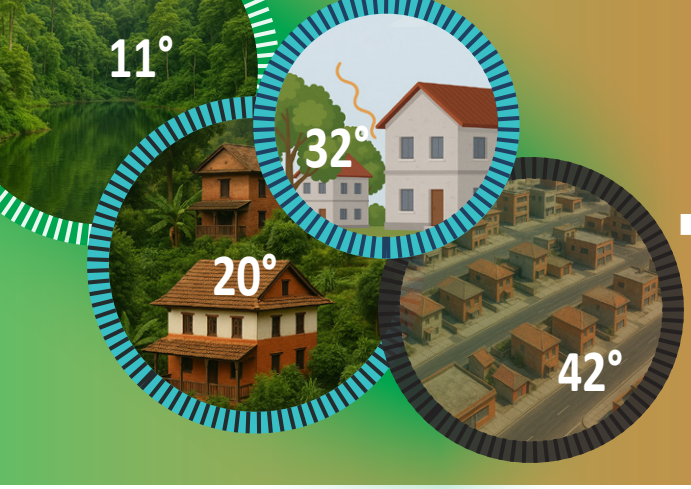


POLICY BRIEF

ADDRESSING THE URBAN HEAT ISLAND EFFECT

INTRODUCTION

The Urban Heat Island (UHI) effect occurs when urban areas become significantly warmer than surrounding rural areas, often by 2°C to 10°C, particularly at night. The phenomenon is primarily caused by replacing natural surfaces with heat-absorbing materials such as concrete, asphalt, and buildings, which store solar energy during the day and release it slowly at night. Densely built zones experience the highest heat, and UHI effect intensifies heat stress, worsening public health. Reducing vegetation eliminates the natural cooling effect of evapotranspiration, while urban geometry traps heat and reduces air circulation.

It contributes to discomfort; vulnerable groups such as the elderly, children, and individuals with pre-existing health conditions who cannot effectively regulate their body temperature. Additionally, UHI effect amplifies climate change impacts, leading to more frequent heat waves and declining air quality. Additionally, UHI effect creates localized microclimates that can disrupt local weather patterns and ecosystem functioning.

STUDY AREA

Changunarayan Municipality in Bhaktapur District, Bagmati Province, is part of the Kathmandu Valley urban zone. It borders several municipalities and is home to the UNESCO-listed Changunarayan Temple. Rapid urban growth since the 1990s has made it a key area for examining UHI effect on Nepal.

METHODOLOGY

This study adopted a socio-ecological framework, recognizing urban areas as complex adaptive systems shaped by social and ecological factors. A political-economic perspective was integrated with scientific methods to assess current impacts and anticipate future scenarios.

The research progressed in three phases: a literature review and impact mapping, stakeholder engagement and institutional assessment, and finally, spatio-temporal analysis with future projections.

Landsat satellite imagery from 1994, 2004, 2014, and 2024 was used to analyze urban heat and vegetation patterns during peak heat months, capturing critical changes linked to Kathmandu Valley's rapid urbanization since the 1990s. Two key indicators were employed to assess UHI effect intensity:

Normalized Difference Vegetation Index (NDVI)

This measure quantifies vegetation density and health, which is crucial for UHI effect assessment because vegetation provides natural cooling through evapotranspiration and shade. Areas with declining NDVI values indicate vegetation loss, which directly contributes to increased surface temperatures and UHI effect formation.

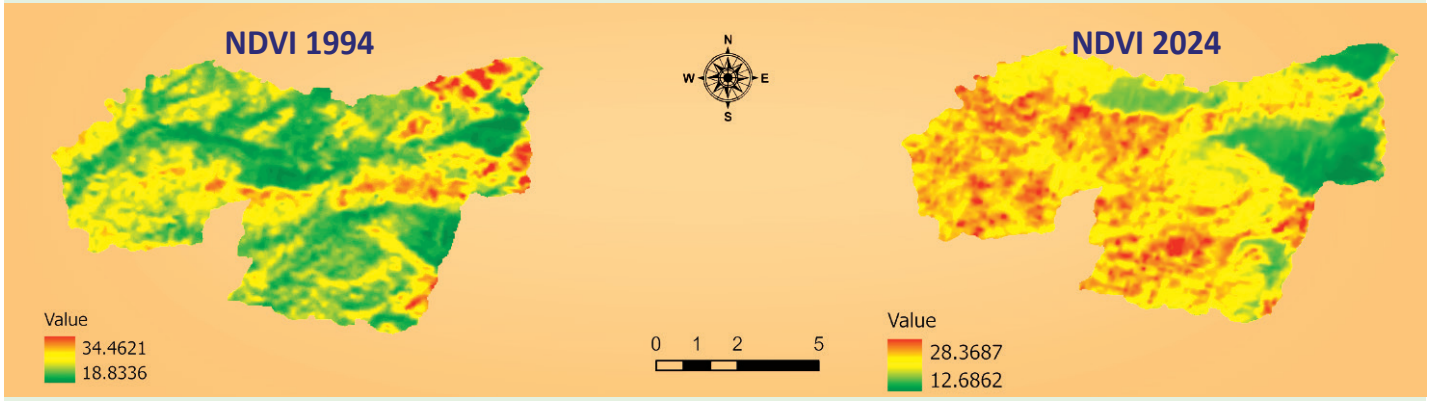
Land Surface Temperature (LST)

This indicator measures the temperature of the Earth's surface as detected by satellite sensors. LST is a primary metric for UHI effect assessment because it reveals the actual thermal conditions experienced in urban areas compared to surrounding regions, showing how built surfaces absorb and retain heat more effectively than natural surfaces.

KEY FINDINGS

Vegetation Cover Decline

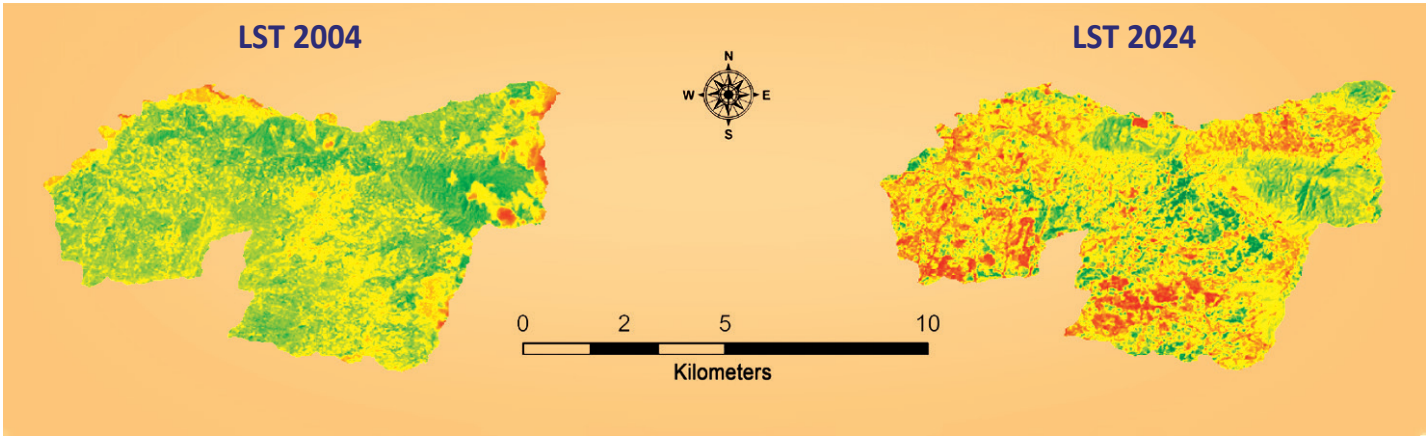
Using the Normalized Difference Vegetation Index (NDVI), the study found a significant decline in vegetation cover over 30 years. Quantitatively, the mean NDVI index dropped by approximately 0.16, indicating a substantial loss of vegetative cover and increased built-up areas. This decline in vegetation cover directly contributes to UHI effect formation by eliminating natural cooling mechanisms and replacing them with heat- absorbing surfaces.



NDVI in high vegetation density

NDVI in low vegetation density

YEAR	VEGETATION COVER DECLINE	NDVI CHARACTERISTICS
1994	Ecologically abundant landscape with extensive green coverage	High NDVI values across the municipality
2004	Initial urban encroachment causing notable reduction in green areas, particularly in central and lower regions	Moderate decline in NDVI, concentrated in development zones
2014	Green spaces fragmented further, with some small patches of regrowth in the municipality's middle east area	Continued NDVI decline with isolated patches of recovery
2024	Dramatic reduction in green areas, with urban zones expanding and vegetation becoming isolated patches	Significant NDVI reduction, indicating widespread vegetation loss



Low Land Surface Temperature (LST)

High Land Surface Temperature (LST)

Environmental Challenges

The region faces growing environmental challenges, including agricultural deforestation, waterlogging, and urban growth. This has led to land degradation through soil erosion and desertification, reducing productivity.

Climate change further disrupts ecosystems through shifting temperature and rainfall patterns. Rising Land Surface Temperature (LST) trends highlight escalating environmental stress and signal emerging threats to long-term sustainability.

LST analysis

LST analysis revealed a complex temperature trend over time. From 1994 to 2004, maximum LST rose sharply from 23.25°C to 34.46°C, reflecting rapid warming linked to urban growth and vegetation loss. After 2004, temperatures decreased slightly, stabilizing around 28°C by 2014 and 2024.

This modest cooling may reflect short-term environmental influences or data variability. Nonetheless, the overall trend indicates increased surface heat stress, highlighting ongoing thermal vulnerability in the municipality due to long-term urbanization and ecological changes.

Population Vulnerability

Around 37% of Changunarayan's population is highly vulnerable to heat stress, particularly children under 15 and elderly residents over 70. These groups cannot regulate body temperature, increasing their risk of heat-related illnesses such as dehydration, heat stroke, and the aggravation of chronic conditions.

The UHI effect further exacerbates these risks due to concrete and asphalt heat retention, lack of greenery, poor airflow, and persistent nighttime warmth, all threatening public health and resilience in the area.

Institutional and Data Challenges

The UHI effect is still a relatively unfamiliar concept for people in Changunarayan, with limited awareness and understanding. Local monitoring focuses mainly on air quality, particularly PM2.5, while heat exposure and health impacts remain untracked.

Financial and technical constraints prevent field data collection on soil moisture or surface permeability, leading to dependence on satellite imagery. Health systems also lack protocols for heat-related illness. Although heat stress is recognized in Nepal's southern plains, it remains underappreciated locally despite growing risks.

CONCLUSION

Rapid urbanization in Changunarayan Municipality has led to substantial vegetation loss and rising surface temperatures, intensifying the UHI effect and heightening health risks for vulnerable groups. Mitigating UHI effect demands integrated urban planning, investment in green infrastructure, robust monitoring, and active community participation. South Asian cities like Kathmandu, Dhaka, and Delhi face similar challenges. Without proactive action, UHI effect will worsen urban hardships and social inequality. A multi-level governance approach supported by data, financing, and inclusive planning is key to creating cooler, healthier, and more resilient cities.

POLICY RECOMMENDATIONS

Expand and Safeguard Green Infrastructure

In line with the National Climate Change Policy (2019), Changunarayan's 2081/82 programs, and Municipality's Environment & Natural Resource Conservation Act (2077 BS), focus on developing and protecting urban parks, street tree networks, and green roofs. Strengthen zoning and community-led greening initiatives to reduce heat exposure and maintain natural buffers.

Integrate UHI effect mitigation into urban planning

Revise municipal land-use plans and building regulations under the Land Use & Management Act (2077 BS) and the 2019 Risk-Sensitive Land Use Plan to require high heat reflect surfaces, permeable pavements, cool roofs, and strategic shading in new and redeveloped areas.

Enhance Monitoring and Research Capacity

Establish an in-city climate monitoring network, supported by the national mandate from the National Climate Change Policy (2019) and the Environment Protection Act (2076 BS). Collaborate with universities and research organizations to monitor surface temperature, health outcomes, and soil moisture.

Raise Awareness & Build Institutional Capacity

Implement public education and official training programs on UHI effect, climate resilience, and heat-health emergency protocols. Use mandates in the National Climate Change Policy and the Environment Protection Act to incorporate these activities into routine municipal operations.

Protect Vulnerable Populations

Within the DRR&M Act framework, develop specific heat action plans for children, the elderly, and patients with pre-existing conditions. These plans should include early warning systems, designated cooling centers, and community-first response protocols.

Strengthen Cross-Level Collaboration

Institutionalize collaboration through existing federal-provincial-local mechanisms established under the National Climate Change Policy and DRR&M Act. Seek coordinated funding support and technical resources from provincial bodies and international development partners.

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