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Spatial Analysis of Vegetation and Thermal Humidity Index Based on Low Carbon Green City Design in Banjarbaru Using Remote Sensing

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ABSTRACT

Rapid urban growth in Banjarbaru, Indonesia has led to environmental challenges, particularly the Urban Heat Island (UHI) phenomenon and reduced carbon sequestration due to declining vegetation cover. This study aims to: (1) analyze spatial patterns of UHI and Thermal Humidity Index (THI) to identify thermally comfortable and uncomfortable areas; (2) assess the relationship between vegetation density (NDVI) and carbon stock potential; and (3) propose spatial strategies to enhance thermal comfort and carbon absorption capacity in support of Low Carbon Green City (LCGC) development. Using a spatial analysis approach, the study utilized Sentinel-2 and Landsat 9 satellite imagery, field measurements via wireless sensor networks (WSN), and GIS-based modeling techniques. Land Surface Temperature (LST), THI, and NDVI were analyzed and correlated with carbon stock data derived from vegetation plot surveys. The results indicate a strong inverse correlation between NDVI and both LST and THI, confirming that vegetation plays a crucial role in regulating microclimate and thermal comfort. Areas with low NDVI exhibited higher surface temperatures and THI values, indicating intense thermal stress. Carbon stock analysis showed that plots with higher NDVI values held significantly greater carbon reserves, with a regression model (R^2 = 0.850) validating NDVI as a strong predictor for aboveground biomass. Furthermore, high UHI and THI zones overlapped with areas of low carbon stock, highlighting the need for targeted ecological interventions. To address these challenges, the study proposes three spatial strategies: urban farming, green building, and green corridor development. These approaches aim to improve biomass density, reduce surface temperatures, and enhance carbon sequestration potential. Collectively, they support climate adaptation, urban resilience, and participation in carbon trading initiatives. This research contributes a practical framework for integrating ecological and spatial planning toward sustainable urban transformation.

Keywords: Urban Heat Island; NDVI; Carbon Stock; Thermal Comfort; Green City Design

INTRODUCTION

Global warming continues to be a pressing global issue, causing a wide range of environmental impacts due to shifts in global climate patterns. One of the most immediate and observable consequences of climate change is the melting of polar ice caps, which has significantly contributed to the rise in global sea levels from an average of 2.2 ± 0.3 mm/year in 1993 to 3.3 ± 0.3 mm/year by 2021 (Mar et al., 2022). Urban areas, in particular, have become hotspots for climate-related challenges, primarily due to their role as major contributors to greenhouse gas (GHG) emissions. Cities are responsible for more than 70% of global carbon dioxide emissions, largely due to transportation, industry, and energy production (Adinugroho et al., 2019). One notable impact is the intensification of the Urban Heat Island (UHI) effect, wherein urban zones exhibit significantly higher surface and ambient temperatures compared to surrounding rural areas (Gadekar et al., 2023). This is largely attributed to the replacement of natural land covers, especially vegetation, with artificial, heat-retaining materials such as asphalt, concrete, and steel. As vegetation is diminished, the cooling effects of evapotranspiration are lost, leading to an increase in thermal discomfort and a decline in overall urban livability (Halder et al., 2021). This study addresses the first research objective: to analyze Urban Heat Island patterns in urban areas to identify zones that are thermally comfortable or uncomfortable for human habitation (KHAN & JAVED, 2022). Understanding these thermal distributions is essential for planning and designing cities that are both livable and resilient to climate-induced stressors. In this context, remote sensing becomes an essential tool in monitoring spatial variations in land surface temperature, vegetation cover, and other thermal indices such as the Thermal Humidity Index (THI), which collectively offer insights into spatial comfort levels across a city (Zhang et al., 2014).

The second major component contributing to UHI is the rapid urbanization and reduction of vegetated land cover. As cities expand, green spaces are often replaced with impervious surfaces, leading to increased heat absorption and reduced carbon sequestration capacity. Research has consistently demonstrated the inverse relationship between vegetation cover and surface temperature; for example, (Leitão et al., 2018) found that every 0.5% decrease in vegetated land corresponds to a 0.25°C increase in surface temperature per decade. Vegetation not only plays a vital role in regulating microclimates through shading and evapotranspiration but also acts as a natural sink for carbon dioxide, thereby mitigating the greenhouse effect. Green Open Spaces (RTH) are recognized as crucial elements in urban areas, capable of reducing daytime temperatures by up to 4°C (Panchasara et al., 2021) and nighttime temperatures by 1°C. Unfortunately, in Banjarbaru, the designated green space only accounts for 1.79% of the city’s land area far below the 30% mandated by Indonesia’s national spatial planning law (UU No. 26 Tahun 2007). This shortfall not only exacerbates the UHI effect but also limits the city's potential for carbon absorption and climate resilience. This study thus pursues the second objective: to analyze land cover in enhancing carbon sequestration potential and increasing the capacity to reduce UHI. By examining the spatial distribution and density of vegetated areas using remote sensing data, this research aims to quantify their cooling effect and estimate their contribution to carbon capture. The integration of vegetation indices such as NDVI (Normalized Difference Vegetation Index) with thermal analysis (THI) provides a comprehensive understanding of the ecological functions of urban green spaces and their potential to mitigate both atmospheric warming and carbon buildup in densely populated areas (Sharma et al., 2021).

Banjarbaru, a rapidly growing urban center and the new capital of South Kalimantan

Province, presents both an opportunity and a challenge in sustainable urban development. As the city expands with a population that doubled between 2000 and 2020, alongside surging infrastructure development the urgency to adopt environmentally conscious urban planning becomes more apparent. Emissions data from 2012 to 2021 shows a rise from 395 to 552 Gg CO_2-eq, highlighting the pressing need for mitigation strategies (Nirwana et al., 2024). However, despite national directives and the RPJMN 2020–2024 agenda, which emphasizes Low Carbon Development (PRK), Banjarbaru currently lacks specific local policies aimed at transitioning into a Low Carbon Green City (LCGC). In response to these conditions, the third objective of this study is proposed: to design a low carbon green city based on land cover characteristics. This objective involves identifying areas suitable for green infrastructure interventions, integrating vegetation-based cooling strategies, and proposing urban zoning reforms that align with sustainable land use. Remote sensing technologies facilitate the mapping of land use changes, the modeling of surface heat distribution, and the evaluation of vegetated zones capable of enhancing urban climate resilience. Moreover, the study incorporates the Thermal Humidity Index (THI) to assess thermal comfort, which is vital for human health and well-being. Excessive urban heat not only increases energy demand for cooling but also leads to thermal stress and reduced productivity. By synthesizing spatial data on vegetation, temperature, and humidity, this research will propose a scientifically-informed green city model tailored to Banjarbaru's context. Such a model aims to provide policy-makers with actionable insights for integrating ecological sustainability into urban planning, ensuring that future development supports a resilient, carbon-efficient, and habitable urban environment.

LITERATURE REVIEW

1. Urban Heat Island (UHI)

Urban Heat Island (UHI) is a phenomenon where urban areas experience significantly higher temperatures than surrounding rural areas due to human activities and land cover changes. The replacement of natural land cover with impervious surfaces such as asphalt and concrete increases heat retention, leading to elevated urban temperatures. According UHI is influenced by factors such as land use changes, air pollution, population density, and urban morphology (da Silva Espinoza et al., 2022). Their study in Lusaka, Zambia, found that rapid urban expansion contributed to a clear spatial pattern of UHI, with higher surface temperatures in the city center with emphasized the negative ecological impact of UHI in Asian megacities (Jabbar et al., 2023), where UHI intensity correlates with rapid urban sprawl and the reduction of green spaces. They suggested that integrating green infrastructure into urban planning is essential to mitigate UHI.

2. Normalized Difference Vegetation Index (NDVI)

NDVI is widely used to assess vegetation health and density through remote sensing techniques. It is derived from the difference between near-infrared (NIR) and red reflectance, offering a normalized measure of vegetation greenness. NDVI plays a crucial role in analyzing the cooling effect of vegetation and its relationship with urban thermal environments. The research from (Sandholt et al., 2002) demonstrated that there is a strong negative correlation between NDVI values and LST in urban areas, confirming the cooling benefits of green spaces.

Moreover, (Huang et al., 2015) investigated the spatial relationship between NDVI and surface temperatures in Shanghai, China. They found that areas with higher NDVI values consistently showed lower surface temperatures. These findings suggest that vegetation coverage can significantly mitigate UHI intensity. In similar studies, (Onačillová et al., 2022) highlighted that NDVI serves as an essential indicator for identifying urban vegetation that supports thermal comfort and ecosystem resilience.

3. Land Surface Temperature (LST)

LST represents the radiative skin temperature of the land surface and is a key parameter in urban climate studies, particularly in the assessment of UHI. Remote sensing, particularly using Landsat thermal bands, provides a reliable means of estimating LST over large areas. Weng et al. (2004) applied Landsat ETM+ data to retrieve LST in Indianapolis, USA, and found a clear correlation between urban built-up areas and elevated LST values.

In their study, (Halder et al., 2021) highlighted that changes in LST are directly related to land use types, especially the transition from vegetated to impervious surfaces. Furthermore, Sobrino et al. (2004) emphasized the importance of LST in monitoring urban thermal environments and proposed algorithms to improve accuracy in LST retrievals.

4. Thermal Humidity Index (THI)

The Thermal Humidity Index (THI) is a bioclimatic index used to quantify human thermal comfort by combining air temperature and relative humidity. It is particularly useful in assessing heat stress in outdoor environments, especially in tropical urban settings. According to (Bento et al., 2018), THI can help determine areas with uncomfortable thermal conditions, often overlapping with regions exhibiting high UHI intensity.

Munsyi et al. (Munsyi et al., 2024) investigated the relationship between thermal comfort and environmental design by using THI and PET (Physiological Equivalent Temperature). Their findings confirmed that green areas improve thermal perception by reducing THI values. Folega et al. (Folega et al., 2023)demonstrated that the presence of urban parks significantly decreases local THI and improves perceived thermal comfort (PTC), suggesting the relevance of THI in climate-adaptive city planning.

MATERIALS & METHODS

The study was conducted in Banjarbaru City, South Kalimantan, Indonesia, which is currently undergoing rapid urban development and is designated as the new provincial capital. This study adopted a spatial analysis approach using remote sensing and GIS (Geographic Information System) technologies to assess the impacts of vegetation cover on urban temperature variations, carbon sequestration, and human thermal comfort. The research was carried out in several phases: data collection, image preprocessing, satellite image analysis, field validation, and modeling. The primary datasets used were multispectral satellite imagery from Sentinel-2 MSI for land cover and vegetation analysis, while land surface temperature (LST) was derived from thermal bands. Ground truth data collection employed Wireless Sensor Networks (WSN) to measure environmental variables such as temperature, humidity, and CO_2 concentration in real-time. These datasets were then integrated into a spatial modeling environment to identify Urban Heat Island (UHI) zones, compute Normalized Difference Vegetation Index (NDVI), Temperature Humidity Index (THI), and develop a low carbon green city design based on vegetative land cover.

The satellite data preprocessing involved radiometric and atmospheric correction using SNAP software to ensure accurate reflectance values. NDVI was calculated using the near-infrared (NIR) and red bands with the formula NDVI = (NIR - Red) / (NIR + Red) (Pangestu et al., 2023). LST was estimated from surface reflectance and emissivity data following standard thermal retrieval equations (Nugroho & Jauhari, 2024). UHI was derived by comparing urban and rural LST values, while THI was calculated by combining air temperature and relative humidity using the formula $THI = T - (0.55 - 0.0055 \times RH) \times (T - 14.5)$, Where T is temperature in °C and RH is relative humidity in %. Vegetation classes and built-up areas were extracted through supervised classification using QGIS. Field sampling employed plot-based surveys, with purposive sampling at high and low thermal zones, and incorporated qualitative surveys to assess human thermal comfort. Regression and spatial autocorrelation models (Moran's I and LISA) were applied to quantify the relationship between vegetation density, carbon sequestration, and urban thermal comfort. Spatial regression analysis also helped in validating predictive relationships between NDVI, LST, and THI.

The final output consisted of thematic maps identifying zones of high UHI, vegetation distribution, THI-based thermal comfort, and priority areas for low carbon green city interventions. The spatial design proposed in this study provides urban planners and policymakers with a geospatial decision-making tool to optimize land use, maximize carbon sequestration, and mitigate UHI through targeted green infrastructure. To ensure comprehensive planning, the study also evaluated the extent of existing green spaces (RTH – Ruang Terbuka Hijau) and compared it with national standards. Table 1 below summarizes key indicators and data sources used in this study.

Table 1. Key indicators and data sources

No.	Parameter	Data Source	Method of Analysys
1	Land Cover (Vegetation, Built-up)	Sentinel-2 MSI	NDVI, Supervised Classification
2	Land Surface Temperature (LST)	Landsat 9 Band 10	Radiative Transfer Equation
3	Urban Heat Island (UHI)	Derived from LST	Δ LST (Urban - Rural)
4	Temperature & Humidity	Wireless Sensor Network (WSN)	THI Calculation
5	Carbon Sequestration	NDVI, Field Carbon Plot Sampling	Regression Modeling
6	Thermal Comfort Zones	THI, Urban Climate Classification	Spatial Interpolation and THI Zoning
7	Green City Design (LCGC)	Green City Design (LCGC)	GIS-Based Multi-Criteria Spatial Modeling

RESULT

The spatial analysis conducted in Banjarbaru using Sentinel-2 satellite imagery and environmental field data reveals significant correlations between vegetation cover (NDVI), Land Surface Temperature (LST), and Thermal Humidity Index (THI). The regression analysis demonstrates a strong inverse relationship between NDVI and LST, indicating that areas with higher vegetation density consistently show lower surface temperatures. This finding aligns with previous studies emphasizing the role of urban vegetation in mitigating UHI effects. Similarly, the THI analysis shows that denser vegetation contributes to a reduction in thermal discomfort by decreasing the combined effect of temperature and humidity.

Land surface temperature (LST) was analyzed based on Landsat 9 satellite imagery and validated through direct field measurements. The results are presented in Table 2 below:

No Plot	Landsat 9 Digital Value (ºC)	Field-Measured Soil Temperature (ºC)
13	27,7	30,9
14	27,4	30,9
48	25,9	30,1
36	26,1	29,7
37	27,7	29,7
8	27,1	29,4
38	27	29,4
46	25,8	29,2
18	26,3	29,1

33	24,9	28,8
49	25,2	27,9
54	24,4	27,9
34	24,6	27,7
68	25,5	27,7
6	24,1	27,3
60	24,9	27,3
67	24,3	27,3
58	23,9	27,1
63	24,4	27,1
62	24,4	27
66	23,9	27
57	24,4	26,9
56	23	26,3

Based on table, a regression model was developed to evaluate the relationship between the satellite-derived LST and the field-measured ground temperature. The resulting coefficient of determination (R^2) was 0.835, indicating a very strong relationship between the two datasets.

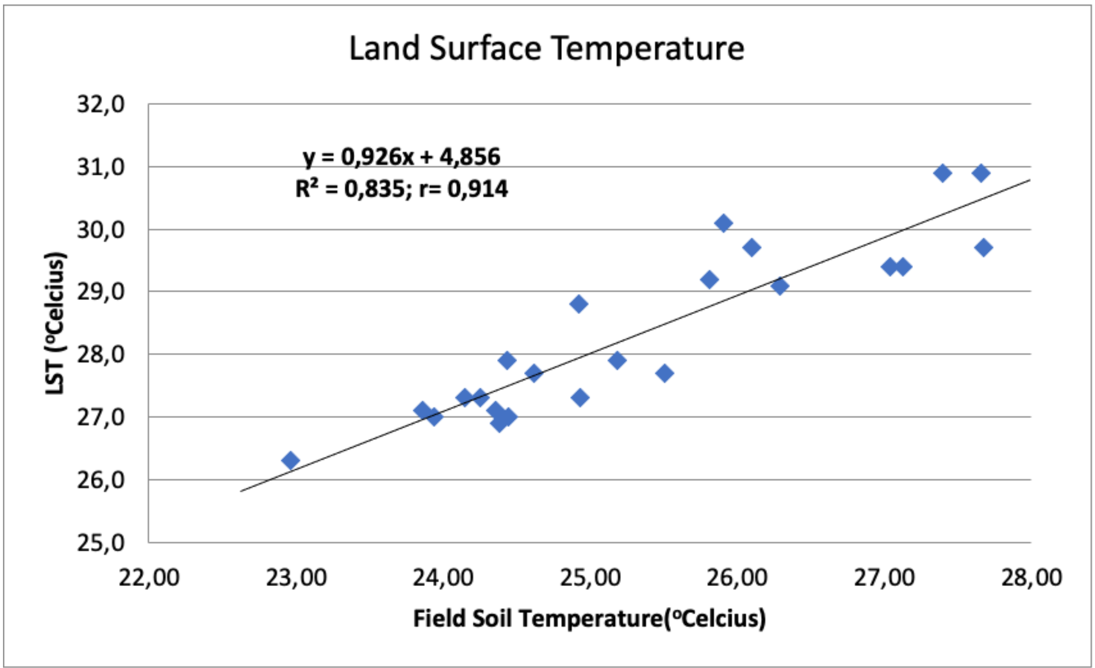

Figure 1. Graph of the relationship between soil temperature and field measurement results

The graph in Figure 1 illustrates this correlation, showing a linear regression equation of $y = 0.926x + 4.856$. The R^2 value of 0.835 indicates that approximately 83.5% of the variation in the satellite-derived land surface temperature can be explained by the field-measured soil temperature. The correlation coefficient (r) is 0.914, which denotes a statistically strong and significant positive correlation. This result confirms that increases in field-measured temperatures are closely aligned with increases in land surface temperatures derived from remote sensing data.

Using the established regression equation, LST values were predicted for the entire study area. The spatial results are presented in Figure 2.

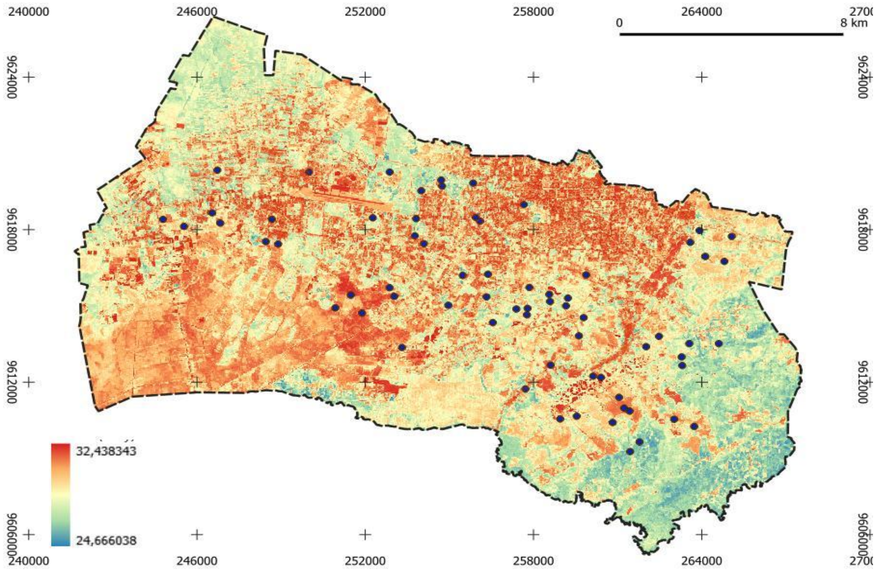

Figure 2. Land Surface Temperature

The surface temperature map demonstrates the distribution of LST across Banjarbaru in September 2023, as derived from Sentinel-2 data. The highest temperature, reaching 32.44°C, is observed in the western urban zones, which are characterized by dense building coverage or bare land with minimal vegetation. These areas tend to exhibit urban heat island effects due to their heat-absorbing materials. Conversely, the lowest recorded temperature, around 24.67°C, is predominantly found in regions with dense vegetation, such as parks, forests, or agricultural zones. These areas benefit from natural cooling mechanisms and generally maintain lower surface temperatures. Overall, the spatial variability of LST in Banjarbaru is significantly influenced by land cover and land use patterns, with built-up areas displaying higher thermal retention compared to vegetated or natural surfaces.

Based on the calculated Land Surface Temperature (LST) values, the Urban Heat Island (UHI) intensity was determined and visualized in a thematic map as shown in Figure 3.

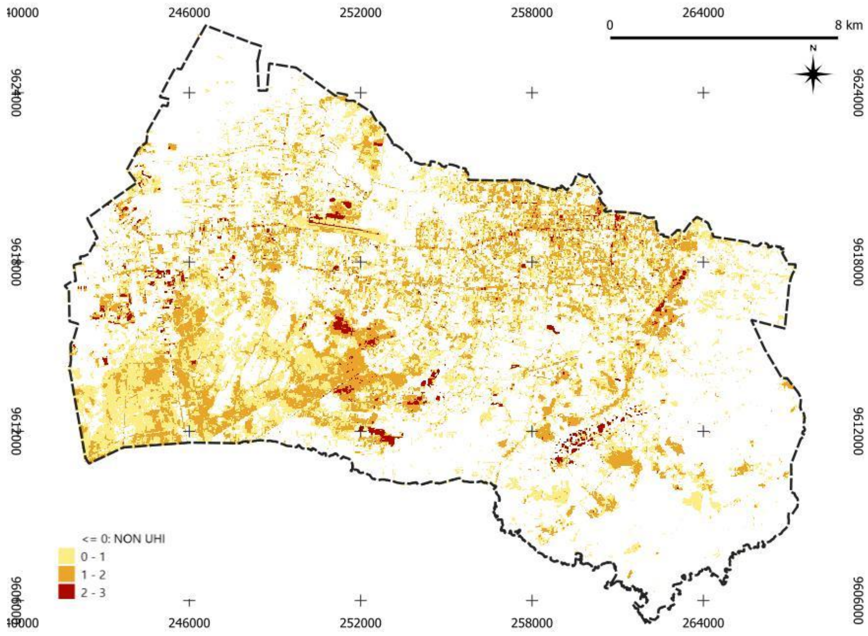

Figure 3. Urban Heat Island Distribution Pattern

Figure 3 presents a thematic map illustrating the distribution of the Urban Heat Island effect within the urban area of Banjarbaru, derived from Sentinel-2 imagery for September 2023. The non-UHI areas, represented in lighter or nearly white colors, indicate zones with no significant temperature increase typically vegetated or open areas that are less affected by urban heat.

UHI Class 1 (0–1°C), marked in pale yellow, represents urban areas experiencing slight temperature increases, often due to moderate urban development with remaining green coverage or open spaces. UHI Class 2 (1–2°C), depicted in deeper yellow tones, corresponds to zones with moderate heat intensity, generally resulting from a mix of infrastructure development and reduced vegetation.

The highest category, UHI Class 3 (2–3°C), is indicated by reddish-brown shades, denoting areas with significant temperature elevation. These zones usually correspond to high-density urban centers or industrial areas where vegetation is minimal and surface materials tend to absorb and retain heat.

This spatial visualization of UHI serves as a critical tool for urban planners to identify heat-vulnerable zones and implement targeted mitigation strategies. Potential solutions include expanding green space networks, enhancing urban vegetation, incorporating reflective or permeable surface materials, and promoting climate-adaptive building designs. Such interventions are crucial in reducing UHI effects, improving thermal comfort, and supporting the broader goal of low carbon and climate-resilient urban development.

Based on the integration of Land Surface Temperature (LST) and humidity data, the Temperature Humidity Index (THI) was calculated to assess thermal comfort across the study area. The spatial distribution of the THI values is presented in Figure 4

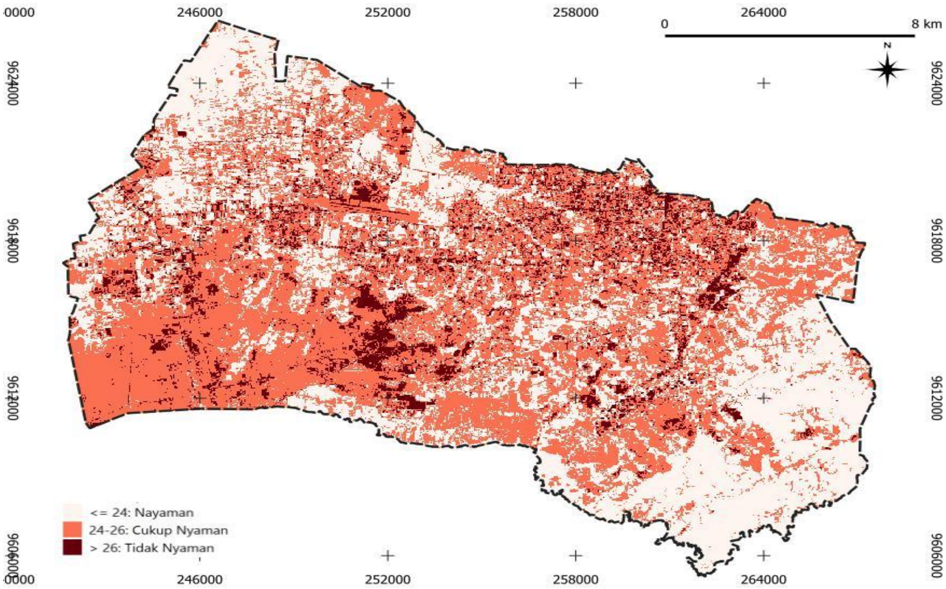

Figure 4. Spatial Pattern of Temperature Humidity Index

Figure 4 illustrates the THI analysis results for Banjarbaru City, derived from Sentinel-2 imagery for September 2023. THI is an index used to evaluate outdoor thermal comfort by combining temperature and relative humidity to reflect perceived human comfort in an area.

The map classifies thermal comfort into three main categories based on THI values. Areas with a THI value of up to 24°C are represented in the lightest colors and classified as "Comfortable" zones. These areas are predominantly located in the eastern and western parts of Banjarbaru, which likely feature dense vegetation or favorable topographic characteristics that help moderate ambient temperatures.

Zones with THI values between 24°C and 26°C, marked in medium tones, fall under the "Moderately Comfortable" class. These areas are indicative of relatively mild thermal stress but are starting to experience the influence of urban factors such as heat-absorbing materials like asphalt and concrete.

In contrast, areas with THI values exceeding 26°C are represented by the darkest colors and are classified as "Uncomfortable". These zones typically cover densely built urban areas, open land, water bodies, and scrublands, which are prone to higher thermal loads due to a lack of vegetation and increased exposure to direct solar radiation.

This THI-based spatial assessment is a vital tool for urban planners and policymakers. It helps in identifying zones that require immediate thermal mitigation efforts such as urban greening, increasing tree canopy cover, and implementing climate-sensitive urban design. Furthermore, it supports the broader goals of developing sustainable, climate-resilient, and human-centered low carbon cities.

Based on field survey data and subsequent processing, the carbon stock potential (kg/pixel) for each vegetation plot was calculated, as shown in Table 2.

Table 2. Potential Carbon Stock Data (kg/pixel) per plot Example

No.	Number Plot	NDVI Value	Total Carbon (kg/pix)	No.	Number Plot	NDVI Value	Total Carbon (kg/pix)
1	10	0,27	10,62	18	35	0,46	103,69
2	11	0,26	7,91	19	39	0,46	124,16
3	12	0,32	10,40	20	40	0,48	152,18
4	13	0,36	8,43	21	41	0,45	108,97
5	15	0,36	30,68	22	42	0,53	148,14
6	16	0,36	56,27	23	44	0,54	200,97
7	17	0,35	28,40	24	46	0,53	160,68
8	18	0,37	43,92	25	48	0,50	254,15
9	19	0,36	60,45	26	49	0,54	133,59
10	20	0,39	23,73	27	51	0,56	357,09
11	22	0,35	29,70	28	56	0,65	419,41
12	24	0,39	60,08	29	57	0,61	398,18
13	25	0,35	39,08	30	59	0,64	450,71
14	28	0,45	27,48	31	60	0,61	412,44
15	31	0,45	87,71	32	62	0,65	452,22
16	32	0,47	138,44	33	63	0,63	298,13
17	34	0,43	99,59	34	64	0,63	295,59
				35	68	0,73	646,20

The data indicates a clear relationship between NDVI values and carbon storage potential, with higher NDVI values generally corresponding to greater carbon content. NDVI values in the study range from 0.26 to 0.73, reflecting varied vegetation density across plots. For example, Plot 68 with an NDVI of 0.73 shows the highest carbon stock at 646.20 kg/pixel, whereas Plot 11 with an NDVI of 0.26 has only 7.91 kg/pixel. This confirms that denser and healthier vegetation holds a higher capacity for carbon sequestration. The data was then further analyzed to produce a statistical model illustrating the relationship between NDVI and carbon stock, as shown in Figure 5.

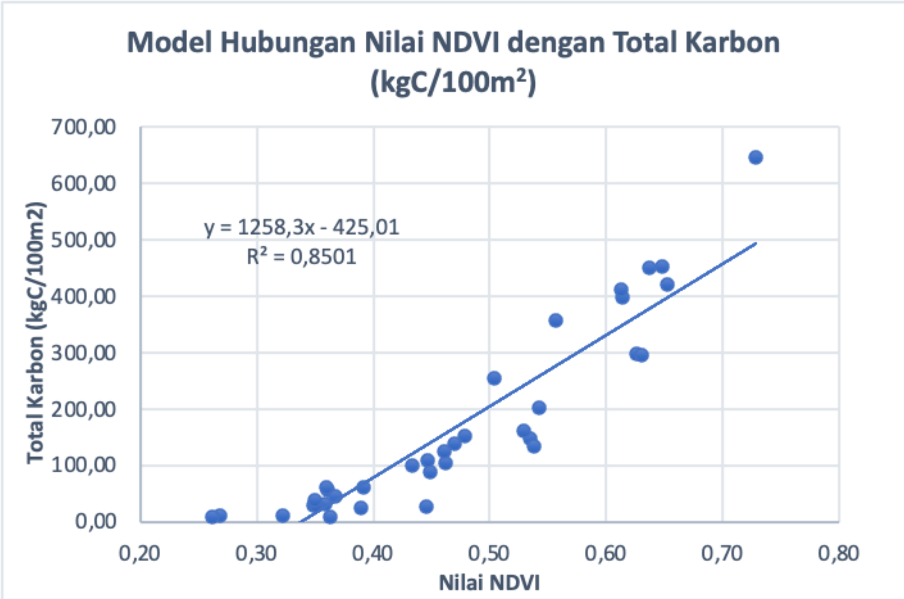

Figure 5. Relationship Model of NDVI Value with Carbon Total

Figure 5 illustrates the relationship model between the Normalized Difference Vegetation Index (NDVI) and total carbon stock (kg/100 m²). The plotted data show a clear positive correlation, where increasing NDVI values correspond with higher levels of carbon stored in vegetation. This trend aligns with ecological understanding that denser, healthier vegetation indicated by higher NDVI has greater capacity to absorb and retain atmospheric carbon through photosynthesis. The linear regression model derived from the data is expressed as y = 1258.3x – 425.01, indicating that each unit increase in NDVI corresponds to an estimated increase of approximately 1258.3 kg of carbon per 100 m², adjusted by a constant. The model's coefficient of determination (R^2) is 0.850, suggesting that 85% of the variation in carbon stock can be explained by NDVI values. Furthermore, the Pearson correlation coefficient (r) of 0.92 confirms a very strong positive relationship, reinforcing NDVI as a reliable predictor for estimating aboveground carbon storage.

Based on the analysis of Objective 1, areas with high Urban Heat Island (UHI) and high Thermal Humidity Index (THI) were identified, indicating zones of significant thermal discomfort. This is further supported by findings in Objective 2, which revealed low carbon stock potential in the same areas, highlighting the lack of vegetation density and biomass. In response, Objective 3 was formulated to address both thermal discomfort and low carbon storage by proposing spatial and economically driven strategies focused on biomass enhancement.

Three key spatial design concepts are recommended: urban farming, green building, and green corridor development. These strategies aim to increase urban vegetation, enhance microclimate regulation, and improve carbon sequestration capacity. Urban farming contributes to localized biomass production and food security, green buildings integrate vegetation and energy-efficient architecture to reduce emissions, while green corridors reconnect fragmented green spaces, supporting both ecological function and pedestrian mobility.

The implementation of these three strategies not only promotes urban thermal comfort and carbon storage but also aligns with broader environmental goals such as greenhouse gas (GHG) reduction and climate mitigation. Furthermore, these efforts can pave the way for participation in carbon trading schemes, turning ecological restoration into economic opportunity.

DISCUSSION

The results of this study reveal a strong spatial correlation between vegetation density, urban microclimate, and carbon storage potential in Banjarbaru City. The inverse relationship between NDVI and Land Surface Temperature (LST), as well as between NDVI and Thermal Humidity Index (THI), reinforces the critical role of vegetative land cover in regulating urban temperature and improving outdoor thermal comfort. Areas with low NDVI values often characterized by dense built-up zones or bare land exhibited higher LST and THI, indicating discomfort zones prone to Urban Heat Island (UHI) effects. These findings align with global patterns where vegetation scarcity contributes to elevated surface temperatures and reduced climate resilience.

In parallel, the carbon stock analysis further substantiates the thermal findings. Plots with lower NDVI values also recorded significantly reduced carbon storage capacity, confirming that degraded vegetative conditions not only intensify thermal stress but also diminish the city's potential for carbon sequestration. The linear regression model ($y = 1258.3x - 425.01$, $R^2 = 0.850$) between NDVI and carbon storage demonstrated that NDVI is a reliable proxy for estimating biomass-based carbon potential in urban landscapes. This model can be effectively applied in other rapidly urbanizing areas to identify strategic zones for ecological restoration and climate mitigation.

Responding to these challenges, three integrated spatial strategies were proposed: urban farming, green building, and green corridors. Each of these concepts is designed to increase biomass, reduce surface temperatures, and enhance carbon absorption in targeted urban zones. Urban farming introduces productive green spaces within the city while supporting food security and community engagement. Green buildings integrate vegetation into architectural forms, reducing thermal load and energy consumption. Green corridors, meanwhile, create interconnected vegetative networks that improve airflow, biodiversity, and human mobility. Together, these interventions not only address localized urban heat and low carbon density but also align with broader goals of low-carbon development and climate adaptation. Additionally, their implementation has the potential to contribute to carbon credit generation and participation in future carbon trading mechanisms, transforming ecological solutions into economic assets.

CONCLUSION

This study demonstrates the critical interplay between vegetation cover, urban microclimate, and carbon storage in the context of developing a Low Carbon Green City (LCGC) in Banjarbaru. Spatial analysis using remote sensing and field data revealed that areas with low NDVI values consistently experienced higher Land Surface Temperature (LST) and Thermal Humidity Index (THI), indicating intensified Urban Heat Island (UHI) effects and reduced thermal comfort. These zones were also characterized by low carbon sequestration potential, emphasizing the ecological vulnerability of rapidly urbanizing spaces. The strong statistical relationships found between NDVI and LST, THI, and carbon stock affirm the reliability of NDVI as an indicator for both thermal regulation and carbon storage estimation. The regression model developed provides a robust basis for spatial planning and urban policy formulation, enabling data-driven decision-making for climate-responsive urban development. To address the identified environmental challenges, this study proposes three spatially and economically viable strategies: urban farming, green buildings, and green corridors. These interventions aim to enhance biomass density, reduce urban temperatures, and increase the city's capacity to store carbon. Beyond improving environmental quality and thermal comfort, these strategies also offer economic potential through future participation in carbon trading schemes. Ultimately, this research provides a practical and scalable framework for integrating ecological sustainability into urban planning, supporting Banjarbaru's transformation into a more livable, climate-resilient, and low-carbon city.

Declaration by Authors

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