Analiysis of Environmental Criticallity Index (ECI) in Bandung Basin Using Remote Sensing

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Abstract: *The Bandung Basin is experiencing intensive land cover change and surface temperature dynamics due to massive population growth and infrastructure development. This study aims to analyze the Environmental Criticality Index (ECI) to identify the spatial patterns of environmental criticality using Landsat 5 TM and 9 OLI/TIRS imagery from 2009 and 2024. The parameters used include Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-Up Index (NDBI), and Modified Normalized Difference Water Index (MNDWI), which are integrated into the ECI model. The analysis results show a significant increase in surface temperature from a range of 8–38 °C in 2009 to 13–40 °C in 2024, accompanied by the expansion of built-up areas into peripheral regions and a decrease in vegetation cover. This condition drives a surge in areas with high to very high levels of environmental criticality, increasing from 2,305.96 ha to 13,094.06 ha, and from 61.51 ha to 129.77 ha, respectively, within the same period. Critical zones are generally concentrated in city centers and new development areas undergoing intensive land conversion. These findings affirm the importance of environmentally sensitive spatial planning policies through controlling land-use change, increasing green open space, and urban heat mitigation strategies. The ECI approach proves effective as a tool for monitoring the impacts of urbanization and as a basis for decision-making to enhance ecological resilience and urban sustainability.*

Keywords: Bandung Basin, Environmental Criticality Index, Land Surface Tempertaure, Remote Sensin, Spatial Planning

Introduction

Rapid urbanization and economic development are pervasive global phenomena that exert varying degrees of pressure on ecological environments, frequently resulting in urban stress and significant environmental degradation (Chen, 2023; Yu et al., 2024). The Bandung Basin, a prominent metropolitan region in Indonesia, serves as a compelling illustration of these burgeoning pressures, characterized by high urbanization rates and extensive land-use change. This demographic and developmental surge has directly contributed to a measurable reduction in natural green spaces, a corresponding expansion of built-up areas, and an overall decline in the environmental quality across Bandung City (Rahmasary et al., 2021).

The compounding effect of rapid urbanization and existing environmental vulnerabilities in Bandung presents a complex challenge. The city is not merely experiencing environmental issues alongside its growth; rather, the rapid, often unplanned, nature of urbanization intensifies pre-existing vulnerabilities, such as flood risks and water scarcity, while simultaneously introducing new forms of degradation, including the urban heat island effect and land subsidence due to excessive groundwater abstraction (Sasmito & Suprayogi, 2018). Peningkatan suhu ini memicu kondisi kekritisan lingkungan yang secara langsung memengaruhi kualitas hidup, kenyamanan, dan kesehatan masyarakat perkotaan, serta meningkatkan permintaan energi (Jayasinghe et al., 2024; Sasmito & Suprayogi, 2018).

The Bandung Basin, as a metropolitan region and the capital of West Java Province, is a highly relevant case study for this analysis. Bandung City and its surrounding areas are experiencing intensive dynamics of land cover and land surface temperature changes due to significant population growth and massive infrastructure development (Fahmi et al., 2024). Research by Purboyo et al. (2024) shows that developed land in this region increased significantly between 2003 and 2023, particularly in Bandung Regency and West Bandung Regency, with a total increase of more than 30,000 hectares. This change directly affects environmental quality and triggers an increase in environmental criticality (Sukojo & Hauzan, 2023). The unique geographical characteristics of the Bandung Basin, as an enclosed basin surrounded by volcanic highlands, combined with its extremely high and continuously increasing population density, create an inherent and aggravated vulnerability to environmental degradation.

In facing these complex urban environmental challenges, remote sensing technology plays a crucial role. Remote sensing is a method of acquiring data and information about an object or phenomenon without direct physical contact, utilizing sensors mounted on platforms such as satellites or aircraft (Sagita et al., 2022). The ability of remote sensing to provide comprehensive spatial and temporal data make it an invaluable tool for continuously monitoring environmental changes. The information obtained from satellite imagery is essential for supporting sustainable urban planning, formulating spatial policy, and adapting to the impacts of environmental change.

The Environmental Criticality Index (ECI) serves as an integrated index to identify areas that deviate from ambient environmental conditions and assists in the early detection of environmental crises. Conceptually, environmental criticality is the ratio between high ground surface temperature and low vegetation cover availability. The higher the ECI value, the more critical an area is (Sukojo & Hauzan, 2023). The Environmental Criticality Index (ECI) plays a pivotal role in identifying regions that are deviating from ambient environmental conditions and helps in the early detection of environmental crises (Sasmito & Suprayogi, 2018). This index is utilized to pinpoint environmentally critical areas by evaluating the quality and sustainability levels of various environmental constituents.

The application of remote sensing-based indices to assess environmental quality has been carried out in Indonesia. Saputra et al. (2023), for example, applied ECI in Yogyakarta and found that surface temperatures increased from 35 °C in 2016 to 42 °C in 2021. The city center was categorized as a critical zone due to high building density, low vegetation, and rising temperatures, while slums along the river showed even higher levels of criticality. Another study by Rangga et al. (2025) in Pontianak City used Landsat 9 with a combination of LST, NDVI, NDBI, and NDWI, and found that 91.8% of the city area was classified as environmentally vulnerable. The highest vulnerability levels are concentrated in residential, office, and industrial areas, with surface temperatures reaching 34.6 °C and built-up land dominating more than 50% of the area.

Despite the proven effectiveness of the Environmental Criticality Index (ECI) in urban studies, most previous research has remained limited in scope. Studies such as Saputra et al. (2023) in Yogyakarta and Rangga et al. (2025) in Pontianak were largely cross-sectional, focusing on a single point in time, and often employed a limited set of indices. Moreover, little attention has been given to complex metropolitan basins such as the Bandung Basin, where unique geomorphological and ecological conditions intensify environmental stress. This study addresses these gaps by integrating NDVI, NDBI, MNDWI, and LST into the ECI framework and applying a spatio-temporal analysis from 2009 to 2024, thereby providing a more comprehensive assessment of environmental criticality and its implications for sustainable spatial planning.

Methodology

a. Study Area

The Bandung Basin is geographically defined as a large intra-montane basin located in West Java Province, Indonesia, uniquely surrounded by late Tertiary and Quaternary volcanic highlands. The central part of the basin has an elevation of approximately 665–700 meters above sea level (masl), while the surrounding volcanic terrains can reach elevations of up to 2,400 meters. Astronomically, the Bandung Basin region is located at positions 6° 73' - 7° 83' S and 107° 21' - 108° 5' E. Administratively, the Bandung Basin region encompasses the areas of Bandung City, Cimahi City, Bandung Regency, West Bandung Regency, and several districts in Sumedang Regency (Tanjungsari District, Jatinangor District, and Sukasari District).

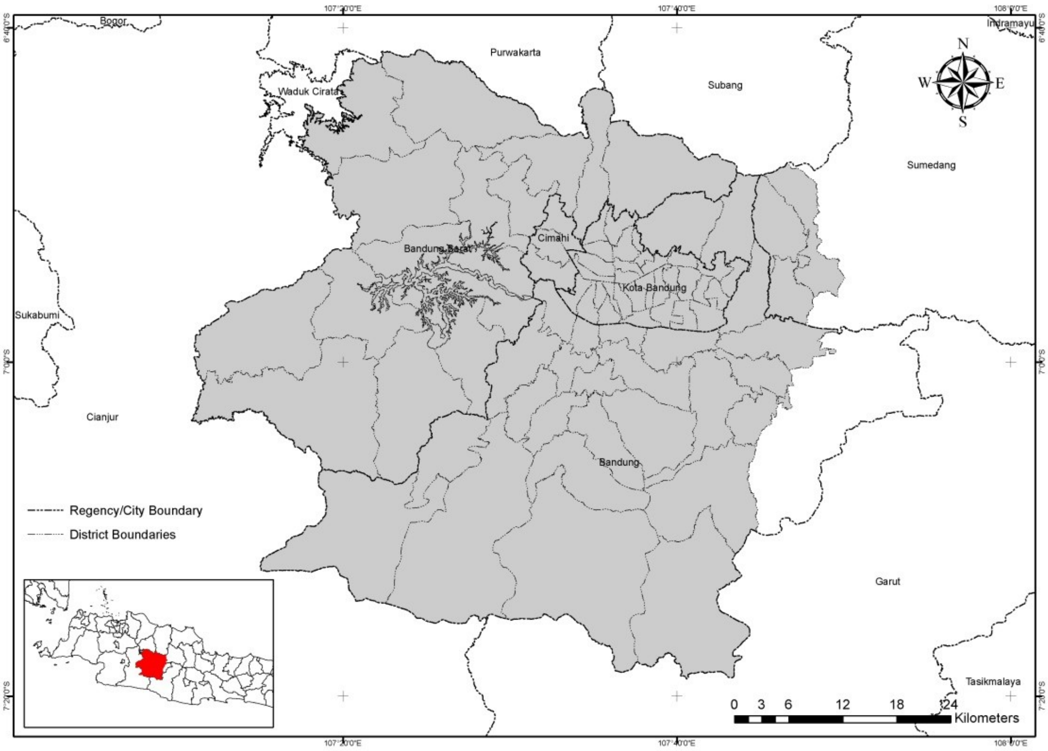

Figure 1. Study Area

The basin covers an area of approximately 2,300 km2, with the larger Bandung Metropolitan Area (also known as the Bandung Basin or Greater Bandung) extending up to 3,484.08 km2. This region is one of the most densely populated areas in Indonesia, inhabited by over seven million people. The population of the Bandung Metropolitan Area even surpassed nine million people in mid-2023, making it the second-largest and second-most densely populated metropolitan area in Indonesia. Besides its demographic significance, the Bandung Basin serves as a crucial economic and political center for Indonesia.

b. Data Collection and Processing

The data used in this study were Landsat 5 TM and 9 OLI/TIRS satellite images of the Bandung Raya region acquired in the years 2009 and 2024 with minimal cloud cover conditions in each period. The presence of clouds can obstruct the thermal sensor from recording objects and have a greater impact on UHI compared to wind (Huang et al., 2016; Levermore et al., 2016, cited in Fawzi, 2017). Cloud cover can also distort the land surface temperature with shadows on certain surfaces. Cloud shadows can create a false impression of relative temperature differences between surface types because UHI occurs under clear skies (without clouds) and with low wind speeds (Fawzi, 2017).

Table 1. Research data.

No	Year	Satellite Image	Cloud Cover (%)	Sensors
1	2009	LT05_L1TP_122065_20090729_20200827_02_T1	2,00	TM
2	2024	LC09_L1TP_122065_20240831_20240831_02_T1	7,64	OLI_TIRS

This step aims to convert pixel values into spectral radiance values. The formula commonly used to calculate spectral radiance is as follows:

$$L\lambda = ML \, x \, QCAL + AL \quad (1)$$

where:

$L\lambda$ - is the spectral radiance at the top of the atmosphere.

ML - is the rescaling constant obtained from the image metadata

QCAL - is the pixel value (DN).

AL - is the additive constant obtained from the image metadata

These constants, ML and AL, are specific to each band of the image and are provided in the image metadata. They are used to convert the digital number values to radiance values at the top of the atmosphere.

Calculating the satellite's brightness temperature

The surface temperature of the ground is analyzed using thermal infrared sensors (TIRS) within the wavelength range (bands 10 and 11) while comparing object emission with blackbody radiation to determine the brightness temperature of objects on Earth (Autarin et al., 2021).The formula used to calculate the satellite brightness temperature, also known as the brightness temperature, can be inputted into the raster calculator tool. The formula is as follows:

$$\mathrm{T} = \frac{K2}{In(\frac{K1}{L\lambda}+1)} - 273.15 \quad (2)$$

where:

Tb - is the satellite brightness temperature.

K1 and K2 - are calibration constants specific to the sensor used.

$L\lambda$ - The value of spectral radiance at the top of the atmosphere (TOA).

These constants can be found in the sensor's documentation or metadata. Please note that the specific values for K1 and K2 will depend on the sensor and calibration parameters used for the image data.

Transformation of Normalized Difference Vegetation Index (NDVI)

NDVI is a numerical representation of the extent to which vegetation covers the Earth's surface (Prohmdirek et al., 2020). For Landsat 5 this was determined by using bands B3 (Red) and B4 (NIR), and for Landsat 9, bands B4 (Red) and B5 (NIR) (Ivan & Benedek, 2017).

$$\text{NDVI} = \frac{Near\ Infrared - Red}{Near\ Infrared + Red} \tag{3}$$

where:

Near Infrared - Band 5 (For Landsat 9), Band 4 (For Landsat 5)

Red - Band 4 (For Landsat 9), Band 3 (For Landsat 5)

To use the raster calculator in ArcGIS software to calculate NDVI and normalize the values to a range of -1 to *1*

Calculating the Proportional Vegetation Index (PVI) and Land Surface Emissivity (LSE)

PVI (Projected Vegetation Index) is defined as the ratio of the projected vertical area of vegetation (including leaves, stems, and branches) above the ground to the total vegetation area (Deardoff, 1978 in Neinavaz et al., 2020). To obtain the Pv value, the following formula is used:

$$\text{Pv} = \left(\frac{NDVI - NDVImin}{NDVImax - NDVImin}\right)^2 \tag{4}$$

where:

Pv - Proportion of Vegetation

NDVImax - Maximum NDVI value

NDVImin - Minimum NDVI value

Once the PVI value is obtained, the next step is to calculate the LSE (Leaf Surface Area) because one of the parameters for LSE is PVI. The formula for calculating LSE is as follows:

$$e = 0.0004Pv + 0.986 \tag{5}$$

where:

e - Land Surface Emissivity

Calculating Land Surface Temperature (LST)

In this study, the land surface temperature calculation is performed by incorporating the calculation of brightness temperature values from band 10 and the land surface emissivity values from band 10. The calculation of LST can be done using the following formula:

$$\mathrm{LST} = \frac{BT}{1} + W\,x\,\left(\frac{BT}{P}\right) x\,In(e) \quad (6)$$

The value of p is obtained from the following calculation:

$$\mathrm{P} = h\,x\,\frac{c}{s} \quad (7)$$

where:

BT - Brightness Temperature (T)

W - Wavelength emitted by radiation (band 4, 5, and 7 (11.45 µm) while Band 10 (10.8 µm) Band 11 (12 µm))

P - h x c/s (1.438 x 10-2mK)

H - Planck's constant (6.626 x 10-34 Js)

S - Boltzmann constant (1.38 x 10-23 J/K)

C - speed of light (2.988 x 108 m/s)

Normalized Difference Built-up Index (NDBI)

The Normalized Difference Built-up Index (NDBI), originally proposed by Zha et al. (2003), is widely used to delineate built-up surfaces from multispectral imagery owing to its sensitivity to SWIR reflectance in impervious materials. NDBI can effectively classify built-up areas, although its accuracy may vary depending on specific urban contexts (Osgouei et al., 2019; Abet et al., 2023). The NDBI algorithm is as follows:

$$\mathrm{NDBI} = \frac{SWIR1 - NIR}{SWIR1 + NIR}$$

Where:

SWIR 1 = Shortwave Infrared Reflectance Value (band 6 of the Landsat imagery).

NIR = Near Infrared Reflectance Value (band 5 of the Landsat imagery).

Built-Up (BU) index

This index is used to identify residential areas, particularly in densely populated urban areas, by integrating the NDVI and NDBI indices. When vegetation reflection decreases, urban areas become more prominent. The BU algorithm is as follow:

$$BU = NDBI - NDVI$$

Where:

NDBI: Normalized Difference Built-up Index

NDVI: Normalized Difference Vegetation Index

Environmental Critically Index (ECI)

To calculate the ECI value, the indicators used in this case are LST and BU, which are stretched in their spectral values to 1-225. This is done to avoid a value of 0 in the pixels. Then, ECI classification is carried out using the equal interval method, resulting in a classification of very low, low, medium, high, and very high. The ECI algorithm is as follow:

$$ECI = LST * BU\ (1 - 255\ \text{streched})$$

Where:

ECI: Environmental Criticality Index

LST: Land Surface Temperature (°C)

BU: Built-Up

Modified Normalized Difference Water Index (MNDWI)

This algorithm is used to separate water and clouds in images. Masking is done with MNDWI > 0 for possible water (positive values indicate a predominance of water reflection), and MNDWI ≤ 0 → non-water (land, vegetation, settlements). MNDWI algorithm is as follow:

$$\text{MNDWI} = \frac{GREEN - SWIR1}{GREEN + SWIR1}$$

Where:

MNDWI: Modified Normalized Difference Water Index

Green: Green band reflectance value (band 3 of the Landsat imagery)

SWIR1: Shortwave infrared reflectance value (band 6 of the Landsat imagery)

Results and Discussion

Analysis of Land Surface Temperature (LST) in the Bandung Basin Area in 2009 and 2024

The analysis of Land Surface Temperature (LST) derived from Landsat 5 TM and 9 OLI/TIRS imagery shows clear spatial and temporal variation across the Bandung Basin. Multi-year Landsat-based studies provide robust frameworks for detecting trends in urban LST and evaluating links with land-cover change (Cetin et al., 2024). In 2009, the LST range in the Bandung Basin was between 8 °C (areas with dense vegetation/water) and 38°C (areas with dense built-up areas). The areas with the highest temperatures were generally concentrated in city centers like Bandung City and Cimahi City, as well as in various dense industrial zones.

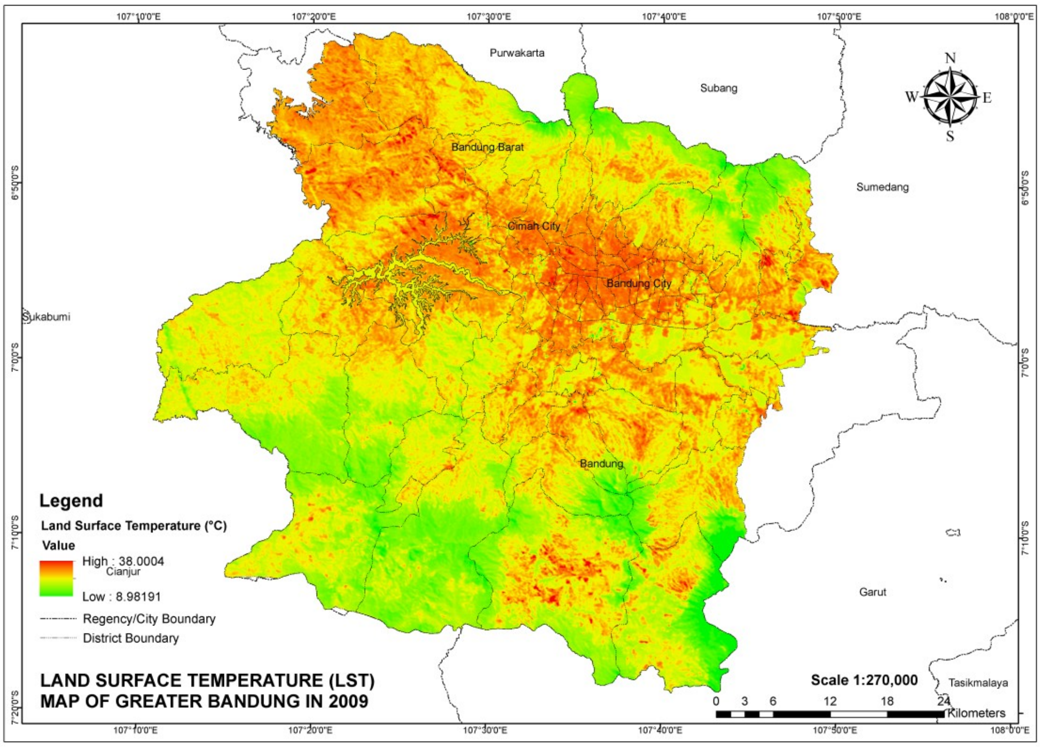

Figure 2. Land Surface Tempertaure (LST) Maps of Greater Bandung in 2009

In 2024, a significant increase in LST was observed across many parts of the Bandung Basin. The LST range rose to between 13∘C and 40∘C. The most noticeable temperature increase occurred in areas that experienced intensive land conversion from vegetation to built-up areas, especially in the rapidly developing suburban areas. For example, several areas that had low LST in 2009 now show a relatively increased LST. This increase indicates the intensification of the Urban Heat Island (UHI) phenomenon as a direct consequence of the expansion of built-up areas and the loss of green cover.

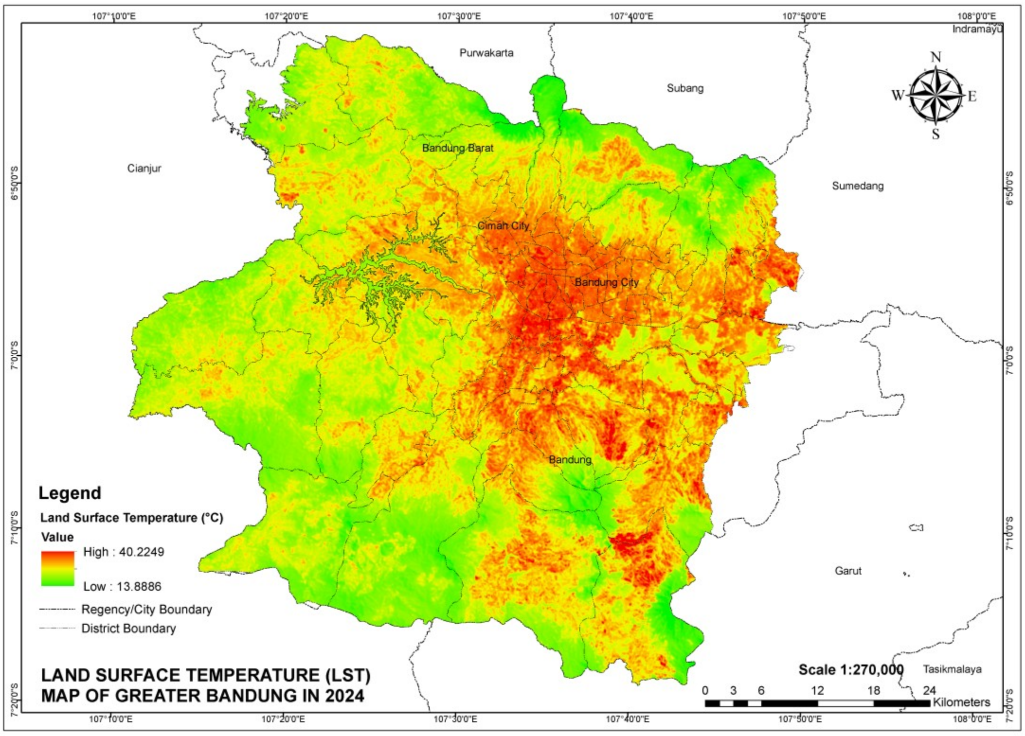

Figure 3. Land Surface Tempertaure (LST) Maps of Greater Bandung in 2024

A comparative analysis of the Land Surface Temperature (LST) maps in the Bandung Basin for 2009 and 2024 reveals a significant pattern of temperature change, reflecting the impact of rapid urbanization. In 2009, the map showed a relatively more even temperature distribution. Although areas with high temperatures (orange-red zones) were already visible in city centers like Bandung City, the proportion of areas with medium to low temperatures (green-yellow) still predominated. This condition indicated that most of the region still had cool land cover. This is also in line with a study that identified Bandung as one of the cities with the highest rate of land conversion in Indonesia (Mahendra et al., 2025). It is therefore not surprising that the rate of land use change in Bandung is very high compared to surrounding areas.

However, the condition changed drastically on the 2024 map. Areas with high temperatures expanded significantly, not just in the city core but also spreading to the suburbs. The increased intensity of the "Urban Heat Island" (UHI) effect is clearly visible. Visually, the red areas on the 2024 map are much denser and more extensive, indicating that surfaces that were originally cool have been replaced by heat-absorbing materials such as asphalt and concrete due to development. A comparison of LST values also reinforces this finding; the highest temperature increased from 38.0004°C to 40.2249°C, while the lowest temperature also rose. This change demonstrates the need for policy intervention focused on mitigating the UHI effect, such as increasing Green Open Space (Ruang Terbuka Hijau - RTH) and implementing more sustainable urban planning to maintain thermal balance in Greater Bandung.

Analysis of Built-Up (BU) Index in the Bandung Basin Area in 2009 and 2024

The Built-Up (BU) Index is used to identify and map built-up areas in the Bandung Basin. This index is generated from the integration of the NDVI and NDBI indices from Landsat imagery. NDBI calculated from Landsat imagery has been proven to be an effective indicator for mapping residential areas with medium spatial resolution (Bhatti & Tripathi, 2014). The BU calculation results clearly show an expansion of built-up areas from 2009 to 2024. In 2009, the BU values showed a high concentration in the center of Bandung City and Cimahi City, with values ranging from -1.36659 to 0.491818.

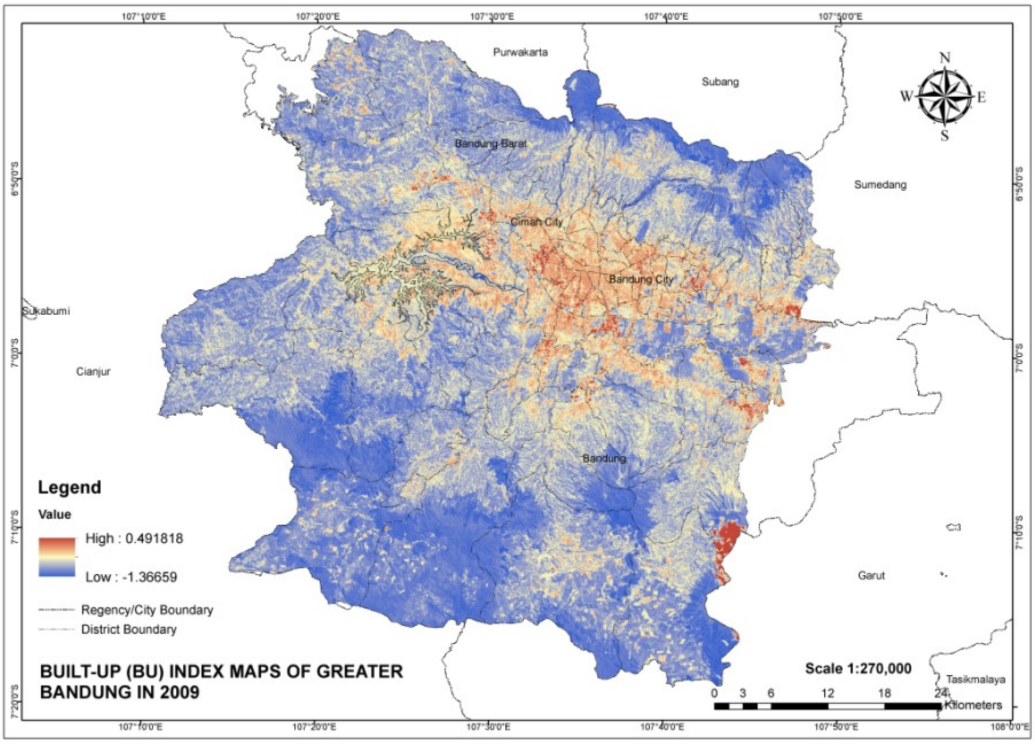

Figure 4. Built-up Index Maps of Greater Bandung in 2009

In 2024, the high BU values expanded significantly into suburban areas, such as the southern and eastern parts of Bandung Regency, with values ranging from -1.08648 to 0.31128. This increase in the BU (Built-Up) values directly reflects the massive land conversion for residential, commercial, and infrastructure purposes.

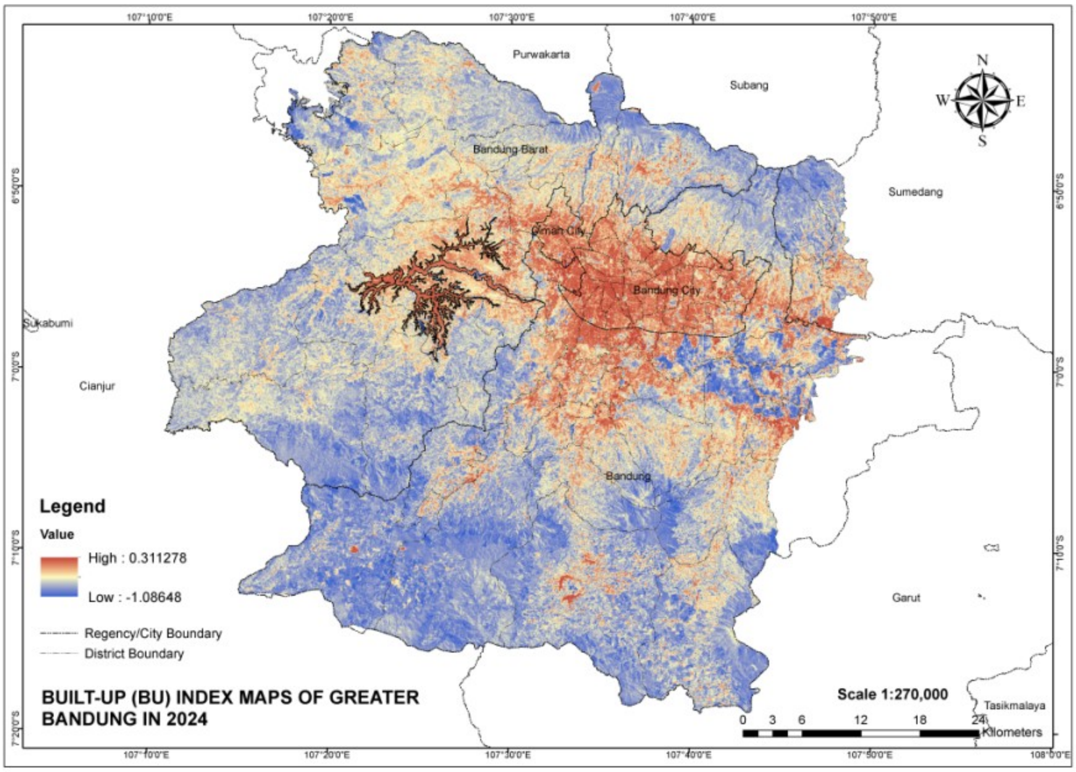

Figure 5. Built-up Index Maps of Greater Bandung in 2024

This expansion of built-up areas is the primary driver of the increased LST (Land Surface Temperature) and significantly contributes to environmental criticality (Sukojo et al., 2025). These results are also consistent with empirical studies that consistently report a positive correlation between NDBI and LST, indicating that increased building coverage promotes surface warming (Guha et al., 2018). In a study in Makassar, the relationship between built-up areas (NDBI) and LST showed a positive correlation and a significant increase in surface temperature from 2014 to 2023; these results support the finding that the growth of built-up areas is a major determinant of LST increases in urban areas (Setiawan & Jumadi, 2024). Therefore, BU index amplification in several sub-areas of Greater Bandung also has the potential to be related to an increase in ECI scores, indicating that land conversion to impervious surfaces increases environmental vulnerability on a local spatial scale.

Environmental Criticality Index (ECI)

The Environmental Criticality Index (ECI) in the Bandung Basin is calculated and classified into several levels: Very Low, Low, Medium, High, and Very High. In 2009, most of the Bandung Basin showed a Very Low to Medium level of environmental criticality, especially in areas with dense vegetation cover and outside the city center. However, several areas with High to Very High criticality were already identified in the center of Bandung City and in some dense industrial areas like the Jatinangor region.

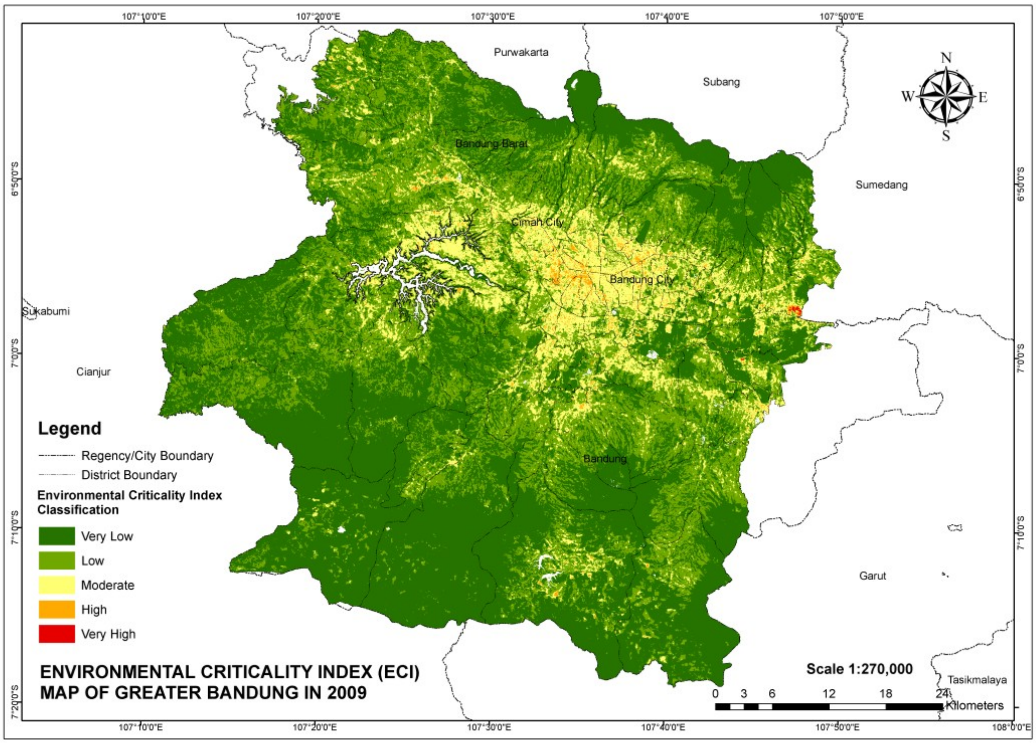

Figure 6. Environmental Criticality Index (ECI) Map of Greater Bandung in 2009

In 2024, the ECI results showed an overall increase in environmental criticality, especially in suburban areas and areas that were previously green or agricultural land. The zone with Medium to Very High criticality expanded significantly. For example, several areas around Bandung City, Bandung Regency, and Jatinangor that had a Medium ECI in 2009 now show a High or even Very High ECI at some points. This increase in criticality is driven by a combination of higher land surface temperatures (LST), a decrease in vegetation cover (low NDVI), and an increase in built-up land density (high NDBI). Areas with Very High criticality spatially coincide with areas that have undergone the most intensive urban expansion and the most drastic temperature changes. The ECI distribution maps for 2009 and 2024 shown in Figures 6 and 7 clearly show the shift and expansion of critical zones.

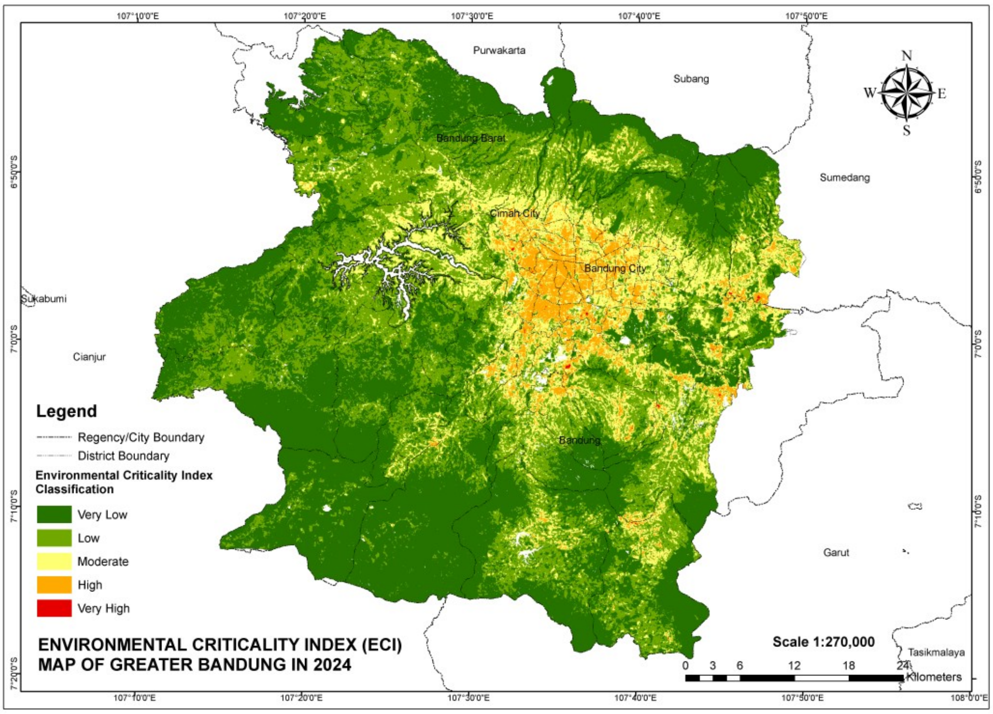

Figure 7. Environmental Criticality Index (ECI) Map of Greater Bandung in 2024

In 2009, most of the Bandung Basin showed a Very Low to Medium level of environmental criticality. Areas with High and Very High criticality were limited to dense urban centers. However, by 2024, a significant shift had occurred. The area with Very Low criticality drastically decreased from 165,017.747 hectares to 144,335.474 hectares. Meanwhile, the areas with High and Very High criticality saw a remarkable increase, growing from 2,305.962 ha to 13,094.065 ha and 61.513 ha to 129.774 ha, respectively. This heightened criticality is driven by a combination of higher land surface temperatures, a decrease in vegetation cover, and an increase in built-up land density. Spatially, the areas with Very High criticality coincide with regions that have experienced the most intensive urban expansion and the most drastic temperature changes.

Table 2. ECI Classification Area 2009 and 2024.

No	Classification	Area (Ha) in 2009	Area (Ha) in 2024
1	Very Low	165017.747	144335.474
2	Low	104520.784	106681.284
3	Moderate	35061.244	42419.241
4	High	2305.962	13094.065
5	Very High	61.513	129.774
	Grand Total	306967.25	306659.838

The ECI analysis was also conducted for each administrative region within the Bandung Basin, namely Cimahi City, KBB (West Bandung Regency), Bandung City, Bandung Regency, and parts of Sumedang Regency. This provides a more detailed picture of the distribution of environmental criticality. Based on the table of Environmental Criticality Index (ECI) area coverage for 2009, it is evident that the environmental condition in Greater Bandung was generally still good and non-critical. Out of a total area of approximately 306,234 hectares, the majority, or about 88%, was classified as having a Very Low to Low level of environmental risk. This indicates that in 2009, most of the region, especially in Bandung Regency and West Bandung Regency, was still dominated by non-built-up areas such as agricultural land, rural areas, and open spaces.

Table 3. ECI Classification Area per District/City in the Bandung Basin 2009.

No	Regency	Area (Ha)				
		Very Low	Low	Moderate	High	Very High
1	West Bandung Regency	64528.277	48026.913	10652.03	384.247	2.009
2	Bandung City	1282.74	5117.575	9210.811	1062.88	4.637
3	Bandung Regency	92945.463	45938.941	11655.025	494.253	7.181
4	Kota Cimahi	263.656	1382.781	2211.805	253.644	1.655
5	Parts of Sumedang Regency	5787.022	3560.744	1303.488	110.434	46.031
	Total	164807.158	104026.954	35033.159	2305.46	61.513
	Grand Total	306234.241				

However, this table also already indicated a concentration of critical areas in urban regions. Bandung City and Cimahi City, as growth centers, already had significant areas with High and Very High risk compared to other regions. This suggests that by 2009, environmental degradation had begun, but was still localized in densely populated areas.

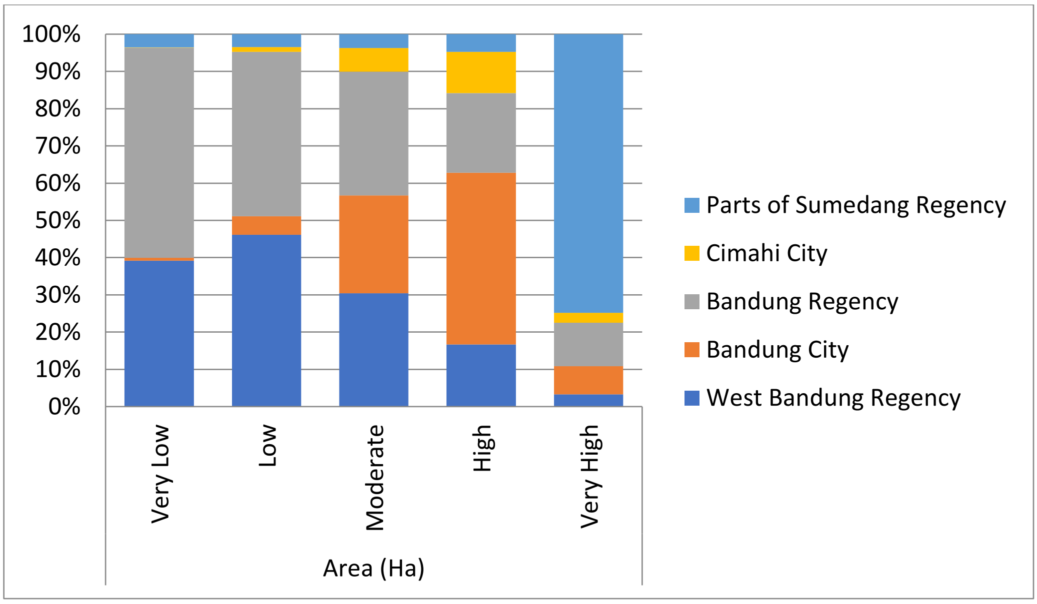

Figure 8. Graph of ECI Area per District/City in the Bandung Basin in 2009.

Based on the table of Environmental Criticality Index (ECI) area coverage for 2024, a significant and worrying shift in environmental conditions is evident compared to 2009. There was a dramatic leap in the area with High and Very High risk, indicating that environmental pressure has increased exponentially over the 15-year period. If in 2009 critical areas were concentrated in city centers, this phenomenon has now spread to other regions.

Table 4. ECI Classification Area per District/City in the Bandung Basin 2024.

No	Regency	Area (Ha)				
		Very Low	Low	Moderate	High	Very High
1	West Bandung Regency	62837.049	51412.174	9140.548	182.544	0
2	Bandung City	473.461	2844.589	8068.095	5284.44	9.315
3	Bandung Regency	68594.463	47995.581	20947.386	5896.08	88.362
4	Cimahi City	105.101	856.95	1988.437	1145.24	11.512
5	Parts of Sumedang Regency	4864.773	3070.433	2230.914	583.534	20.585
	Total	136874.847	106179.727	42375.38	13091.8	129.774
	Grand Total	298651.568				

Bandung Regency, which previously had the best environmental conditions, now has the largest area of High and Very High criticality. This indicates that the pace of development and its impact have encroached upon the region that was formerly dominated by open land. Although the critical areas have expanded, Bandung City and Cimahi City remain the epicenter with the highest concentration of risk.

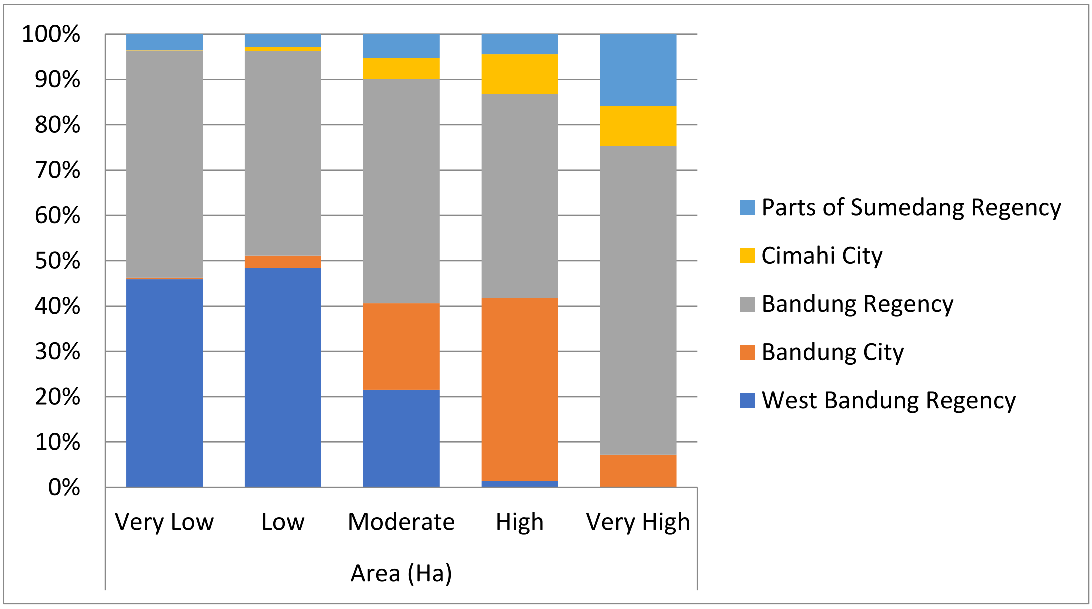

Figure 9. Graph of ECI Area per District/City in the Bandung Basin in 2024

The results of the increase in built-up area identified through the Environmental Criticality Index (ECI) in this study are in line with the findings of Purboyo et al. (2024), which show significant expansion of built-up land in the Bandung Basin over the last two decades. The results of the study revealed a drastic increase in developed land in Bandung Regency (+24,198 ha in 2003–2013 and +7,098 ha in 2013–2023) and West Bandung Regency (+11,634 ha in 2003–2013 and +10,233 ha in 2013–2023).The consistency between the ECI results and the land cover change analysis confirms that the conversion of vegetation and agricultural land into built-up areas is a dominant factor driving the increase in surface temperature and expanding zones with high levels of environmental criticality.

Conclusion and Recommendation

This study confirms that rapid urbanization in the Bandung Basin between 2009 and 2024 has significantly intensified environmental stress. Land Surface Temperature (LST) rose from 8–38 °C to 13–40 °C, while built-up expansion and vegetation loss accelerated environmental degradation. Consequently, the area of High and Very High environmental criticality increased more than fivefold, with critical zones concentrated in urban cores and newly developed areas. These results demonstrate that the Environmental Criticality Index (ECI), integrated with remote sensing indices, provides an effective approach for assessing and monitoring urban environmental change.

To mitigate the escalating environmental criticality in the Bandung Basin, local governments and urban planners should prioritize sustainable land-use management by limiting uncontrolled urban sprawl, protecting and expanding green open spaces, and conserving water bodies as part of blue–green infrastructure strategies. At the same time, promoting compact city development and energy-efficient building standards will help reduce the thermal burden associated with rapid urban growth. Regular monitoring using multi-temporal remote sensing data and ECI models should be institutionalized as a decision-support system, ensuring that urban development is guided by ecological resilience and long-term sustainability considerations.

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