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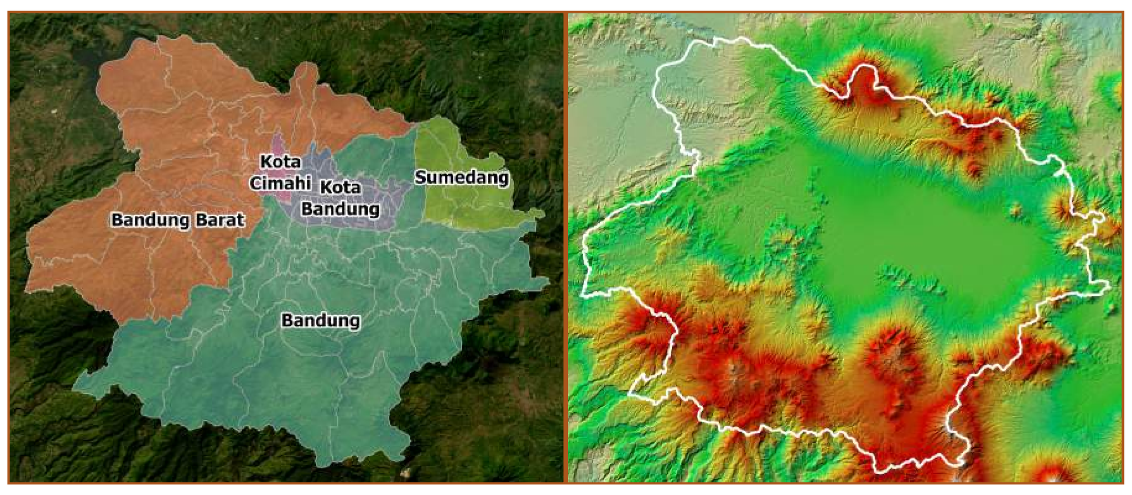
# The Heat That Hides: Silent Surge in the Bandung Basin's Temperature

Take a Look at The Story Maps !!!

## Background

**Global warming** is intensifying, with 2024 recorded as Indonesia's hottest year (+0,8°C anomaly), a crisis amplified in cities by the **Urban Heat Island (UHI) effect**. However, current mitigation relies on generalized **policies** such as the blanket "30% Green Open Space" target which **fail to address local nuances**. A dense urban core requires different cooling strategies than a rapidly developing fringe.




Bandung Basin Area

**The Bandung Basin Area**, a National Strategic Area (KSN) enclosed by mountains, faces a critical tipping point. **Explosive development** between 2013 and 2023 has massively converted green spaces into concrete, threatening to turn the basin into a permanent "heat trap". This study argues that normative, "one-size-fits-all" approaches are ineffective; resilient mitigation demands **spatially adaptive strategies** tailored to the unique drivers of each local microclimate.

## Literature

### Key Concepts

1. **Local Extreme Heat (LEH)**: Defined not by a fixed temperature, but as a heatwave event exceeding the 90th percentile of historical max temperatures for at least 3 consecutive days.
2. **Surface Urban Heat Island Intensity (SUHII)**: The standard measure of the thermal gap between urban surfaces (LST urban) and the rural baseline (LST rural).
3. **ΔSUHII (The Thermal Surge)**: The core metric of this study. It isolates vulnerability by quantifying how much the heat island intensity amplifies during extreme events compared to normal conditions.

$$SUHII_t = LST_t - \frac{1}{M}\sum_{j=1}^{M} LST_{j,t}$$

$$SUHII_{LEH} = \frac{1}{T}\sum_{t\in T} SUHII_t$$

$$SUHII_{Non-LEH} = \frac{1}{T'}\sum_{t\in T'} SUHII_t$$

$LST_t$ = Land Surface Temperature on the day $t$ (°C)
$j$ = Rural grids
$M$ = Number of rural grids
$T$ = Number of days of LEH conditions
$T'$ = Number of days of Non-LEH conditions

$$\Delta SUHII_{LEH} = SUHII_{LEH} - SUHII_{Non-LEH}$$

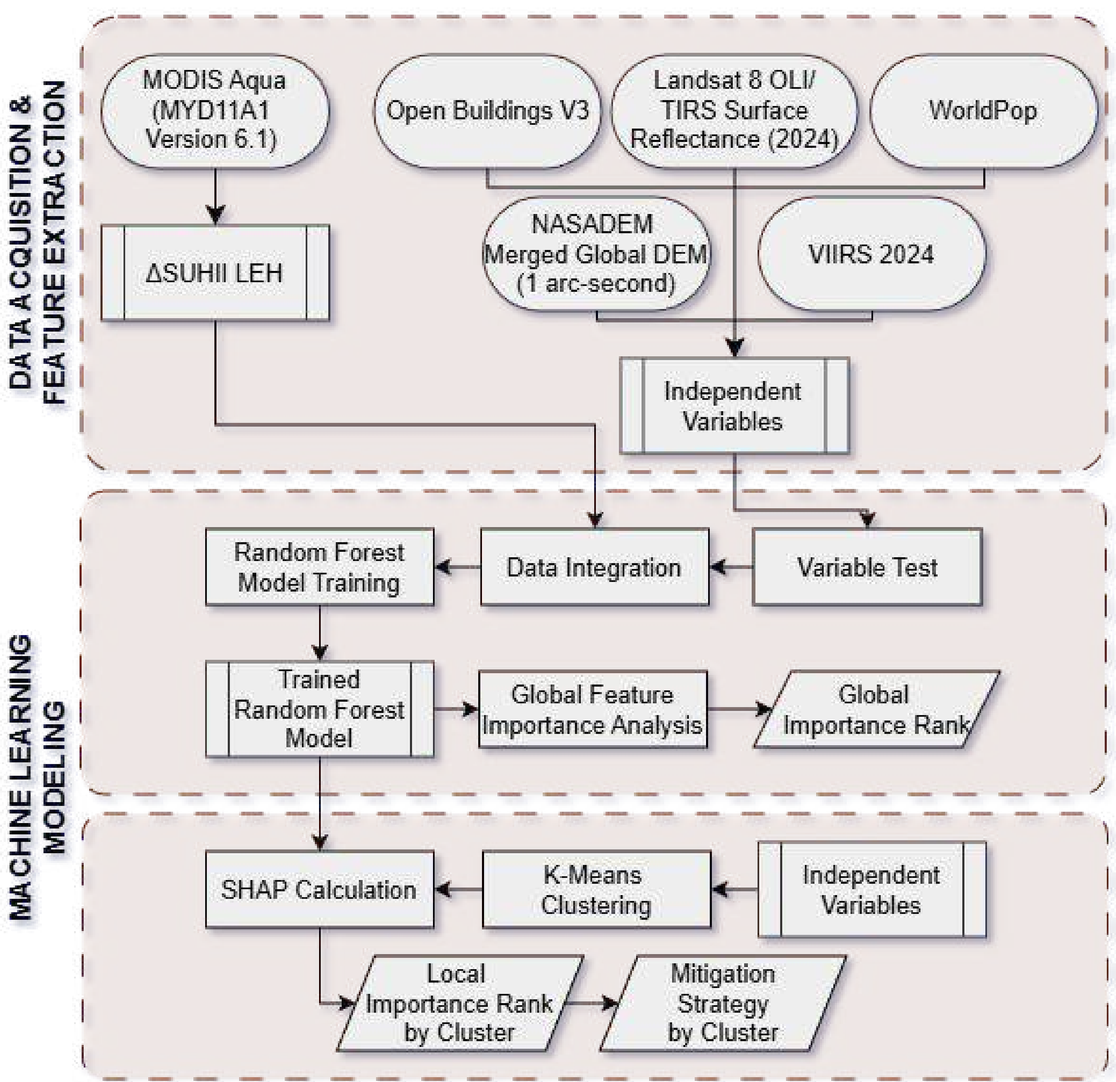
ΔSUHII Calculation Formula

### Independent Variable

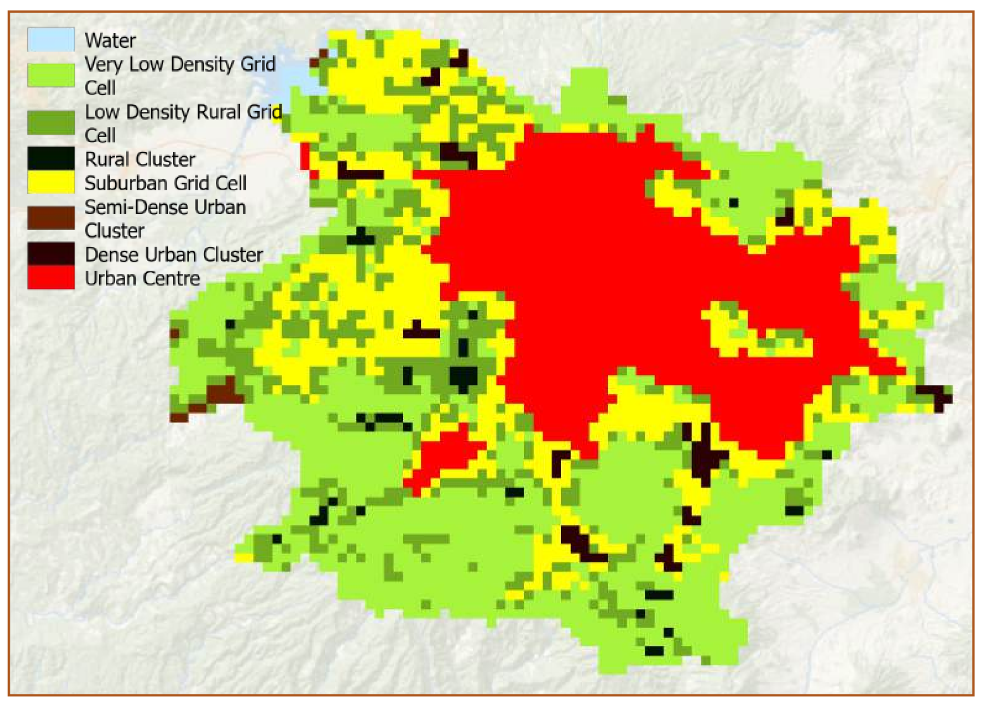
1. **Biophysical Environment**: Captures natural thermal regulators using Elevation, **NDVI (vegetation health), and NDWI (surface moisture)**.
2. Urban Morphology: Represents the city's 3D physical form and heat-trapping capacity via **Building Density and Building Height**.
3. Socio-economic: Proxies anthropogenic intensity and energy consumption using **Night-Time Lights (NTL) and Population Density**.

## Analysis & Results

### Overall Analysis Flowchart



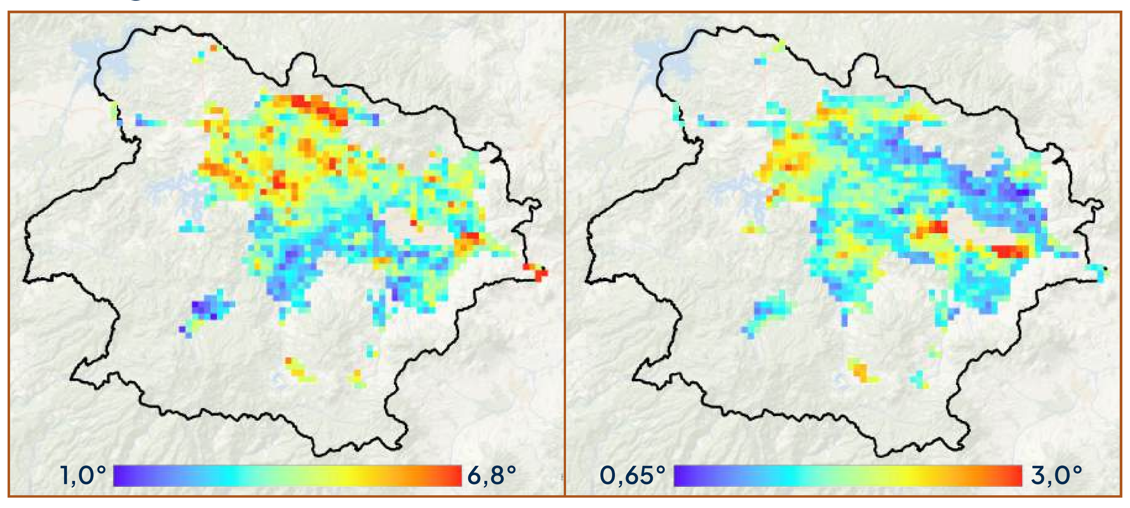

### Urban – Rural Segmentation




Map of Degree of Urbanisation

To establish a precise baseline for SUHII calculation, the study segmented the basin using the **Degree of Urbanisation** (DoU) method. The **Urban category** aggregates the **Urban Centre and Dense Clusters**, while the Rural reference encompasses all remaining low-density areas. This strict binary classification ensures that thermal anomalies are measured against a valid non-urbanized standard.

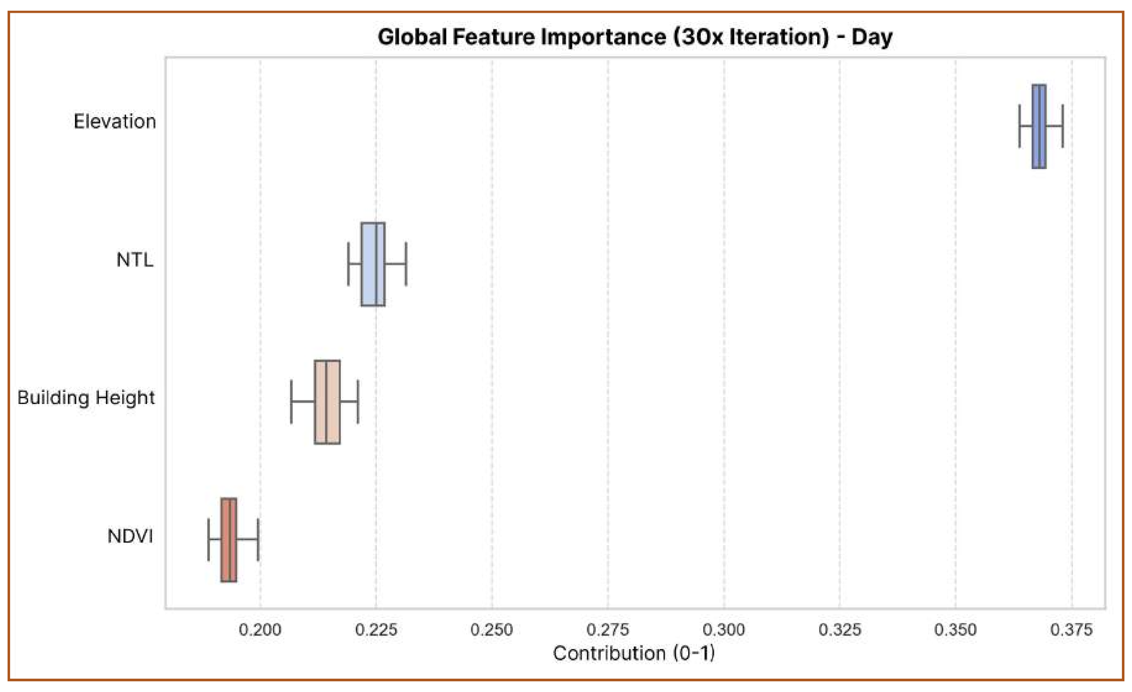
### Change of SUHII in LEH Condition



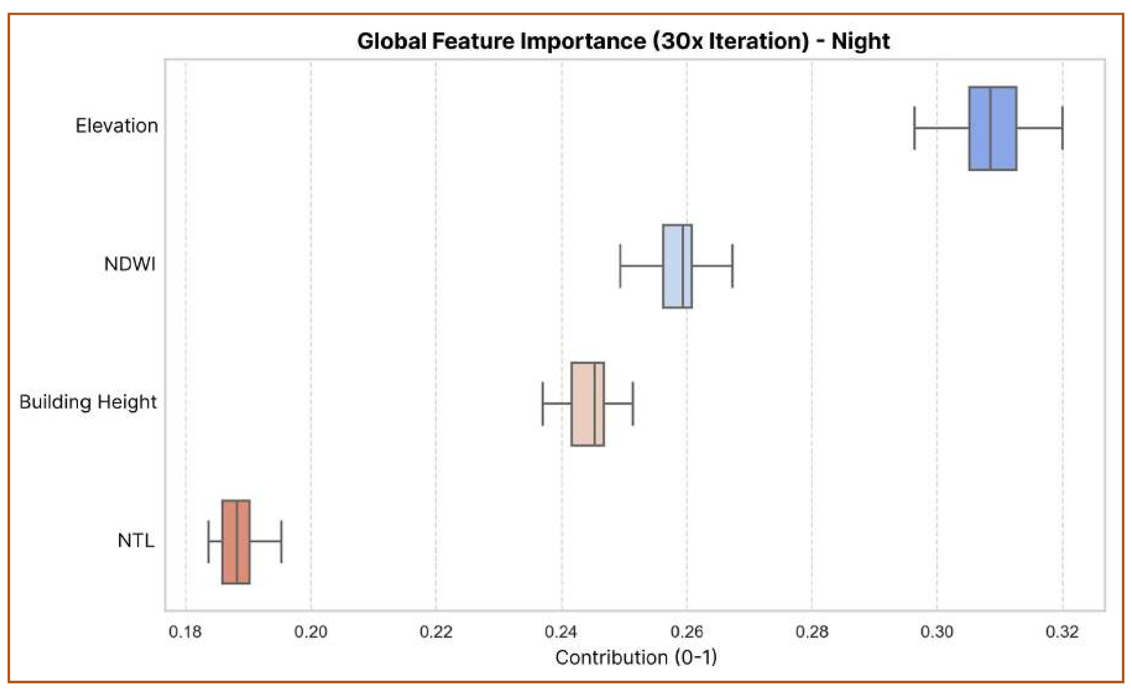

Map of Daytime ΔSUHII    Map of Nighttime ΔSUHII

**Thermal Surge Analysis (ΔSUHII)** The analysis isolates a massive thermal amplification during extreme events, with **Daytime ΔSUHII skyrocketing by up to 6,76°C** due to aggressive solar trapping. **Nighttime** dynamics reveal a sharp spatial contrast, where the urban core retains significant heat **(surge up to 2,97°C)** while peripheral areas remain stable (0,60°C), confirming that the built environment actively acts as a thermal amplifier under climate stress compared to the surrounding rural landscape.

### Random Forest Model



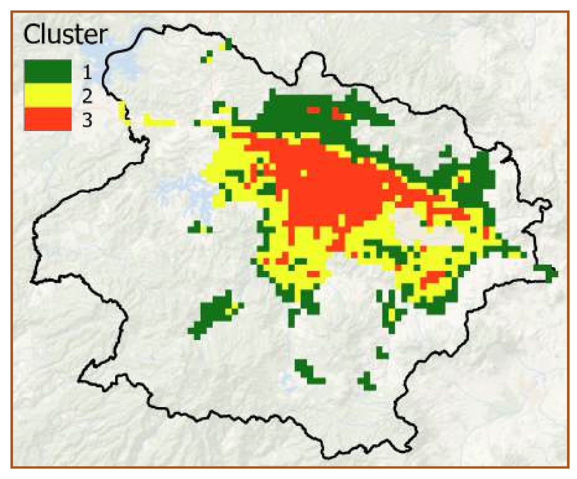

Global Feature Importance – Day




Global Feature Importance – Night

**The Random Forest analysis** confirms that **Elevation** is the **paramount thermal dictator** across the basin. However, a critical temporal shift occurs in secondary drivers. **Daytime** heat is driven by **anthropogenic intensity**, where **NTL (0.225) and Building Height (0.214)** override vegetation effects to trap solar radiation. Conversely, **Nighttime** dynamics shift toward biophysical regulation; **NDWI (0.259)** emerges as the second most influential factor, proving that surface moisture rather than urban form alone is the primary governor of nocturnal heat release.

### K-Means Clustering




Map of Cluster

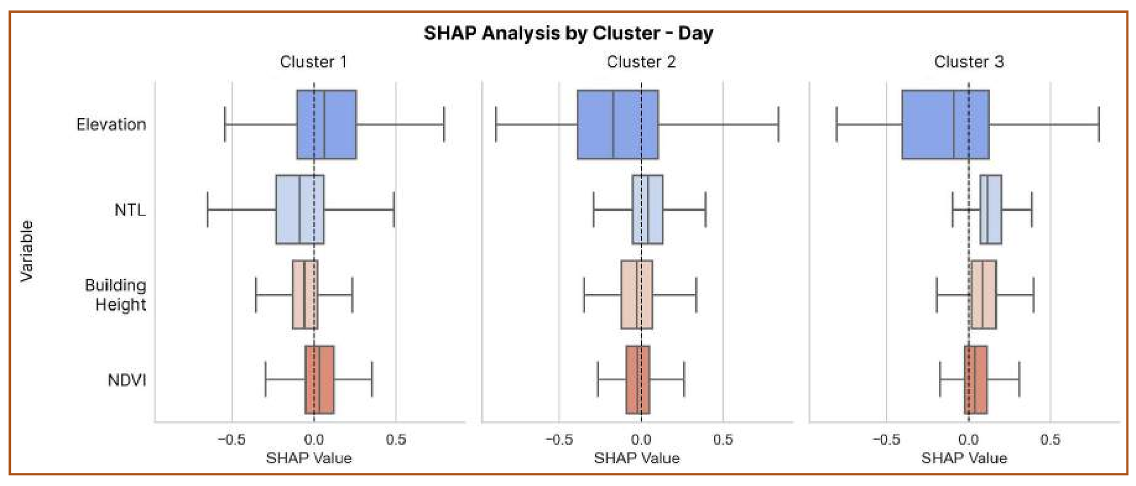
The K-Means algorithm successfully **segmented** the Bandung Basin into **three distinct microclimates** based on biophysical and anthropogenic signatures:

1. **Cluster 1 (Highlands)**: The natural cooling engine, characterized by high elevation, dense vegetation (High NDVI), and minimal development.
2. **Cluster 2 (Peri-Urban)**: The transitional buffer zone with moderate density, currently facing the highest risk of land conversion.
3. **Cluster 3 (Urban Core)**: The heat center, defined by high Building Density, intense Night-Time Lights (NTL), and critically low moisture levels.

| Cluster | Elevation | NDWI | NDVI | Building Height | Population Density | NTL | Building Density |
|---|---|---|---|---|---|---|---|
| 1 | 913,30 | -0,61 | 0,64 | 2,63 | 27,56 | 4,94 | 0,10 |
| 2 | 655,05 | -0,49 | 0,50 | 4,09 | 48,84 | 9,33 | 0,18 |
| 3 | 718,55 | -0,37 | 0,33 | 8,93 | 131,17 | 22,89 | 0,43 |

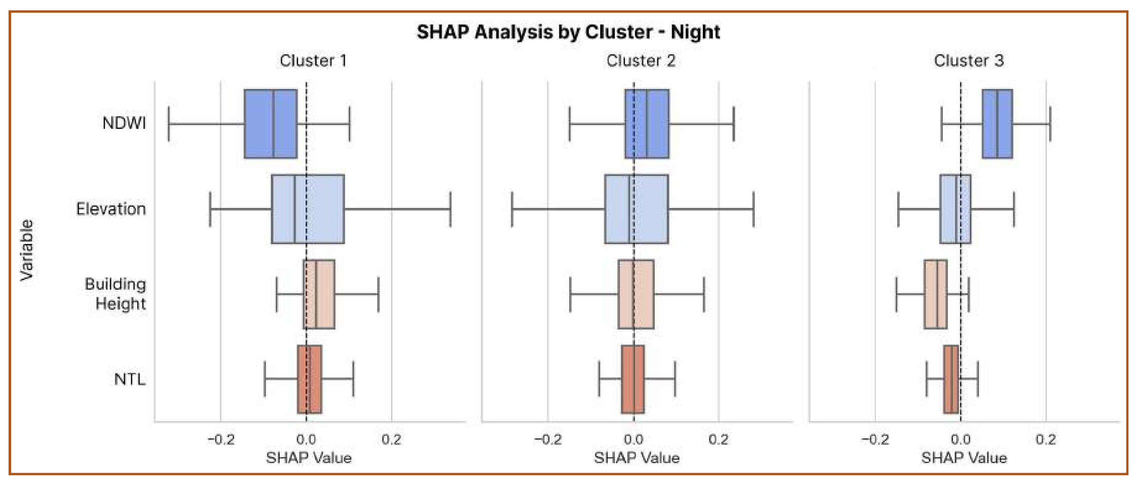
Cluster Characteristics

### SHAP Analysis by Cluster




SHAP Analysis by Cluster – Day

**Daytime SHAP** Analysis The analysis reveals a sharp mechanism split. In the **Urban Core (Cluster 3)**, heat is unequivocally anthropogenic, driven by **Night-Time Lights (+0.139) and Building Height (+0.107)** which actively trap solar radiation. In contrast, the **Highlands (Cluster 1)** are governed by **Elevation (+0.111)**, confirming that natural topography rather than land cover dictates the thermal baseline in non-urbanized zones.




SHAP Analysis by Cluster – Night

**Nighttime SHAP** Analysis Nocturnal heat is dictated by thermal inertia rather than structure. In the **Urban Core (Cluster 3)**, the primary driver is surface dryness **(NDWI +0.083)**, which actively prevents cooling. This dynamic flips in the **Highlands (Cluster 1)**, where high moisture acts as a powerful cooling agent **(NDWI -0.096)**, while sparse structures **(Building Height +0.037)** surprisingly emerge as localized heat traps in the open landscape.

## Recommendations

1. **Cluster 1**: **Rural Preservation** (Highlands) Focus on Conservation. Enforce strict **Agroforestry Zoning** to maintain the **regional cooling buffer (NDVI)** and implement **Low-Impact Development limits** on building massing to prevent the formation of nocturnal heat traps.
2. **Cluster 2**: **Smart Growth Control** (Peri-Urban) Focus on Density Management. Mandate **Green Corridors** and **building setbacks** to break the continuity of thermal accumulation, alongside **Smart Lighting Standards** to minimize emerging anthropogenic heat emissions (NTL).
3. **Cluster 3**: **Urban Retrofitting** (Urban Core) Focus on Surface Modification. Combat daytime heat with **Vertical Greening and Cool Roofs** to reduce solar absorption. For nighttime cooling, prioritize **Water Sensitive Urban Design (WSUD)** such as permeable pavements to restore surface moisture and lower thermal inertia.