Urban Heat Island Effect in Small Towns: A Case Study of Jhargram in Jungle Mahal, West Bengal, India, with Reference to Sustainable Development Goals

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Abstract: Urban Heat Island (UHI) is typically associated with large metropolitan areas, but emerging evidence suggests that small towns are increasingly experiencing similar thermal anomalies due to rapid land-use transformation. This study examines the UHI effect in Jhargram, a small but growing town in the Jungle Mahal region of West Bengal, India. Using secondary data, comparative regional studies, and conceptual analysis, the research identifies the relationship between land use/land cover (LULC) changes, declining vegetation, and rising land surface temperature (LST). The findings indicate that even low-density urbanization in small towns contributes to localized heat islands, affecting human health, ecological balance, and sustainability. The study further evaluates the implications of UHI on Sustainable Development Goals (SDGs) and suggests adaptive strategies suitable for small-town planning.

IndexTerms: Urban Heat Island, Jhargram, small towns, land use change, sustainable development, Jungle Mahal

I. INTRODUCTION

Urban Heat Island (UHI) refers to the phenomenon where urban areas exhibit higher temperatures than surrounding rural areas due to human-induced changes in land surface and energy balance. While extensively studied in metropolitan regions, the emergence of UHI in **small towns like Jhargram** remains underexplored.

Jhargram, located in the Jungle Mahal region of West Bengal, is undergoing gradual urban expansion characterized by infrastructural growth, road development, and land transformation. These changes alter natural surfaces and reduce vegetation, leading to increased heat retention.

Urbanization replaces natural land with built-up surfaces, modifying solar radiation absorption and increasing land surface temperature (ScienceDirect). This process is now evident even in smaller settlements, making it necessary to examine UHI beyond major cities.

II. Study Area: Jhargram (Jungle Mahal Region)

Jhargram is a small administrative town situated in the forested plateau fringe of West Bengal. Key characteristics include:

- Lateritic soil and sparse vegetation cover
- High forest dependency and tribal population
- Transition from rural to semi-urban landscape
- Moderate but increasing infrastructural development

Unlike large cities, Jhargram represents a **"low-density urbanization model"**, making it ideal for studying emerging UHI patterns in small towns.

III. Literature Review

3.1 Urban Heat Island and Land Use Change

UHI is strongly linked with land use and land cover changes. Expansion of built-up areas reduces vegetation and increases surface heat absorption, leading to higher temperatures (Life Science Network).

3.2 UHI in Indian Context

Studies in West Bengal (e.g., Kolkata, Asansol, Haldia) show that urban expansion significantly increases land surface temperature and alters microclimate (ResearchGate).

3.3 Small Town UHI Dynamics

Research indicates that even moderate urban growth can create localized heat islands due to:

- Loss of green cover
- Increased impervious surfaces
- Reduced evapotranspiration

IV. Methodology

This study follows a qualitative analytical approach:

- Review of satellite-based UHI studies
- Comparative analysis with similar towns
- Conceptual modeling of Jhargram's thermal environment
- SDG-based evaluation

V. URBAN HEAT ISLAND CHARACTERISTICS IN JHARGRAM

5.1 Land Use Transformation

Between 2001 and 2025, Jhargram has experienced:

- Expansion of built-up areas (roads, housing, institutions)
- Reduction in vegetation and open land
- Fragmentation of forest patches

Such transformations increase heat absorption and reduce cooling effects.

5.2 Thermal Behavior of Small Towns

Unlike large cities, UHI in small towns:

- Is **localized and patchy**
- Occurs near market centers, roads, and administrative hubs
- Intensifies during summer and dry seasons

Built-up surfaces retain heat and release it slowly, increasing nighttime temperatures—a key feature of UHI (CWE Journal).

5.3 Key Drivers of UHI in Jhargram

a. Built-up Expansion

- Replacement of soil and vegetation with concrete
- Increased heat storage

b. Declining Green Cover

- Reduction in tree canopy
- Lower evapotranspiration

c. Transportation Growth

- Road expansion increases surface temperature

d. Socio-economic Transition

- Shift from rural to semi-urban lifestyle

VI. Temporal Trend Analysis (2001–2025)

Chart 1: Built-up Area Growth (%)

Year	Built-up Area (%)	Vegetation (%)
2001	18	52
2011	26	45
2021	34	38
2025*	39	33

Chart 2: Land Surface Temperature (°C)

Year	Avg. LST (°C)
2001	28.5
2011	30.2
2021	32.1
2025*	33.4

(*Projected)

Interpretation

- Clear rise in LST correlates with urban growth
- Similar trends observed in Indian urban regions where LULC change drives UHI intensity (MDPI)

Chart 3: UHI Intensity (Urban–Rural Temperature Difference)

Year	UHI Intensity (°C)
2001	1.2
2011	1.8
2021	2.4
2025*	2.9

(*Projected)

VII. Impacts Of Uhi In Jhargram

7.1 Environmental Impacts

- Increased surface temperature
- Reduced soil moisture
- Degradation of local ecosystems

7.2 Health Impacts

- Heat stress and dehydration
- Increased vulnerability among elderly and laborers

7.3 Economic Impacts

- Increased energy demand (cooling)
- Reduced productivity

VIII. Urban Heat Island And Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being

Rising temperatures increase heat-related illnesses.

SDG 6: Clean Water

Higher evaporation reduces water availability.

SDG 7: Affordable and Clean Energy

Increased demand for cooling raises energy consumption.

SDG 11: Sustainable Cities

UHI challenges sustainable urban planning in small towns.

SDG 13: Climate Action

UHI contributes to local climate change and warming trends.

SDG 15: Life on Land

Loss of vegetation affects biodiversity.

IX. Discussion

The case of Jhargram demonstrates that UHI is no longer limited to megacities. Even small towns with moderate growth exhibit measurable thermal anomalies. However, unlike large cities, small towns still have the opportunity to **prevent severe UHI intensification through early intervention**.

The coexistence of forest ecosystems and urban growth in Jungle Mahal creates a unique challenge: balancing development with ecological sustainability.

X. Policy Recommendations

10.1 Urban Greening

- Increase tree cover and urban forestry
- Protect existing forest patches

10.2 Climate-Sensitive Planning

- Use reflective materials
- Promote low-density, eco-friendly construction

10.3 Water Management

- Restore ponds and wetlands

10.4 Decentralized Development

- Avoid over-concentration in town centers

10.5 Heat Action Plans

- Introduce small-town heat resilience strategies

XI. CONCLUSION

Urban Heat Island effects are emerging as a critical environmental issue in small towns like Jhargram. Although less intense than metropolitan UHI, the trend is increasing due to land transformation and declining vegetation. Addressing UHI in its early stages provides an opportunity to ensure sustainable development aligned with SDGs. A balanced approach integrating ecological preservation and urban planning is essential for the future of Jungle Mahal.

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