

Spatiotemporal Analysis of Surface Temperature Changes and Their Associated Factors in West Java

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Abstract: Land Surface Temperature (LST) is an important indicator for understanding environmental dynamics associated with regional development and changes in biophysical conditions. This study aimed to analyze the spatial-temporal changes in LST and identify anthropogenic and biophysical factors associated with surface temperature changes in West Java Province during 2014–2026. The analysis was conducted for 2014, 2018, 2022, and 2026 using Landsat 8 and Landsat 9 Collection 2 Level-2 imagery processed through Google Earth Engine. LST was derived from surface temperature data, while the analyzed factors included changes in NDVI, NDBI, built-up areas, building density, elevation, slope, water-body density, and soil moisture. LST changes were analyzed using image differencing and classified into five categories. Pearson correlation analysis was applied to examine the relationships between LST changes and the selected factors. The results showed heterogeneous spatial patterns of LST changes, with increasing temperatures mainly occurring in urban areas, development corridors, lowland regions, and several coastal areas. Changes in built-up areas showed the strongest relative correlation with LST changes ($|r|=0.061$), although the relationship remained very weak, followed by changes in NDBI ($|r|=0.046$), while changes in soil moisture showed the weakest correlation ($|r|=0.002$). Overall, LST changes represent a complex phenomenon that cannot be explained by a single factor. Therefore, a multivariate approach and integrated spatial management are needed to better understand thermal dynamics and support climate-resilient regional development in West Java.

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INTRODUCTION

Changes in surface temperature are an important indicator for understanding environmental changes resulting from the interaction between natural processes and human activities (Beaugrand et al., 2025). Rising surface temperatures can affect thermal comfort, energy demand, hydrological conditions, environmental quality, and the sustainability of urban areas. In the context of climate change, increasing temperatures also interact with land-use changes, resulting in spatially heterogeneous warming patterns (Liu et al., 2023; Gogoi et al., 2019). The Meteorology, Climatology, and Geophysics Agency (BMKG) reports that Indonesia's average air temperature during the period 1981–2024 showed an increasing trend of approximately 1.02°C over the 44-year period. Notably, 2024 was recorded as the hottest year, with a temperature anomaly of 0.8°C relative to the 1991–2020 normal period.

This phenomenon becomes increasingly complex in regions experiencing rapid population growth and urban expansion. West Java is one of the provinces facing substantial development pressure and high population density, reaching approximately 1,385 inhabitants/km² in 2024. Population growth, urbanization, and economic activities have increased demand for housing, infrastructure, industry, and transportation, thereby placing greater pressure on land and

environmental resources (Zhang & Xie, 2019). The conversion of vegetation, agricultural land, and open spaces into built-up areas alters the physical characteristics of the land surface, including albedo, emissivity, heat storage capacity, and water availability. Buildings, roads, and construction materials tend to absorb and store more energy than vegetation. Consequently, increasing development intensity may contribute to higher surface temperatures (Khan et al., 2020).

Various studies in Indonesia have also demonstrated associations between land-cover changes, built-up area expansion, vegetation changes, and increases in Land Surface Temperature (LST). LST is an important parameter for identifying spatial variations in surface temperature because it represents surface thermal conditions at a finer spatial resolution than air-temperature measurements obtained from meteorological stations (Tang et al., 2024). Landsat satellite data provide a multitemporal archive that enables long-term analysis of LST changes, while Google Earth Engine facilitates the efficient processing of multitemporal imagery over large areas. LST analysis can also be integrated with various indicators, such as the Normalized Difference Vegetation Index (NDVI) to represent vegetation conditions and the Normalized Difference Built-up Index (NDBI) to characterize built-up areas. In general, better vegetation cover is associated with lower surface temperatures due to evapotranspiration and shading effects, whereas the expansion of built-up areas tends to be positively associated with increasing LST (Hasyim et al., 2025; Zhou et al., 2023).

In addition to land cover and vegetation, the biophysical characteristics of a region also influence the spatial distribution of surface temperature. Elevation and slope are related to topographic conditions, solar radiation, and air circulation. Water bodies can function as cooling elements through their heat capacity and evaporative processes, while soil moisture is related to water availability for evapotranspiration. Thus, changes in LST reflect the interaction of multiple anthropogenic and biophysical factors. Consequently, an analysis based on a single indicator is insufficient to comprehensively explain the spatial variability of temperature changes (Hu et al., 2022).

The need for a multifactorial approach is particularly important in West Java because the province is characterized by substantial spatial heterogeneity, encompassing metropolitan and industrial areas, agricultural lands, mountainous and coastal regions, and diverse land-use types. These conditions result in distinct temperature-change patterns across densely urbanized, peri-urban, agricultural, mountainous, and coastal areas. Although previous studies have examined the relationships between Land Surface Temperature (LST) and factors such as urbanization, vegetation, and built-up areas across various regions of Indonesia, there remains an opportunity to investigate LST changes at the provincial scale in West Java during the 2014–2026 period while simultaneously assessing their associations with multiple anthropogenic and biophysical factors. This time span enables the identification of the direction, magnitude, and spatial distribution of temperature changes, including dynamics occurring before, during, and after the COVID-19 pandemic, as well as recent development trends.

The main contribution of this study lies in integrating multitemporal LST change analysis at the provincial scale in West Java with multiple anthropogenic and biophysical factors simultaneously. This approach enables the identification of spatial patterns of temperature change and the variables exhibiting relatively higher, although weak, correlations with LST changes across highly diverse urban, peri-urban, agricultural, mountainous, and coastal environments, including dynamics before, during, and after the COVID-19 pandemic. In this way, the study complements previous research, which has

generally focused on specific urban areas or individual factors, by providing a more comprehensive perspective on LST changes at the provincial scale.

Against this background, this study aims to analyze the spatiotemporal dynamics of surface temperature in West Java Province in 2014, 2018, 2022, and 2026, and to identify the factors associated with LST changes. This approach is expected to provide a more comprehensive understanding of temperature-change patterns and the factors associated with these changes in West Java, while providing a scientific basis for heat-risk-responsive spatial planning, the development of green open spaces, the protection of vegetation and water bodies, and the formulation of climate change adaptation strategies.

RESEARCH METHOD

Research Location and Period

The study was conducted in West Java Province, Indonesia, covering the analysis period of 2014–2026. Surface temperature analyses were performed for the years 2014, 2018, 2022, and 2026 to identify the spatiotemporal dynamics of Land Surface Temperature (LST) changes. West Java was selected due to its heterogeneous regional characteristics—encompassing metropolitan, residential, industrial, agricultural, mountainous, and coastal areas—which result in significant variations in surface conditions and relatively high levels of anthropogenic pressure.

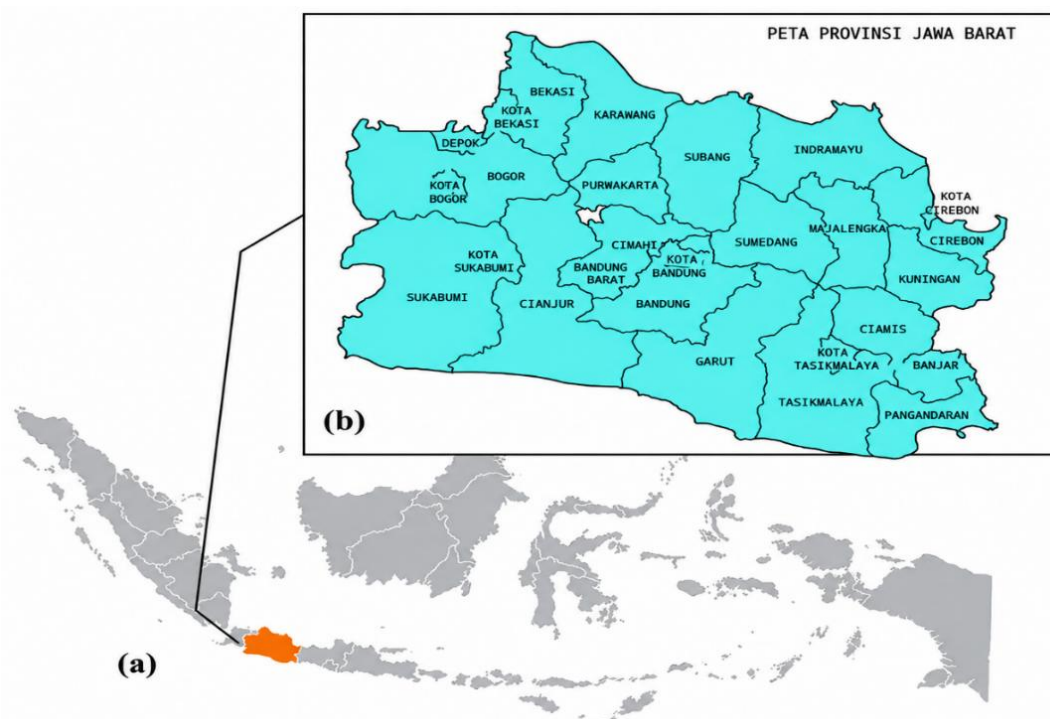


Figure 1. Research Location

Data and Data Sources

The primary data consist of Landsat 8 and Landsat 9 Collection 2 Level-2 imagery obtained via Google Earth Engine (GEE). Landsat data were used to derive LST, NDVI, NDBI, and information on built-up areas. Elevation data were obtained from the SRTM Digital Elevation Model (DEM) with a spatial resolution of 30 m, while slope was calculated from the DEM using the terrain slope function.

Information on water bodies was derived from JRC Global Surface Water data, and soil moisture data were obtained from ERA5-Land. The administrative boundary of West Java Province served as the study area limit. Analyses were conducted during relatively consistent observation periods each year—specifically June–July—to minimize the influence of seasonal variations on surface temperature estimates. For 2026, the data used represent conditions during the observation period available at the time the study was conducted.

Image Pre-processing

All image processing was conducted using Google Earth Engine. Landsat images were first selected based on the study area, time period, and cloud cover. Cloud and cloud-shadow masking was performed using QA_PIXEL information. Subsequently, scale factors were applied to the reflectance and surface temperature bands. The filtered images were then combined using the median composite method to produce a single representative image for each year of observation. Consistent time periods and compositing methods were employed to minimize the impact of temporal variations between images.

Land Surface Temperature Estimation

LST is derived from the ST_B10 band of Landsat Collection 2 Level-2 data. Surface temperature values are converted from digital values to temperature in Kelvin using scale factors and offsets, and subsequently converted to degrees Celsius using the following equation:

$$\text{LST (}^{\circ}\text{C)} = (\text{ST_B10} \times 0.00341802 + 149.0) - 273.15$$

The processing results yielded LST maps for the years 2014, 2018, 2022, and 2026 with a spatial resolution of 30 m.

LST changes were calculated using the image differencing method, namely:

$$\Delta\text{LST}_{2014-2026} = \text{LST}_{2026} - \text{LST}_{2014}$$

In addition to long-term changes, inter-period changes were also calculated for the periods 2014–2018, 2018–2022, and 2022–2026. Positive values indicate an increase in surface temperature, while negative values indicate a decrease. The LST changes were then classified into five categories: very high decrease ($<-2^{\circ}\text{C}$), decrease (-2 to $<-0.5^{\circ}\text{C}$), relatively stable (-0.5 to $<0.5^{\circ}\text{C}$), increase (0.5 to $<2^{\circ}\text{C}$), and very high increase ($\geq 2^{\circ}\text{C}$).

Analysis of Factors Associated with LST Changes

To identify the factors associated with LST changes, the study utilized several anthropogenic and biophysical variables: changes in NDBI, NDVI, built-up area, and building density; elevation; slope; water body density; and changes in soil moisture.

NDVI was used to represent vegetation conditions and was calculated using:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$$

For Landsat 8/9, NIR uses Band 5 and Red uses Band 4. NDVI change is calculated based on the difference in values between 2026 and 2014.

NDBI is used to represent the characteristics of built-up areas:

$$\text{NDBI} = (\text{SWIR} - \text{NIR}) / (\text{SWIR} + \text{NIR})$$

with SWIR using Band 6 and NIR using Band 5. Changes in NDBI are calculated in the same way as NDVI.

Built-up areas are extracted using a combination of NDBI and NDVI information. Changes in the built-up area are determined based on changes in pixel status from non-built to built. Next, building density is calculated using neighborhood analysis with a radius of 500 m to obtain the proportion of built-up area around each pixel. Density change is calculated as the difference in density in 2026 and 2014.

The elevation is obtained from the SRTM DEM, while the slope is calculated using the terrain slope function. These two variables are used as relatively static topographic factors. Water body density is calculated based on the proportion of water bodies present in the environment around the pixel. Soil moisture is obtained from the volumetric soil water parameter ERA5-Land and changes in humidity are calculated based on differences in conditions in 2026 and 2014.

Statistical Analysis

The relationship between LST changes and each variable was analyzed using Pearson correlation (r). The dependent variable is changes in LST (ΔLST), while the independent variables consist of changes in NDVI, changes in NDBI, changes in built-up area, changes in building density, elevation, slope, density of water bodies, and changes in soil moisture.

The Pearson coefficient value is used to determine the direction and strength of the relationship between variables. Positive values indicate a unidirectional relationship, while negative values indicate an opposite relationship. The coefficient of determination (R^2) value is used to show the proportion of variations in LST changes that can be explained by each variable linearly.

RESULTS AND DISCUSSION

Spatial analysis results indicate that changes in Land Surface Temperature (LST) in West Java Province during the 2014–2026 period exhibit a spatially heterogeneous pattern. These variations are reflected in differing intensities of surface temperature increases and decreases across various regions, suggesting the influence of environmental factors, land cover/land use changes, and the expansion of anthropogenic activities. The spatial distribution of LST changes was further analyzed to identify areas experiencing rising or falling surface temperatures and to understand the characteristics of the change patterns observed during the study period. The results of the spatial analysis regarding land surface temperature changes are presented in Figure 2.

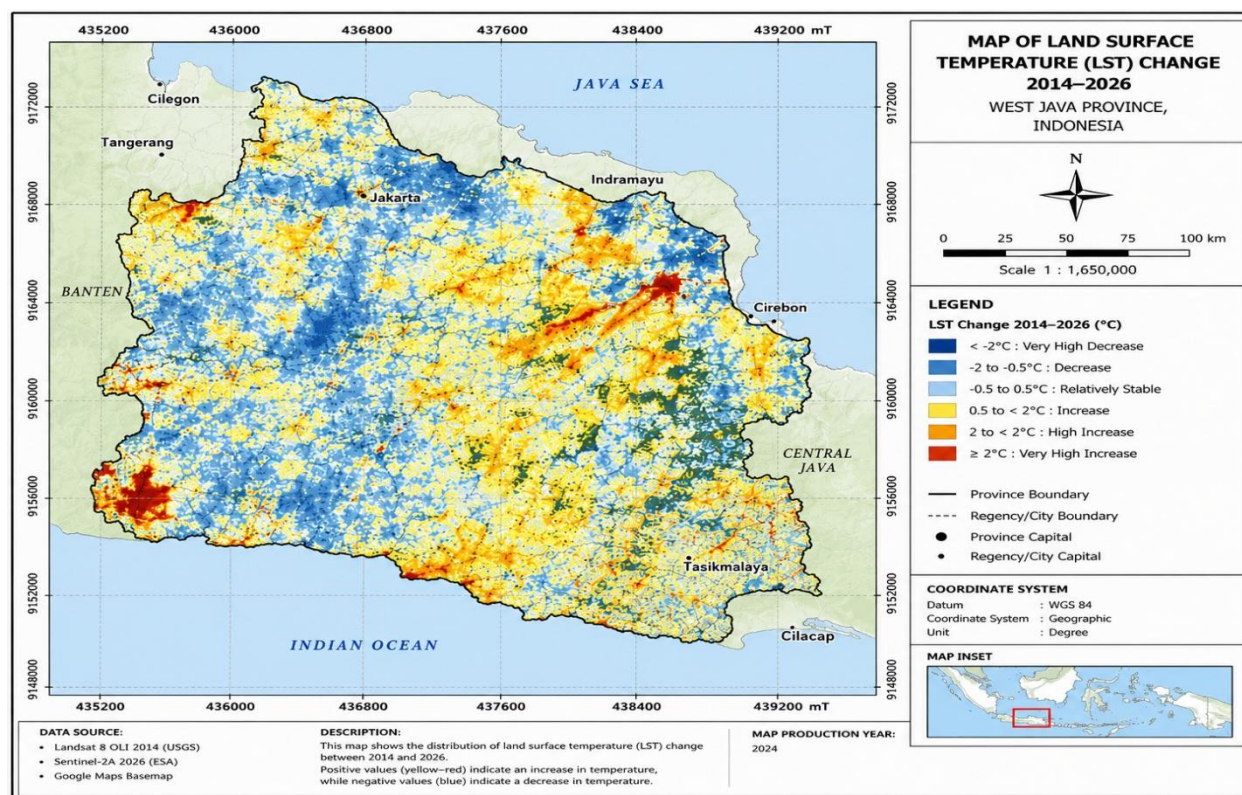


Figure 2. Changes in Land Surface Temperature (LST) in West Java Province 2014-2026

Analysis results indicate that changes in Land Surface Temperature (LST) in West Java Province during the 2014–2026 period exhibit a heterogeneous spatial pattern. Temperature changes did not occur uniformly across the region but formed a mosaic ranging from areas experiencing temperature decreases or relative stability to those seeing increases, including very high temperature rises. This pattern demonstrates that surface temperature dynamics in West Java are closely linked to land cover characteristics, vegetation levels, the expansion of built-up areas, and local environmental conditions. In general, areas showing positive temperature changes tend to coincide with regions undergoing development pressure and land-use changes, whereas areas experiencing temperature decreases are predominantly found in regions that retain relatively good vegetation cover (Kanga et al., 2022; Halefom et al., 2024). The map reveals that LST increases (ranging from 0.5 to <2°C and ≥2°C) are distributed across various parts of West Java, particularly in urban areas, regional development corridors, and certain coastal and lowland zones. Colors ranging from yellow to red indicate surface temperature increases of progressively higher intensity. These conditions suggest that the transformation of surface characteristics—shifting from vegetation or open land to more impervious surfaces such as settlements, industrial zones, roads, and urban infrastructure—can enhance the surface's capacity to absorb and store solar radiation. Research in Cirebon indicates that the city center exhibits relatively high surface temperatures and that LST variations are statistically influenced by vegetation density and building density (Liviona et al., 2020).

This pattern aligns with research findings from Bekasi Regency, which indicate a rise in surface temperatures between 2004 and 2020, coinciding with the expansion of built-up areas around the Jakarta metropolitan region. The expansion of built-up areas within the metropolis exerts pressure on

surrounding peri-urban zones; consequently, land-use change emerges as a significant factor driving increases in Land Surface Temperature (LST) (Asi et al., 2022). These findings are relevant to patterns observed in northern and western West Java—specifically within metropolitan systems and economic corridors—where residential, industrial, transport, and infrastructure developments are taking place. The trend of rising temperatures in built-up areas can also be explained by the urban heat island (UHI) phenomenon. Surfaces such as concrete, asphalt, roofing, and construction materials possess thermal characteristics distinct from those of vegetation and water bodies, leading to increased surface heat retention (Proutsos et al., 2022). Thus, the distribution of red and orange hues on the map should be viewed not merely as a meteorological temperature shift, but also as an indicator of changes in physical surface conditions. Conversely, areas experiencing a decrease in LST—represented by dark blue and blue shades—tend to be characterized by more natural surfaces or relatively high vegetation cover. Vegetation plays a crucial role in regulating surface temperature through processes such as evapotranspiration, humidity enhancement, shading, and the alteration of surface energy balance (Soltanifard & Amani-Beni, 2025). Various studies have demonstrated a negative correlation between vegetation and LST. Research results also identify areas categorized as relatively stable (temperature changes ranging from -0.5°C to 0.5°C). These areas indicate minimal LST fluctuation during the 2014–2026 period. A stable condition does not necessarily imply an absence of environmental change; rather, it may reflect a balance between warming and cooling factors. For instance, while the expansion of built-up areas can drive up temperatures, the simultaneous presence of vegetation, water bodies, specific topographical features, or shifts in local climatic conditions can mitigate the magnitude of LST changes. Therefore, the relatively stable class should be understood as an area with low net LST change, rather than an area that undergoes absolutely no land-cover change.

Regionally, the patterns of Land Surface Temperature (LST) change in West Java highlight the significance of the region's topography and physiographic characteristics. West Java exhibits substantial elevation variation, ranging from coastal areas and lowlands to mountainous terrain. Higher-elevation areas generally experience thermal conditions distinct from those of the lowlands; consequently, patterns of LST increase or decrease cannot be explained solely by urbanization. Additional controlling factors—such as topography, vegetation cover, soil moisture, water bodies, and atmospheric conditions—must also be considered. These findings are significant because the characteristics of urban development in West Java mirror those of other rapidly urbanizing regions in Southeast Asia. International studies indicate that LST changes result from the interplay of urbanization, climate change, and inter-annual climate variability; thus, rising surface temperatures cannot be attributed exclusively to land-use changes (Chen et al., 2024; Chakraborty & Qian, 2024). Therefore, the observed pattern of LST increases of $\geq 2^{\circ}\text{C}$ should be interpreted as an indication of shifting surface thermal conditions, rather than direct evidence that the entire rise is solely caused by urbanization.

Based on these spatial patterns, it can be inferred that West Java experienced increasingly complex thermal differentiation between 2014 and 2026. Areas showing LST increases are generally associated with the expansion of built-up areas, economic activity, land-cover changes, and vegetation loss, whereas areas experiencing decreases or relative stability likely retained surface characteristics that provide a cooling effect. These patterns demonstrate that LST change is a crucial indicator for evaluating the environmental impacts of land-use changes and regional development. In particular, zones exhibiting LST increases of $\geq 2^{\circ}\text{C}$ warrant attention as priority areas, as such changes signify a

relatively high intensity of thermal alteration. These areas could serve as targets for further analysis by integrating LST data with NDVI, NDBI, land-cover changes, population density, road networks, elevation, and precipitation. Integrating these variables may help further investigate the factors associated with increases in Land Surface Temperature (LST) and assess whether temperature changes are related to urban expansion, vegetation loss, agricultural land conversion, or other environmental factors.

Consequently, the study's findings not only map where surface temperature changes are occurring but also highlight areas experiencing thermal stress versus those that continue to serve an ecological function by cooling the surface. This information can serve as a foundation for formulating spatial management strategies—specifically through vegetation protection, enhanced green space connectivity, the control of built-up area expansion, and the adoption of climate-adaptive development concepts.

Drivers of Land Surface Temperature (LST) Change in West Java Province

Changes in Land Surface Temperature (LST) in West Java Province are influenced by various biophysical and anthropogenic factors characterized by distinct spatial patterns. To identify the relationship between these factors and LST changes, an analysis was conducted on several environmental and land-use variables, including changes in soil moisture, water body density, slope gradient, elevation, building density, and the Normalized Difference Built-up Index (NDBI). The spatial distribution of each of these factors is presented in Figure 3.

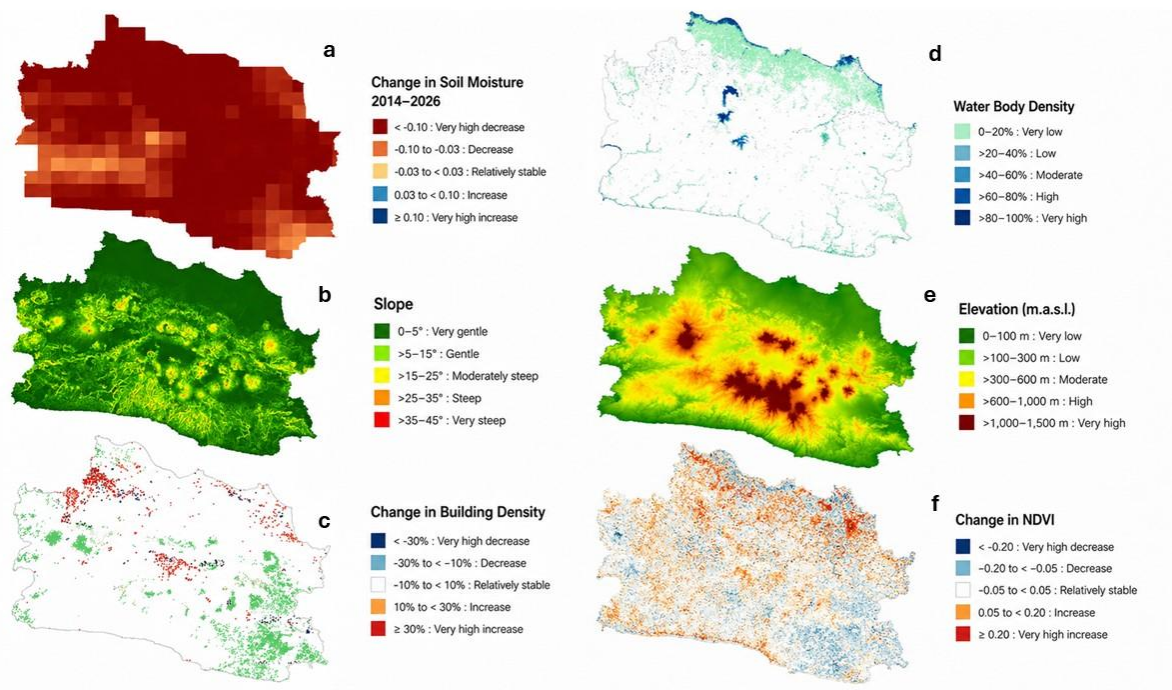


Figure 3. Spatial distribution of environmental and physical characteristics of the study area: (a) change in soil moisture from 2014 to 2026; (b) slope; (c) change in building density 2014-2026; (d) water body density; (e) elevation; and (f) change in NDVI.

The spatial distribution of environmental variables reveals substantial variations in the physical and anthropogenic characteristics of the study area. The change in soil moisture between 2014 and 2026 is predominantly characterized by a very high decrease, particularly across the areas represented by dark red. Only limited areas show relatively stable conditions or increases in soil moisture. This overall decline may be associated with changes in land use and land cover, vegetation conditions, topographic characteristics, and hydrological processes.

The slope map indicates that most of the study area is characterized by very gentle to gentle slopes (0–15°), while moderate to very steep slopes are concentrated in localized areas. These variations in slope are important because they influence surface runoff, infiltration, soil erosion, and slope stability. The elevation map further demonstrates a distinct topographic gradient, ranging from lowland areas at approximately 0–100 m above sea level to mountainous areas exceeding 1,000 m. Higher-elevation areas are generally concentrated in the central and mountainous portions of the study area and may influence vegetation distribution, soil moisture, drainage patterns, and land-use characteristics.

Changes in building density indicate an overall tendency toward increasing development intensity, particularly in areas classified as having a high to very high increase. This pattern reflects the expansion of built-up areas and increasing anthropogenic pressure, which may reduce infiltration capacity and increase surface runoff. Meanwhile, the water body density map shows that most of the study area has very low water body density (0–20%), with higher densities occurring locally along rivers, lakes, reservoirs, and other water features. These spatial variations provide important information regarding drainage characteristics, water availability, and potential areas of water accumulation.

The change in NDVI demonstrates a heterogeneous pattern of vegetation dynamics, with both decreases and increases distributed across the study area. Areas with declining NDVI may indicate vegetation degradation, land-use conversion, infrastructure development, or other forms of environmental disturbance, whereas increasing NDVI may reflect vegetation recovery or improvements in vegetation density. Overall, the combination of soil moisture, slope, building density, water body density, elevation, and NDVI provides an integrated representation of the environmental and anthropogenic processes shaping the landscape. These variables provide relevant environmental and anthropogenic information for examining spatial patterns and associations with LST changes, particularly for evaluating the interaction between land-use dynamics, hydrological conditions, vegetation change, and human development.

Relationship of Anthropogenic and Biophysical Factors with Surface Temperature Changes

Pearson correlation analysis results indicate that all variables tested exhibit a weak relationship with surface temperature changes in West Java during the 2014–2026 period. Based on absolute correlation coefficient (r) values, changes in built-up areas showed the highest value at 0.061, followed by NDBI changes (0.046), slope (0.018), water body density (0.014), elevation (0.012), and soil moisture changes (0.002). With all (r) values falling below 0.10, the bivariate linear relationship between each variable and LST change can be categorized as very weak. Detailed correlation values for each variable are presented in Figure 4.

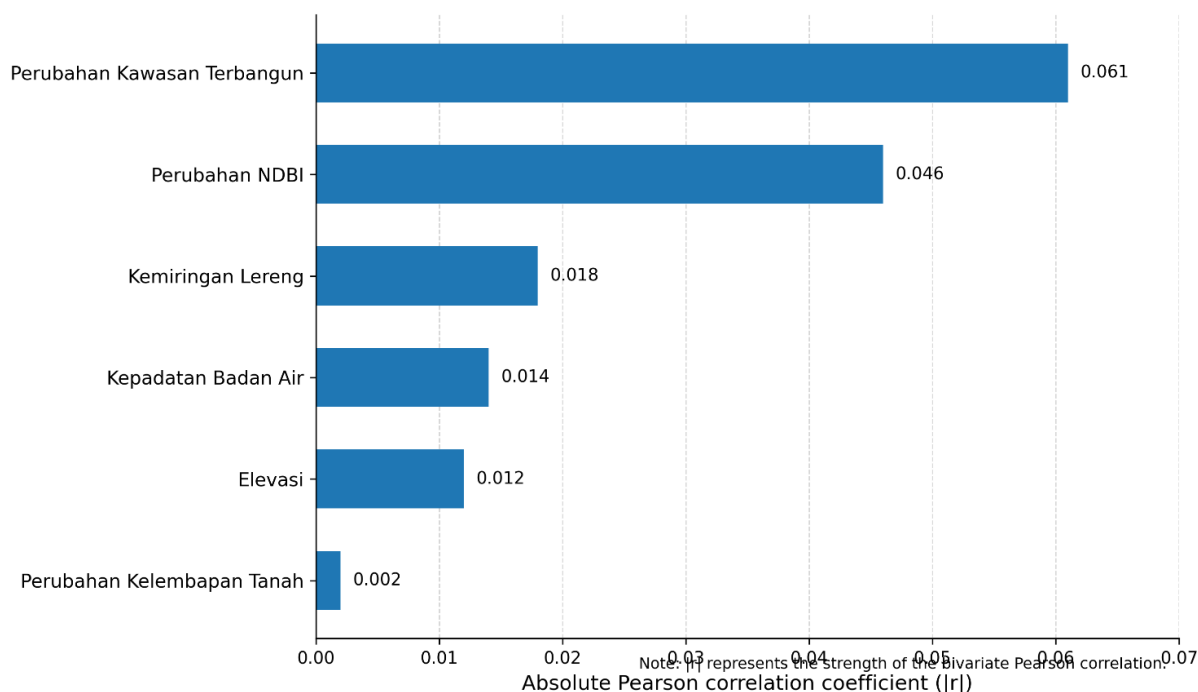


Figure 4. Correlation Strength between Explanatory Variables and LST Changes

Figure 4 shows that changes in built-up areas exhibit the highest absolute correlation value with changes in LST, specifically (r) = 0.061. Therefore, these results cannot be used to claim that changes in built-up areas are the primary cause of changes in surface temperature. Theoretically, the expansion of built-up areas can raise surface temperatures because the conversion of vegetation and open land into buildings, roads, and impervious surfaces alters surface thermal characteristics, including the capacity to absorb and store energy. Thus, conceptually, the findings in West Java remain consistent with the mechanism of surface warming driven by built-up area development. However, the value of r = 0.061 indicates a very weak relationship. The squared correlation value is only approximately R^2 = 0.0037 (or 0.37%); consequently, changes in built-up areas, in isolation, explain only a very small proportion of the variation in LST changes. Therefore, these results cannot be used to claim that changes in built-up areas are the primary cause of changes in surface temperature. The low correlation value is likely linked to the study's scale of analysis. The very low correlation values can also be explained by the substantial spatial heterogeneity of West Java Province. The province encompasses diverse regional settings, including densely urbanized and industrial areas, agricultural landscapes, mountainous regions, and coastal zones, each with different land-cover characteristics, climatic conditions, topography, and development intensity. Consequently, the relationship between changes in built-up areas and LST is not spatially uniform across the province. A relationship that may be relatively strong within a particular urban or peri-urban area can become weaker when aggregated across a much larger and heterogeneous provincial area. Thus, the low correlation values should be interpreted as reflecting the weak overall linear association at the provincial scale rather than the absence of a potential relationship at the local scale. West Java possesses highly heterogeneous regional characteristics, ranging from metropolitan and industrial zones to agricultural, mountainous,

and coastal areas. Furthermore, the relationship between urban morphology and LST is known to vary spatially.

NDBI change yielded an (r) value of 0.046, making it the variable with the second-highest correlation. NDBI is a spectral indicator widely used to characterize built-up surfaces (Oknisia, 2025). Theoretically, an increase in NDBI can be associated with a rise in LST, as built-up surfaces possess distinct physical and thermal characteristics compared to vegetation and moisture surfaces. These results align with previous studies conducted in Indonesia; however, the correlation between NDBI and LST change in this study was significantly lower. This discrepancy may be attributed to the scale of the study area. In city-scale studies, land-use characteristics tend to be relatively homogeneous, allowing the NDBI–LST relationship to appear more distinct. Conversely, at the West Java Province scale, variations in topography, vegetation, water bodies, local climate, and urbanization levels can diminish the strength of the linear relationship between NDBI change and LST change. Slope gradient yielded an (r) value of 0.018, while elevation yielded an (r) value of 0.012; both variables demonstrated a very weak relationship with LST change. Physically, topography can influence surface temperature distribution through variations in solar radiation reception, slope orientation, air circulation, and moisture conditions. The low correlation values in this study indicate that, individually, elevation and slope gradient do not strongly explain LST changes at the scale of West Java Province. Their influence is likely localized and involves interactions with other factors such as vegetation, moisture, land use, and built-up area density.

Water body density yielded a correlation value of (r) = 0.014. Although the correlation is very weak, ecologically, water bodies retain the potential to act as surface cooling elements. The presence of water influences thermal conditions through heat capacity and evaporation processes; consequently, areas surrounding water bodies have the potential for lower surface temperatures (Wu & Zhang, 2019). The relationship between water bodies and LST has also been identified in previous research. Studies on LST modeling indicate that surface characteristics—such as water bodies, vegetation, built-up areas, and topography—can simultaneously contribute to LST variations (Yin et al., 2022). The low correlation value in this study is likely attributable to the localized nature of water body effects. While the cooling effect of rivers, reservoirs, and lakes can be significant within a specific radius, analyzing the entire West Java region in aggregate may diminish the relative impact of these local effects compared to temperature variations driven by other factors. Changes in soil moisture showed the lowest correlation value, at (r) = 0.002. This value indicates that, based on the analysis performed, there is virtually no linear relationship between changes in soil moisture and changes in LST. Theoretically, soil moisture is linked to surface temperature through evapotranspiration; water availability allows a portion of surface energy to be consumed by evaporation, thereby reducing the energy available to raise the surface temperature. However, this relationship is influenced by vegetation conditions, soil characteristics, precipitation, radiation, and atmospheric conditions. Furthermore, interpreting these results requires considering the disparity in spatial resolution between the Landsat LST data and the soil moisture data used. Landsat LST data has a resolution of 30 m, whereas the soil moisture data has a much coarser resolution. This difference in scale may result in local-level soil moisture variations not being fully captured in the analysis of their relationship with LST. Overall, the research findings indicate that changes in built-up areas and changes in NDBI are the two variables exhibiting the highest absolute correlation with LST changes, even though the strength of these relationships remains very weak. Meanwhile, topographic and hydrological factors

exhibited lower correlation values. These results indicate that surface temperature changes in West Java are a complex phenomenon that cannot be explained by a single variable alone. Thus, the low correlation values observed in this study do not necessarily imply that these variables are unimportant; rather, they indicate that their individual relationships with LST changes at the West Java provincial scale are relatively weak. The broad scale of analysis involves the simultaneous interaction of various local and regional processes, thereby weakening the simple relationship between any single variable and LST changes.

CONCLUSION

This study reveals that changes in Land Surface Temperature (LST) in West Java Province during the 2014–2026 period exhibit heterogeneous spatial patterns. Increasing surface temperatures are generally observed in urban areas, regional development corridors, lowlands, and several coastal zones, whereas areas with greater vegetation cover and more natural surface characteristics tend to experience lower or relatively stable surface temperatures. The correlation analysis shows that changes in built-up areas have the highest correlation coefficient with LST changes ($r = 0.061$), followed by changes in NDBI ($r = 0.046$), slope ($r = 0.018$), water body density ($r = 0.014$), elevation ($r = 0.012$), and changes in soil moisture ($r = 0.002$). Nevertheless, all correlation coefficients fall within the very weak category, indicating that the relationships between the examined variables and LST changes are weak at the provincial scale. Therefore, none of the variables analyzed can be identified as a dominant factor or interpreted as a primary cause of LST changes in West Java based on the present analysis. These findings suggest that LST dynamics are likely associated with the combined and complex interaction of multiple anthropogenic and biophysical factors, as well as the substantial spatial heterogeneity of the province. Accordingly, the findings should be interpreted as evidence of weak statistical associations rather than direct causal relationships. From a spatial planning perspective, efforts to reduce thermal stress should nevertheless consider the management of built-up areas, the protection and enhancement of vegetation cover, the development and connectivity of green open spaces, and the preservation of water bodies. Future studies should employ multivariate and spatially explicit analytical approaches, preferably at the city/regency scale, to further investigate the relative contribution and spatial variability of multiple factors associated with LST changes.

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