesh. *ISPRS Int. J. Geo-Inf.* 2012, 1, 3-31.
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