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Urban Development Priority Analysis Based on NDVI, NDBI, and Road Accessibility Using Geographic Information Systems in Bandar Lampung City

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Abstract

Rapid urban growth in Bandar Lampung City increases the need for spatial information to support targeted and sustainable development priorities. This study aims to analyze urban development priorities by integrating the Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), and road accessibility using Geographic Information Systems. The data consisted of Sentinel-2 imagery, administrative boundaries, and road network data. NDVI was derived from red and NIR bands, NDBI was derived from SWIR and NIR bands, while accessibility was analyzed through road buffers of 100 m, 300 m, and 500 m. All parameters were reclassified and combined using weighted overlay with weights of 40% for NDVI, 30% for NDBI, and 30% for road accessibility. The results indicate that high vegetation density is mainly located in peripheral areas, whereas dense built-up areas dominate the city center and coastal zones. The final priority map classifies the area into low, medium, and high priorities. High-priority zones are mainly located in the southern, southwestern, and several coastal areas, indicating the need for controlled development based on environmental carrying capacity.

Keywords: Transit-Oriented Development; Rajabasa Terminal; ITDP TOD Standard; Spatial Analysis; Sustainable Urban Mobility

1. Introduction

Urban growth in Indonesia continues alongside population growth, economic activity, and increasing demand for land for housing and infrastructure. Bandar Lampung City, as one of the growth centers in Lampung Province, faces development pressure reflected in land-cover changes. Darmawan and Santoso (2024) documented settlement expansion and declining forest cover in Bandar Lampung during 2013–2023. These changes highlight the importance of

considering vegetation conditions alongside built-up development when assessing urban development priorities.

Land conversion can reduce urban vegetation and contribute to higher surface temperatures, as reported in remote-sensing studies (Aldzahabi et al., 2024; Frimpong et al., 2023). The Normalized Difference Vegetation Index (NDVI) represents vegetation greenness, while the Normalized Difference Built-up Index (NDBI) provides a spectral indication of built-up characteristics. Multi-temporal analysis in Surabaya illustrates the use of these indices to examine urban landscape change (Widiastuti et al., 2025). For a single observation period, however, they describe spatial variation in surface conditions rather than directly measuring land-cover change.

Geographic Information Systems (GIS) enable land-cover indicators and road proximity to be considered together. NDVI represents vegetation conditions, NDBI adds information on built-up characteristics, and road proximity represents a dimension of accessibility that neither spectral index directly measures. For Bandar Lampung, where settlement expansion and forest-cover decline have been documented, this combination makes the vegetation–development trade-off explicit while identifying locations near existing road infrastructure. Considering vegetation alongside development objectives is consistent with territorial planning approaches that incorporate ecosystem services (Billaud et al., 2020) and with green-space prioritization for urban resilience (Pratomo et al., 2024).

The indicators are combined using Weighted Linear Combination, which expresses an evaluation through criterion scores and preference weights (Malczewski, 2011). The weights are assigned by researcher judgment: 0.40 for NDVI and 0.30 each for NDBI and road proximity. The greater NDVI weight expresses a preference to reduce development priority in highly vegetated areas; the other two indicators receive equal emphasis. These numerical weights define a planning scenario and are not presented as literature-derived coefficients or empirically optimized values. Under the stated inverse NDVI scoring, a highly vegetated cell can theoretically reach at most 2.20, below the high-priority threshold of 2.34. This is a consequence of the scoring design rather than evidence of model validation.

The applied contribution is a citywide development-priority map for Bandar Lampung that makes the joint influence of vegetation, built-up characteristics, and road proximity explicit. Related Indonesian research has used NDBI, spatial overlays, and development controls for residential planning in a transit-oriented area (Irsal et al., 2023). Here, the emphasis is on preliminary screening across the city under a transparent vegetation-sensitive weighting scenario. The map is intended as supplementary information for review alongside the spatial plan (RTRW) and detailed spatial plan (RDTR). It does not establish statutory development permission, and no empirical comparison with those plans was conducted. The contribution therefore concerns local application and explicit prioritization, without claiming a new algorithm or superiority over existing planning frameworks.

This study aims to describe the spatial patterns of NDVI, NDBI, and road proximity and produce relative urban development priority zones for Bandar Lampung City. A single weighting scenario is used without sensitivity testing. Consequently, the stability of the classification under alternative weights has not been established, and the findings are conditional on the selected indicators, scoring rules, and weights.

2. Materials and Methods

The study was conducted in Bandar Lampung City, Lampung Province, located approximately between 5°20'-5°30' S and 105°28'-105°37' E. The area was selected because it has experienced rapid urban development and contains varied land cover, including built-up areas, vegetation, coastal zones, and urban fringe areas. The city administrative boundary was used as the main analysis area.



Figure 1. Study area of Bandar Lampung City.

The main data used in this study included Sentinel-2 imagery, road network data, and the administrative boundary of Bandar Lampung City. Data processing was carried out using Google Earth Engine and ArcGIS. A summary of the datasets and their functions is presented in Table 1.

Table 1. Data used in the study.

Data	Source/type	Purpose
Sentinel-2 MSI Level-2A imagery (2024)	Copernicus/ESA via Google Earth Engine (COPERNICUS/S2_SR_HARMONIZED). Selection period: 1 June–29 September 2024; cloud cover <30% per granule.	NDVI and NDBI calculation using a cloud-masked median composite.
Road network	INA-Geoportal; road network vector data.	Accessibility analysis using road buffers of 100 m, 300 m, and 500 m.
Administrative boundary	INA-Geoportal; Bandar Lampung administrative boundary vector data.	Study area delineation, spatial data clipping, and map visualization.

The research stages consisted of data collection, image preprocessing, NDVI and NDBI calculation, road buffer analysis, reclassification, weighted overlay, and result visualization. The methodological workflow is shown in Figure 2.

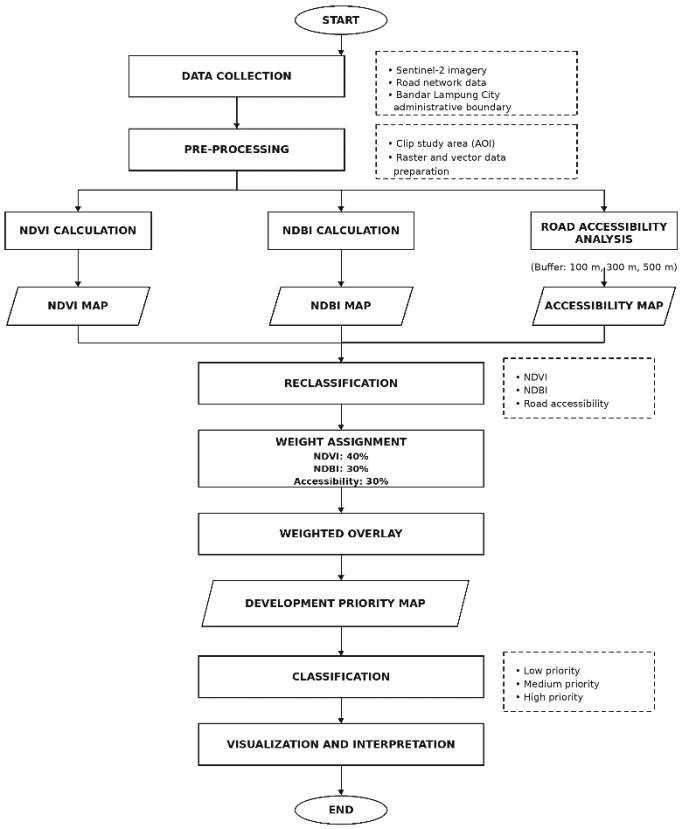


Figure 2. Data processing and analysis workflow.

NDVI was calculated using the red and near-infrared (NIR) bands of Sentinel-2 imagery. The NDVI values were used to identify vegetation density, where high values indicate stronger ecological functions, while low values represent limited vegetation or non-vegetated areas.

NDBI was calculated using the shortwave infrared (SWIR) and NIR bands. This index was used to identify built-up areas because built-up surfaces generally have a higher spectral response in SWIR than in NIR. High NDBI values indicate dense built-up areas, while low values indicate vegetation or non-built-up surfaces.

Road accessibility was analyzed using buffers generated from the road network. The 100 m buffer was classified as high accessibility, the 300 m buffer as medium accessibility, and the 500 m buffer as lower accessibility. This approach represents the decreasing influence of road proximity on urban development potential.

Each parameter was reclassified into three score classes: low, medium, and high. For NDVI, the score was reversed because areas with lower vegetation were considered more suitable for development than highly vegetated areas that should be maintained for ecological functions. For NDBI and accessibility, higher values received higher priority scores. The weighted overlay model was formulated as follows:

$$P = (0.40 \times S_NDVI) + (0.30 \times S_NDBI) + (0.30 \times S_Accessibility) \quad (1)$$

where P is the development priority score, S_NDVI is the reclassified NDVI score, S_NDBI is the reclassified NDBI score, and S_Accessibility is the road accessibility score. The final values were grouped using the equal interval method into low priority (1.00-1.66), medium priority (1.67-2.33), and high priority (2.34-3.00).

The results of the spatial analysis were integrated with the modified ITDP TOD scoring 3. Results

3.1 NDVI Distribution

The NDVI map shows spatial variation between the central and peripheral parts of Bandar Lampung City (Figure 3). Higher NDVI values are prominent in western and southwestern peripheral areas, while lower values occur across parts of the central urban area. These patterns describe relative vegetation greenness during the 2024 composite period.

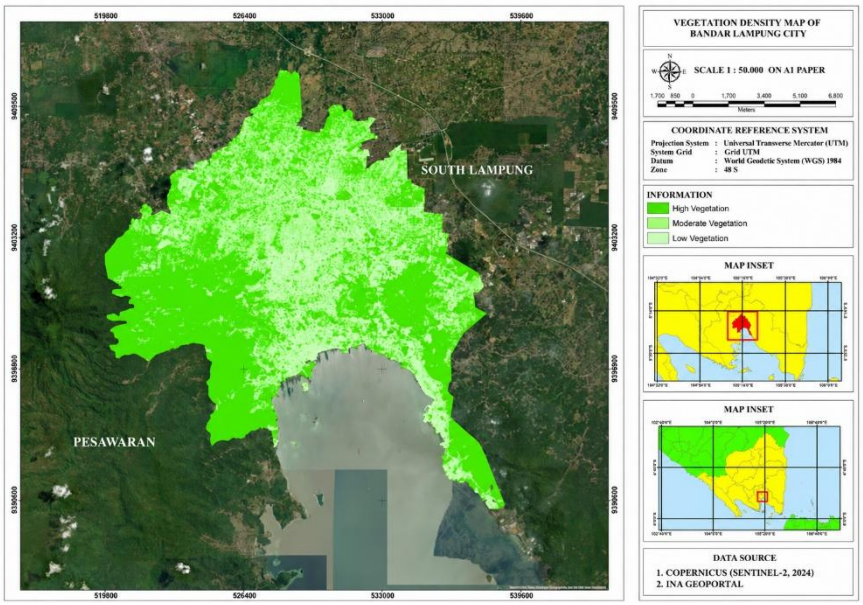


Figure 3. NDVI map of Bandar Lampung City.

The spatial contrast is consistent with vegetation differences between urban and peripheral settings. However, a single-year composite cannot establish the timing or rate of vegetation loss. Darmawan and Santoso (2024) provide separate multi-temporal evidence of settlement expansion and forest-cover decline in Bandar Lampung. In the present prioritization scenario, NDVI introduces vegetation considerations into the evaluation, while the ecological functions of individual sites require additional information.

3.2 NDBI Distribution

The NDBI map shows higher index classes across parts of the central city and several coastal areas (Figure 4). The pattern indicates spatial variation in built-up spectral characteristics and should be interpreted together with NDVI and the underlying land-cover context.

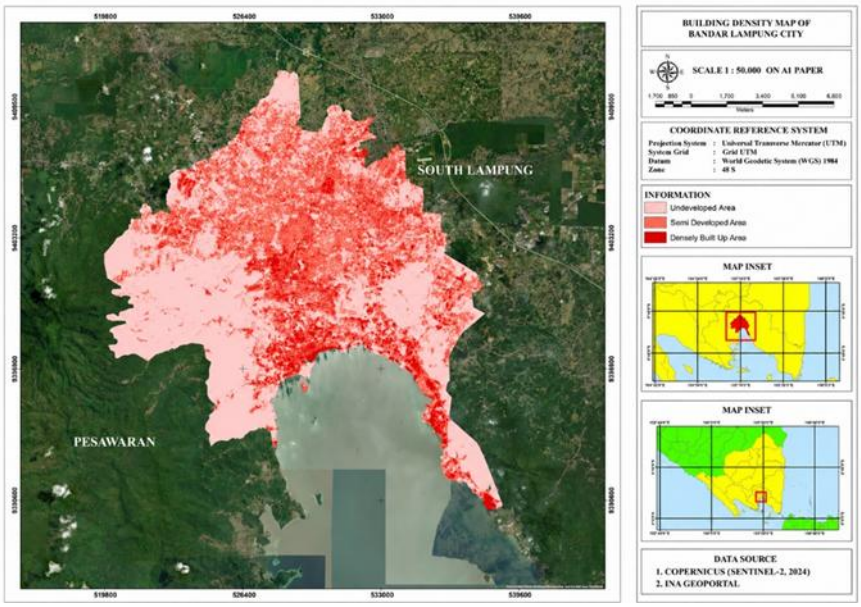


Figure 4. NDBI map of Bandar Lampung City.

Lower NDBI values occur in parts of the urban fringe and other areas with different surface characteristics. Because NDBI can confuse built-up surfaces with bare soil, these classes should not be interpreted as direct measurements of building density (Javed et al., 2021). In the overlay, NDBI contributes a relative indicator of existing built-up characteristics; a high score alone does not establish that a site is available or suitable for additional construction.

3.3 Road Accessibility

The road-buffer map shows the spatial reach of the mapped road network and the distribution of the three proximity classes (Figure 5). The 100 m, 300 m, and 500 m thresholds distinguish locations with progressively greater distance from roads. The mapped pattern represents physical proximity rather than a complete assessment of transport accessibility.

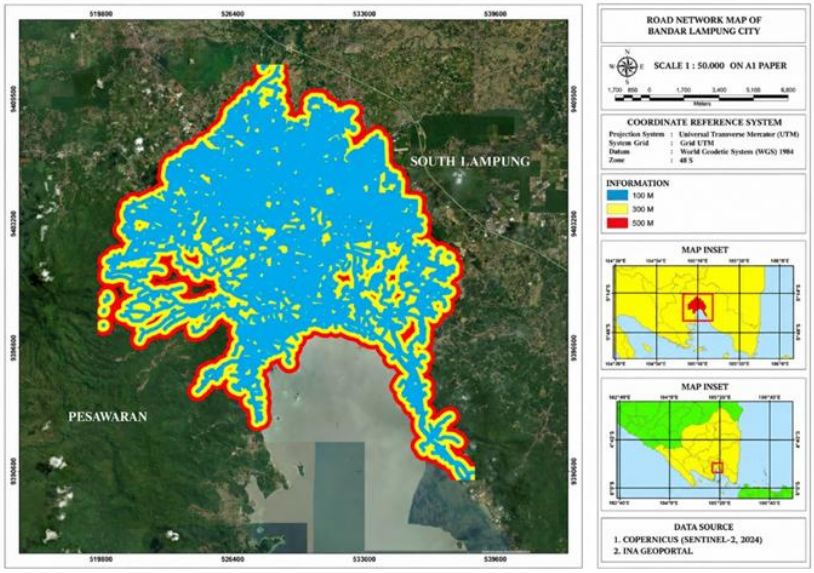


Figure 5. Road accessibility map of Bandar Lampung City.

Road proximity is important for development planning because it influences mobility, connectivity, and service efficiency. Areas close to roads are easier to develop; however, spatial control is needed to prevent urban growth from exceeding environmental carrying capacity.

3.4 Urban Development Priorities

The weighted overlay combines the three reclassified indicators under the 40:30:30 weighting scenario. The resulting map distinguishes low, medium, and high relative development priorities (Figure 6). These labels describe the model output and do not constitute a verified land-suitability classification.

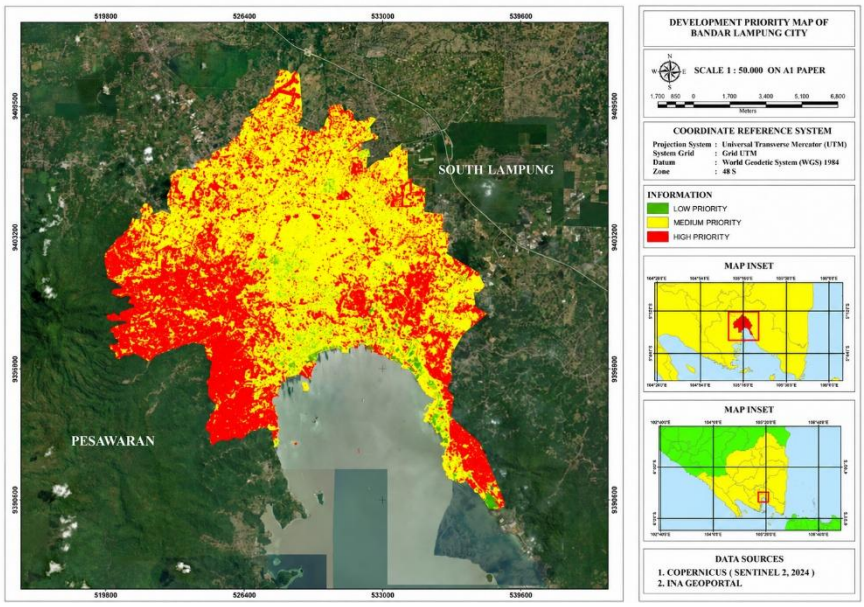


Figure 6. Urban development priority map of Bandar Lampung City.

High-priority zones are mapped mainly in southern, southwestern, and several coastal parts of the city. They are candidate areas for further assessment under the selected evaluation scenario. Their mapped priority does not establish land availability, environmental carrying capacity, or suitability for housing and infrastructure. Such decisions require checks against zoning, protected areas, hazard exposure, and site conditions.

Medium-priority zones are widespread across central and northern parts of the city, while low-priority zones occur in smaller patches. The classes reflect combinations of the input scores and cannot, by themselves, identify infiltration areas or ecological buffers. No area-based class proportions or sensitivity results are reported, so class dominance and robustness are not quantified. The output should be used as an initial screening layer alongside planning controls, consistent with approaches that connect spatial indicators to development regulations (Irsal et al., 2023).

4. Conclusions

Integrating NDVI, NDBI, and road proximity in GIS provides a spatial representation of relative development priorities for Bandar Lampung City. The applied contribution is an explicit weighting scenario that considers vegetation greenness, built-up spectral characteristics, and proximity to

existing roads together. The 40:30:30 weights express the study's evaluation preferences and are not established as optimal coefficients.

Higher NDVI values occur mainly in peripheral areas, whereas higher NDBI values are visible in central and several coastal areas. The priority map distinguishes three classes, with high-priority zones mapped mainly in the south, southwest, and several coastal locations, and medium-priority zones widespread in central and northern areas. These results are conditional on the indicator classifications and weighting scenario; the indices do not directly establish ecological function, building density, or site suitability.

The map can provide preliminary information for review alongside RTRW/RDTR and site-specific development constraints. Future work should evaluate alternative weights, validate the input classifications and priority results, and incorporate socio-economic conditions, hazard exposure, protected areas, and infrastructure capacity. These steps are needed before the mapped priorities can support detailed development decisions

5. Declaration of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

6. Acknowledgement

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