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Research Paper Presentation Topic

Evaluating the Impact of Urbanisation on Climate Change: A Case of Kochi City, Kerala State, India.

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INTRODUCTION

Worldwide fertility rate is becoming a most significant context of anthropological condition. **Rapid population pressure** is one of the increasing factors for global land crisis and gradually **effect in the environment and boosting the climatic vulnerability**. **Rapid urbanization, industrialization and technologically build-up area** created more **land scarcity** in worldwide.

Land use and land cover (LULC) alterations is the foremost concentrating issues for **global climate impact and change studies** due to regional and universal climate-changing like **biophysical, biogeochemical and biogeographical** characteristics of the earth system process.
Population pressure, urban expansion, industrialization are the main reason for the land cover change. The controlling factors for LULC change in an area are depending on **social, economic and political characteristics.**

The **urban expansion** is a significant aspect of monitoring the **anthropogenic activities**, the transformation of the **physical landscape, industrialization, transportation accessibility, increased of public vehicles, air quality impact** and moreover the impacts on the environmental component like **land and water bodies.** In **India, 30% of urban expansion** has been increased in the **last 50 years**.

In **Kochi city, Kerala State**, Southern India, due to **population pressure and accessibility of transportation** systems are increased the **urban expansion and change the local environment**.

Urbanization has profoundly affected the **environment and climate** all over the world and has **intensified the climate change impacts**.

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INTRODUCTION

Climate change, which is mainly caused by **carbon emissions, has attracted attention worldwide**.

With the **continuous increase in temperature, the urban heat island effect, extreme weather, and water shortages** have seriously affected **the urbanization process.**

Climate change has a nonlinear effect on urbanization. When the **urbanization level is greater than the threshold**, the negative impact of climate change on urbanization weakens.

First, the existing literature mainly studies the **relationship between the economy and the environment and seldom examines social factors**. This study examines urbanization, an important **indicator of the social dimension**, and improves relevant research in the field of **sustainable development**.

Second, as temperature is the most intuitive feeling of climate change, this study adds the **highest and lowest temperatures** based on average temperature, which improves the robustness of the research; alternatively, it can enable the government to utilize more ways to **analyze the specific causes of climate change** and provide a basis for **formulating policies** related to **environmental protection and sustainable urban development**..

This study may be helpful for the urban planners, administrators and policy makers for sustainable development and urban planning of Kochi Region.

INTRODUCTION

- **Over half** the world lives in cities.
- **70%** of the population will live in cities by 2050.
- Over **60%** of the land expected to become **urban** by **2030** is undeveloped.
- Asia's urbanisation rate is **50% in 2020**.
- **Cities** emit up to **70%** of **greenhouse gases**.
- **Urban economic activity** accounts for **55% of GNP** in **low-income** nations, **73%** in **middle-income countries**, and **85%** in **high-income ones.**
- Slums are housing **889 million** people in **2020**.
- **227 million** developing world residents left ghettos between **2000 and 2010.**

CASE AREA

- **Kochi Municipal Corporation-** Ernakulam District- Kerala- India-Area: **94.88 km2**
- The climate in Kochi is **tropical monsoon** and due to its proximity to the equator and seaside position.
- Temperatures in the air range from **20 to 35 °C**.
- The Corporation has **74 wards**, and the city's population is **6.5 lakhs** in 2021.

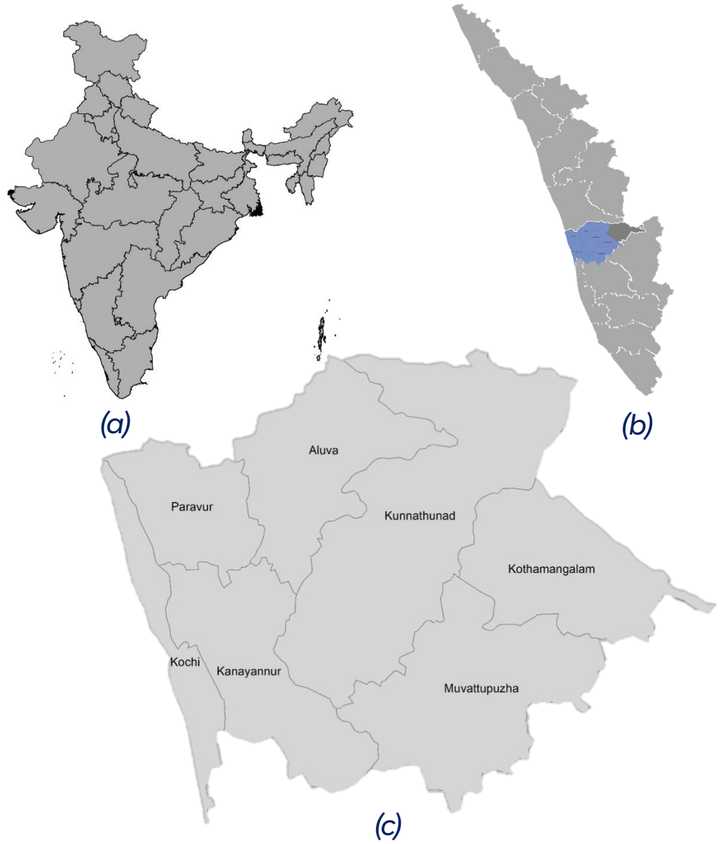


Figure 1: (a) India, (b) Kerala (c) Ernakulam District

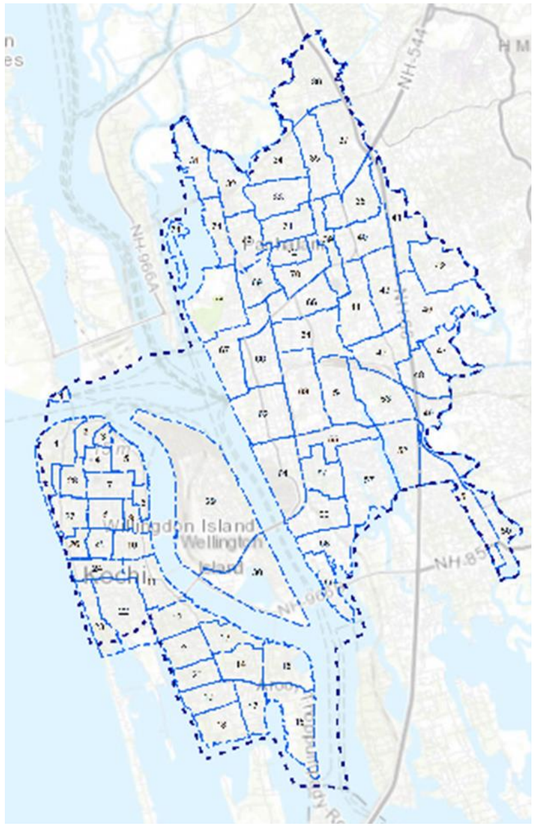


Figure 2: Kochi Municipal Corporation

VULNERABILITY ASSESSMENT

Urban Sprawl

- Urbanisation expands metropolitan areas by making homes and businesses farther from urban centers.
- Urban or suburban sprawl refers to the expansion of a city and its suburbs to low-density, auto-dependent areas on rural land.
- As the city's population grows, housing and infrastructure needs increase, causing uncontrolled urban expansion.
- Traffic, infrastructure, and environmental issues arose. Kochi's urbanisation has destroyed farmland, natural habitats, and water quality.
- Kochi's urban growth has led to rural migration, livelihood loss, and increased social and economic inequality.

Land Surface Temperature

- Urbanisation, which reduces vegetation, impacts surface climate by affecting materials with the same solar radiation temperature.
- Metropolitan areas have higher surface temperatures than vegetated and water-covered areas.
- Urbanisation can disrupt natural processes, making studying its effects on Land Surface Temperature (LST) crucial.
- As metropolitan areas expand, land surface temperatures rise, and land use changes, such as agricultural land development, can also affect LST.

Urban Climatic Map

- Urban climate maps identify urban heat islands, air pollution, and floods by highlighting hotter areas with few trees, high building density, and concrete and asphalt.
- Increased green space, green roofs, and surface reflectivity can reduce heat islands. Air pollution levels can be influenced by industrial activity, traffic, and green spaces.

Urban Heat Island

- Cities typically have higher temperatures than rural areas due to changes in ground cover, buildings' shape, and vegetation decline.
- Heating and energy use increase city temperatures, particularly at high latitudes in winter. Lower latitudes experience air conditioning, which cools indoors.
- The urban water balance shifts due to reduced evaporation cooling and forced rainwater drainage, creating the Urban Heat Island.

METHODOLOGY

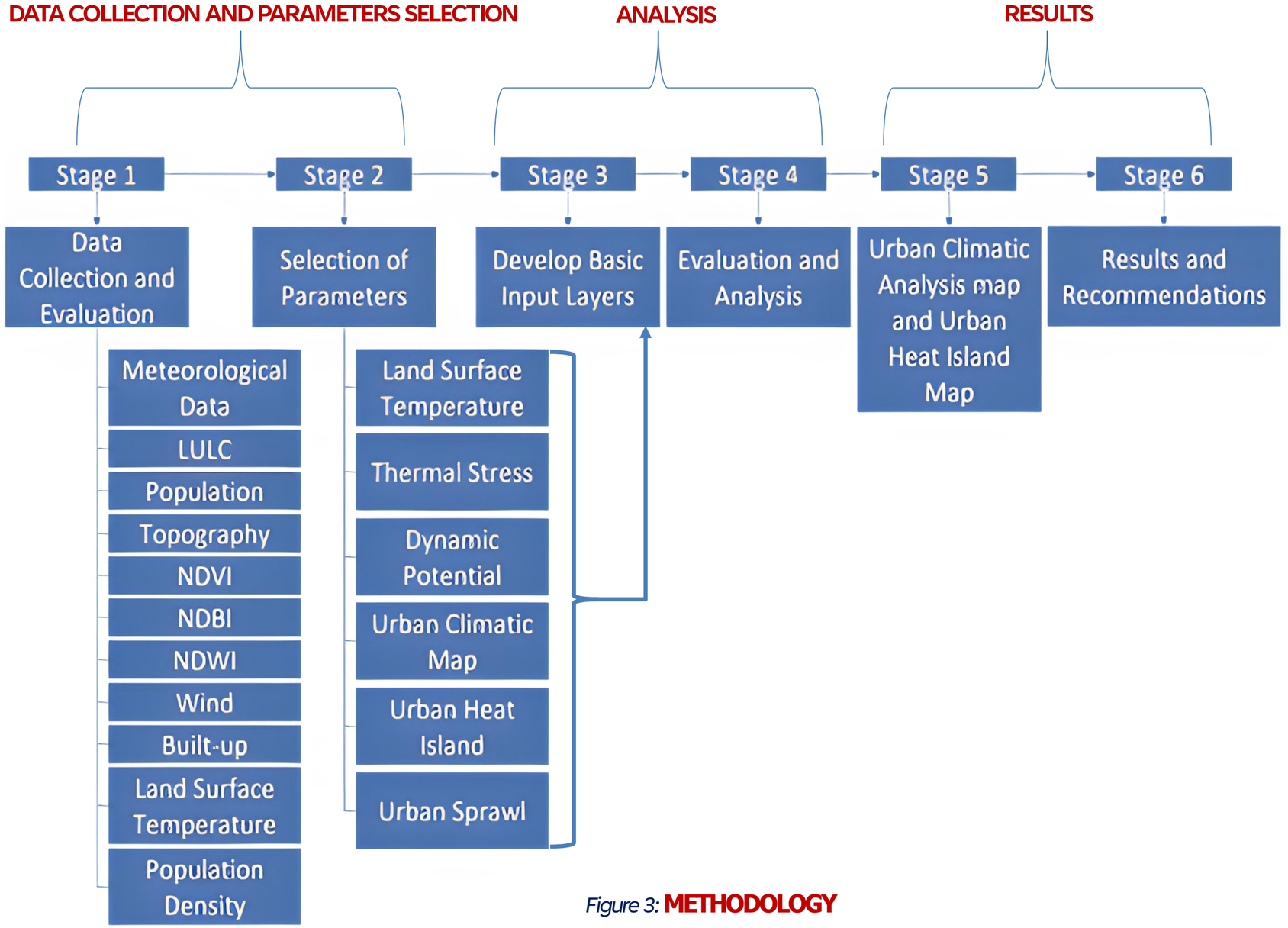


Figure 3: **METHODOLOGY**

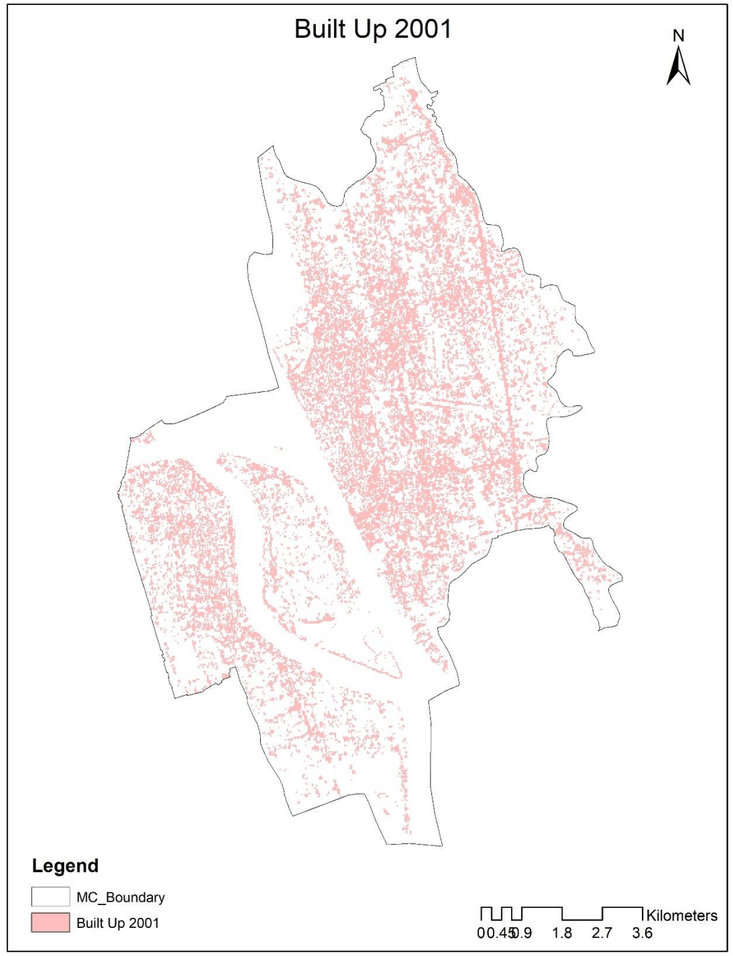
Parametric Maps

Major Outputs

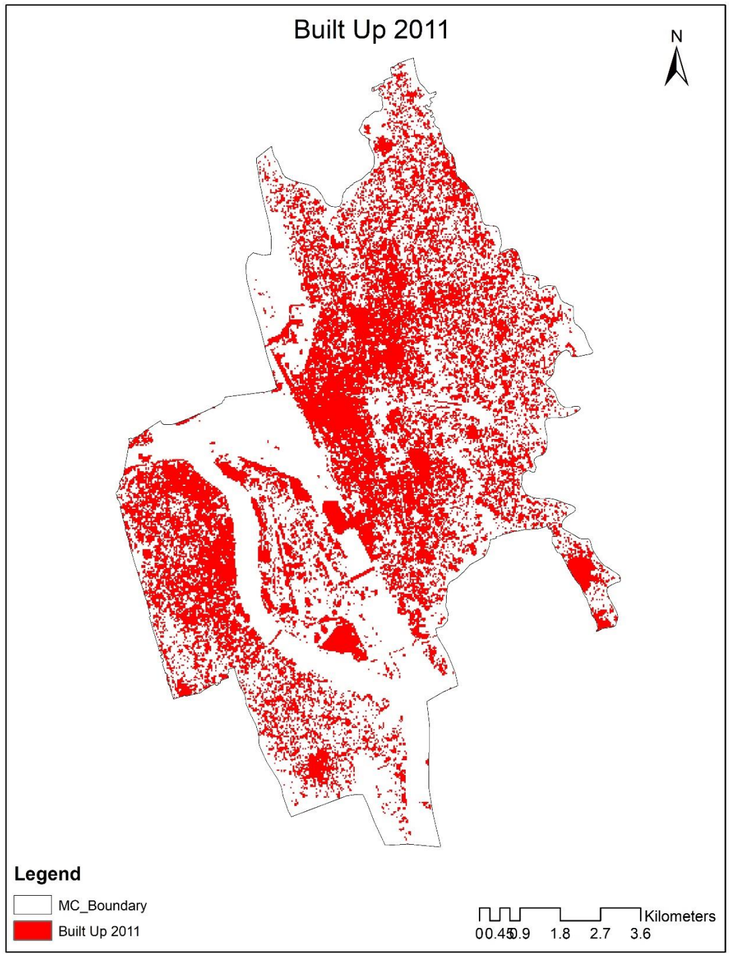
1. **Built-up**
   - Built-up 2001
   - Built-up 2011
   - Built-up 2021
2. **Thermal Load**
3. **Dynamic Potential**
4. **Urban Climatic Map**
5. **Urban Heat Island**

Urban Sprawl and Built-up

- **Urban sprawl** was studied in 2001, 2011, and 2021.
- Figure 4 shows that the built-up area has raised considerably in the last two decades.
- Due to emerging enterprises and commercial facilities, several vacant lands have been built up. Tree cover decreases with urbanisation.



(a)



(b)

(c)

Figure 4: Built-up (a)2001 , (b) 2011 (c) 2021

Land Surface Temperature

- The **radiative skin temperature** of the land derived from **solar radiation** is known as **land surface temperature (LST).**
- **LST** measures the **amount of thermal radiance emitted by the land surface** where incoming solar energy interacts with and heats the ground or the canopy surface in vegetated areas.
- The land surface temperature can be significantly influenced by **urbanisation**.
- As cities and towns grow, natural landscapes are often replaced with buildings, roads, and other impervious surfaces that absorb and store heat differently than vegetation and soil.
- This can result in what is known as the **urban heat island effect**, in which cities have higher temperatures than surrounding rural areas.
- **Kochi's development** has had a considerable effect on land surface temperature. According to satellite imagery analysis, the **LST in Kochi's urban regions** was around **35°C**, with a maximum of **36°C**, while it was around **31°C** in **rural areas**.

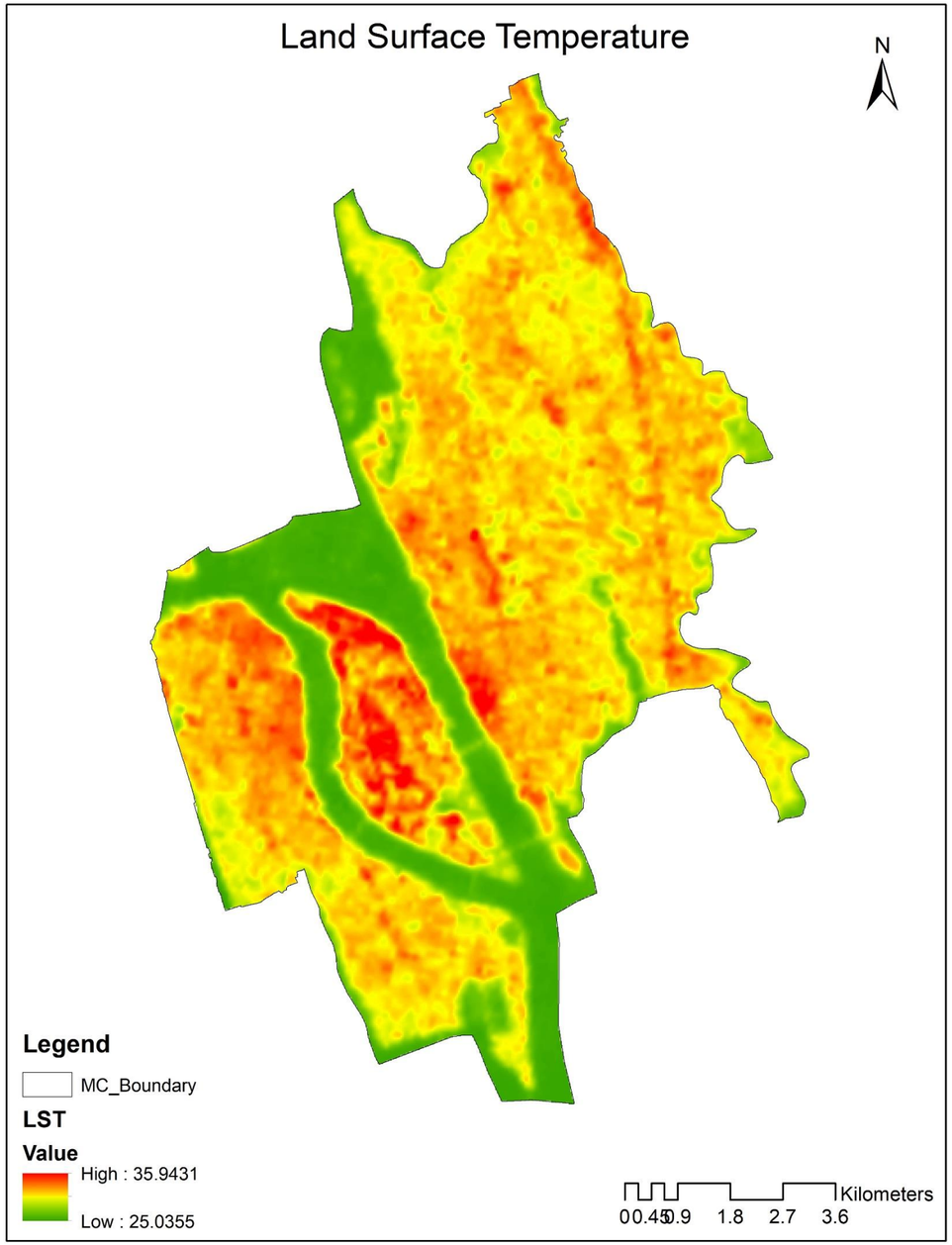


Figure 5: Land Surface Temperature

Thermal Load

- **Thermal load** in the context of **urban climate** refers to the quantity of **heat energy created** or **absorbed** by buildings, automobiles, and other sources in the urban environment.
- Because of the concentration of thermal load, this **can contribute to the urban heat island effect**, in which metropolitan regions suffer greater temperatures than surrounding rural areas

Factors affecting Thermal Load

Parameter	Scoring Range	Very low temperature	Low temperature	Moderate temperature	High temperature	Very high temperature
	Score	1	2	3	4	5
LST	Parameter Range	very high comfort	high comfort	moderate comfort	low comfort	very low comfort
	Value	25-27	27-28	28-29	29-31	31-36
NDBI	Parameter Range	very low NDBI	low NDBI	moderate NDBI	high NDBI	very high NDBI
	Value	<-0.23	-0.22--0.15	-0.14--0.078	-0.077--0.0046	-0.0045-0.29
Population Density	Parameter Range	very low population density	low population density	moderate population density	high population density	very high population density
	Value	[illegible]0-3200	3300-6400	6500-11000	12000-16000	17000-36000
Air Temperature	Parameter Range	very high comfort	high comfort	moderate comfort	low comfort	very low comfort
	Value	27.3-27.364	27.364-27.431	27.431-27.478	27.478-27.529	27.529-27.6
Topography	Parameter Range	very high topography	high topography	moderate topography	low topography	very low topography
	Value	0-0.86	.86-2.4	2.4-4.46	4.46-7.46	7.46-27.09

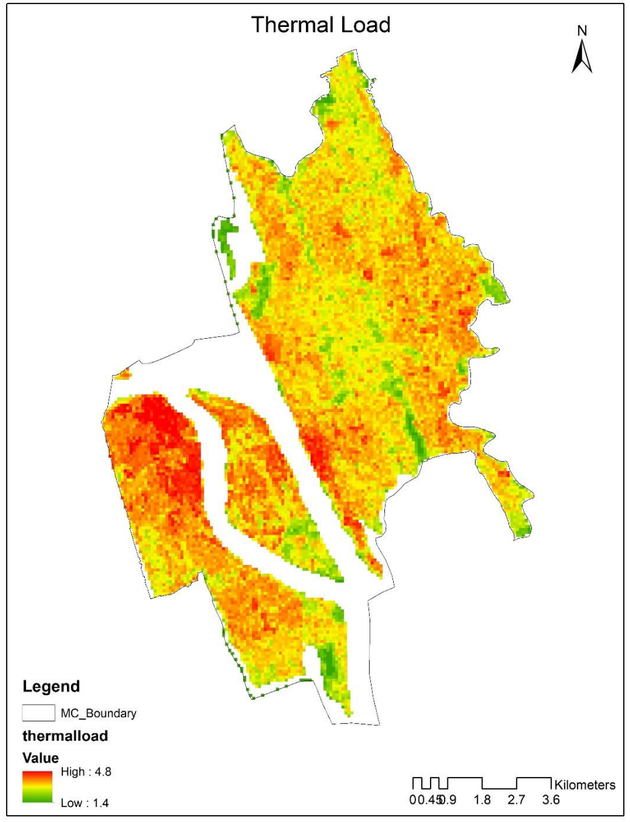


Figure 6: Thermal Load

Dynamic Potential

- The **capacity** of the **urban environment** to **adjust** and **react** to changing circumstances, such as variations in **temperature, precipitation, and other meteorological events**, is referred to as dynamic potential in the context of urban climate.
- This can involve using **green infrastructure**, like trees and **green roofs**, to offer shading and cooling, using **reflecting materials** to lessen heat absorption and creating smart buildings that can vary their thermal load based on outside circumstances.

Factors affecting Dynamic Potential

Parameter	Scoring Range	Very low temperature	Low temperature	Moderate temperature	High temperature	Very high temperature
	Score	1	2	3	4	5
NDVI	Parameter Range	very high NDVI	high NDVI	moderate NDVI	low NDVI	very low NDVI
	Value	0-0.86	0.86-2.4	2.4-4.46	4.46-7.46	7.46-27.09
NDWI	Parameter Range	very high NDWI	high NDWI	moderate NDWI	low NDWI	very low NDWI
	Value	-0.47--0.264	-0.264--0.18	-0.18--0.076	-0.076-0.054	0.054-0.179
Prevailing wind	Parameter Range	fresh breeze	moderate breeze	gentle breeze	light breeze	light air
	Value	2.6-2.82	2.82-2.89	2.89-2.96	2.96-3.02	3.02-3.12

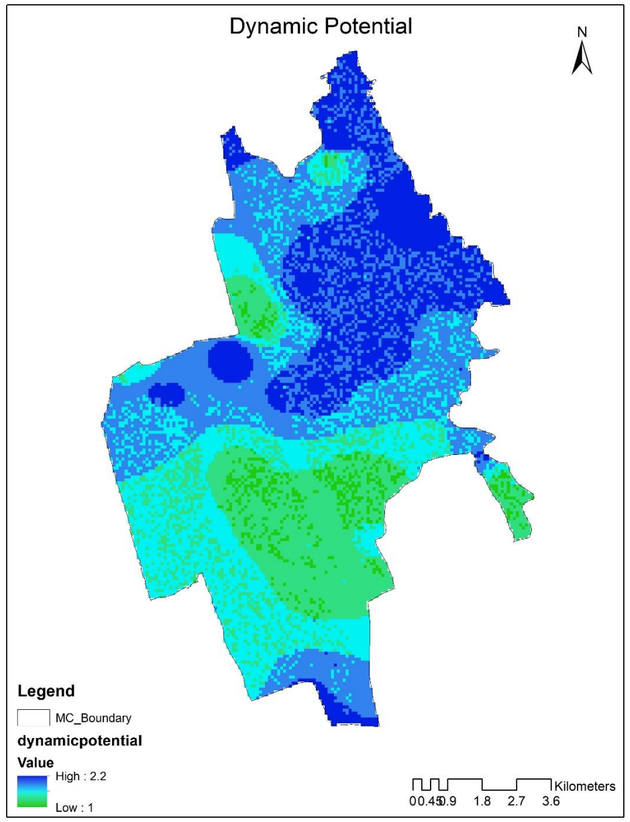


Figure 7: Dynamic Potential

Urban Climatic Map

- The **Urban Climatic map** has been synergized from the **dynamic potential** and **thermal load** values.
- The map shows the **sensitive areas** which need **planning intervention**.
- The map shows that parts of the areas in Kochi and on the western side of the mainland and some parts of Vytilla which is in the main **commercial hub** have **higher sensitivity** as compared to the other parts of the study region.

- The urban climatic map makes it clear that some areas of Fort **Kochi, Vytilla**, and some of the **eastern** sections of the study zone require intervention, such as parks and **green spaces**, the positioning of buildings to decrease heat gain, and the **orientation of streets** and **buildings to optimize ventilation.**

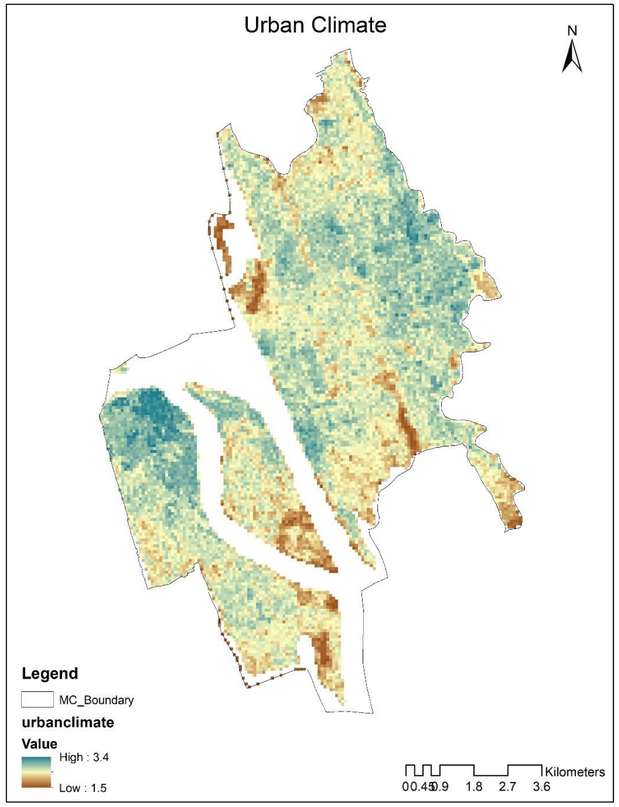


Figure 8: Urban Climatic Map

Urban Heat Island

- **Urban Heat Island** has been generated by utilizing the **land surface temperature**.
- According to analysis, Kochi's UHI impact is strong, with temperature disparities between **highland low-built-up regions** of up to **4-5°C** ranging from **33** to **26 degrees** in the **city limits**.
- The high **population density**, **urbanization**, and **development** are the **primary causes** of the temperature increase in Kochi.

- A **rise** in the **number of structures, paved** areas, and automobiles because of the city's recent **fast expansion** has increased the UHI impact.
- On the environment and people's health, the UHI effect in Kochi has several effects.
- It might result in **higher cooling** and air **conditioning energy usage**, which would raise **greenhouse gas emissions** and air pollution.
- The **maximum temperature zone** is on **Willington Island** which is a **cantonment area.**

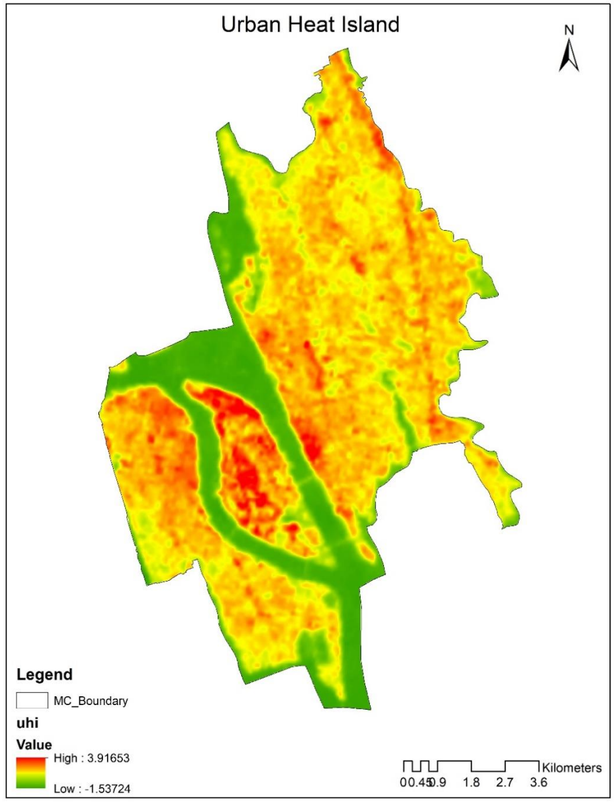


Figure 9 : Urban Heat Island

Urban Heat Island (UHI) Effect Identification:

- Satellite imagery analysis reveals a significant temperature difference between urban and rural areas in Kochi.
- Urban areas exhibit higher land surface temperatures (LST) compared to rural areas, indicating the presence of the UHI effect.

Key Regions Requiring Intervention:

- Specific areas such as Fort Kochi, Vytilla, and certain eastern sections show elevated land surface temperatures, highlighting the need for intervention measures.
- Recommendations include the establishment of parks and green spaces, strategic building placement, and optimization of ventilation through street and building orientation.

Impact of Urban Expansion:

- Rapid urbanization in Kochi has led to an increase in structures, paved areas, and automobile usage, intensifying the UHI effect.
- This expansion contributes to higher energy consumption for cooling and air conditioning, resulting in increased greenhouse gas emissions and air pollution.

Implications for Environment and Health:

- The UHI effect has various environmental and public health consequences.
- Elevated temperatures and increased energy demand for cooling contribute to climate change and worsen air quality, affecting both the environment and human health.

Identification of Hotspot Zones

- The highest temperature zone is observed on Willington Island, despite being a military area, emphasizing the need for intervention even in less densely populated regions.

Urgency of Intervention:

- Proactive urban planning and policy interventions are crucial to mitigate the UHI effect in Kochi.
- Implementing measures to enhance green spaces, optimize urban design, and reduce energy consumption can improve livability and sustainability while mitigating climate change impacts.

RECOMMENDATIONS AND CONCLUSION

- **Land use and land cover** is the upper most layer of the earth which is very dynamic **due to anthropogenic activities, climate change and natural phenomenon.** Forest and vegetation land are very essential for life, but an **overwhelming population is hammering the natural environment and increase the CO2 level, global warning, and air pollutant and affected our biodiversity.**

- **Remote sensing and GIS techniques** are widely used to identifying the **land dynamics** over an area. This study is to mapping, monitoring and analysis of land use and land cover change and urban expansion over Kochi city, Kerala in India.

- The **Urban Climatic Map** in Kochi reveals the **impact of built-up areas** and other factors on the **formation of heat islands** and **climate-sensitive zones**.

- The **city center region** has the highest **anthropogenic activity intensity**, while open, sparsely built areas have lower temperatures. Differences between **low and high built-up** regions are **4-5°C** due to **urban heat island pockets**.

- **Shade trees**, **shrubs**, vines, grasses, and ground cover cool the metropolis. Leaves and branches limit solar energy reaching the canopy.

- In summer, **10 to 30%** of the sun's energy reaches the area under a tree, with the rest absorbed by leaves for photosynthesis and reflected into the sky. Forests and plants "transpire" water through their roots and leaves. **Evapotranspiration** cools air by evaporating water using air temperature.

- **Evapotranspiration** alone or with shade can **lower peak summer air temperatures**, according to research.

- The **highest air temperatures in tree groves are 5 °C lower than on open land**, irrigated **agricultural fields** are **3 °C** lower than bare ground, and **suburban areas** with mature trees are at **2 to 3 °C lower levels**. Cooler than **new suburbs without trees**, while grass sports grounds are **1 to 2 °C cooler.**

- **Green roofing**, a vegetative covering on a roof, helps reduce urban heat by shading surfaces and cooling the air through evapotranspiration. It can be installed on various buildings, while cool roofing, made of highly reflective and emissive materials, can reduce heat islands generated by multiple hot roofs.

- **Cool roofs** reduce energy usage, air pollution, greenhouse gas emissions, and human comfort but may be more expensive than standard roofing materials.

- A huge number of **public vehicles and industrialization** are increased the **air pollutant related problem** and directly affected public health. This study can be considered as a strategic guide for an **urban planner, administrative authorities to build future planning and urban expansion** to enable them for **sustainable city planning and balance between urban expansion and ecological environmental conservation.**

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