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Landscape Planning for Public Green Open Space Based on the Urban Heat Island Phenomenon in Tanah Sareal District, Bogor City

Perencanaan Lanskap Ruang Terbuka Hijau Publik Berbasis Fenomena *Urban Heat Island* di Kecamatan Tanah Sareal Kota Bogor

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ABSTRAK

Fenomena Urban Heat Island (UHI) merupakan masalah lingkungan perkotaan yang semakin signifikan, khususnya di daerah dengan tingkat urbanisasi tinggi, seperti Kecamatan Tanah Sareal, Kota Bogor. Studi ini bertujuan untuk merumuskan rencana lanskap ruang terbuka hijau publik sebagai strategi mitigasi peningkatan suhu permukaan. Pendekatan yang digunakan menggabungkan analisis spasial citra satelit Sentinel-2A dan analisis sosial partisipatif berdasarkan hasil survei dan observasi lapangan. Hasil penelitian menunjukkan bahwa Desa Sukaresmi memiliki potensi terbesar untuk dikembangkan sebagai ruang terbuka hijau publik, dengan total luas lahan potensial sekitar 0,305 km², melebihi persyaratan minimum 20% dari total luas lahan. Rencana lanskap tersebut mencakup perencanaan spasial, sirkulasi ekologis, dan penataan vegetasi untuk fungsi ekologis, sosial, dan estetika. Studi ini menekankan pentingnya integrasi spasial dan sosial dalam perencanaan lanskap perkotaan yang adaptif terhadap perubahan iklim.

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ABSTRACT

The Urban Heat Island (UHI) phenomenon is an increasingly significant urban environmental problem, particularly in areas with high urbanization rates, such as Tanah Sareal District, Bogor City. This study aims to formulate a landscape plan for public green open spaces as a mitigation strategy for increasing surface temperatures. The approach combines spatial analysis of Sentinel-2A satellite imagery and participatory social analysis based on survey results and field observations. The results indicate that Sukaresmi Village has the greatest potential for development as a public green open space, with a total potential land area of approximately 0.305 km², exceeding the minimum requirement of 20% of the total area. The landscape plan includes spatial planning, ecological circulation, and vegetation arrangement for ecological, social, and aesthetic functions. This study emphasizes the importance of spatial and social integration in urban landscape planning that is adaptive to climate change.

1. INTRODUCTION

1.1 Background

The development of urban areas in Indonesia is showing rapid growth in line with population growth and the intensity of urbanization (Firman, 2014; Hudalah et al., 2019). Bogor City, as one of the supporting cities of DKI Jakarta, is experiencing high development pressure, particularly in areas with dominant residential functions and intensive urban activities (Winarso et al., 2015). Tanah Sareal District is one of the most densely populated districts in Bogor City, with a population growth rate of approximately 3.38% per year, accompanied by rapid expansion of built-up areas. Spatial analysis indicates that residential land use accounts for more than half of the district area, while the availability of public green open space remains far below the national standard of 20% mandated by Indonesian spatial planning regulations. The reduction of vegetated surfaces and the dominance of impervious land cover have contributed to a measurable increase in land surface temperature (LST), particularly between 2013 and 2023, with several areas consistently recording surface temperatures above 30°C. These quantitative conditions strongly indicate the emergence and intensification of the Urban Heat Island (UHI) phenomenon in Tanah Sareal District (Oke, 1982; Voogt & Oke, 2003; Seto et al., 2012).

The UHI phenomenon is a critical urban environmental issue that directly affects thermal comfort, public health, and overall environmental quality (Santamouris, 2015; Heaviside et al., 2017). One strategy proven effective in mitigating UHI is the provision of public Green Open Space (Ruang Terbuka Hijau/RTH), which functions not only as an ecological buffer but also as a social space for urban communities (Bowler et al., 2010; Norton et al., 2015). Vegetation in green open spaces contributes to reduced temperatures through shading and evapotranspiration (Shashua-Bar et al., 2011). However, in densely built urban areas such as Tanah Sareal District, land availability for public green open space is extremely limited. In addition, green space development is often not optimally planned due to the lack of spatially explicit planning approaches and insufficient integration of multidimensional considerations (Kabisch et al., 2016).

Several previous studies have demonstrated that public green open spaces can effectively reduce land surface temperature and mitigate UHI effects (Weng et al., 2004; Zhou et al., 2017). Nevertheless, most existing studies still emphasize physical and biophysical parameters, while social, economic, and cultural dimensions, as well as community preferences, remain underrepresented in site selection processes (Jim & Chen, 2006; Haaland & van den Bosch, 2015). Moreover, the application of multi-criteria decision analysis (MCDA) for determining public green space locations at the sub-district scale remains limited, particularly in rapidly urbanizing cities in developing countries (Malczewski, 2006; Geneletti & van Duren, 2008). This gap highlights the need for integrative research that incorporates both spatial-environmental and socio-cultural factors in urban green space planning.

Based on these challenges, this study aims to analyze and map the most potential locations for UHI mitigation-based public green space landscape development in Tanah Sareal District, Bogor City. This study employs spatial analysis, Land Surface Temperature (LST) mapping, and a Multi-Criteria Decision Analysis (MCDA) approach by integrating physical, biophysical, social, economic, and cultural variables. The research questions focus on identifying the spatial characteristics of the UHI phenomenon in Tanah Sareal District and determining priority locations for public green space development. The findings of this study are expected to contribute scientifically to adaptive urban landscape planning and provide a robust decision-support basis for sustainable public green space development in Indonesian cities

1.2 Research Objectives

This research aims to formulate a landscape plan for public green open spaces as a mitigation strategy for increasing surface temperatures.

2. METHOD

2.1 Tools and Materials

This study used satellite-based remote sensing data and supporting spatial datasets to analyze land surface temperature (LST) and land-use characteristics in Tanah Sareal District. Landsat 8 Operational Land Imager and Thermal Infrared Sensor (OLI/TIRS) imagery was employed as the primary data source due to its moderate spatial resolution (30 m), availability of thermal bands, and suitability for urban-scale UHI analysis. Landsat imagery has been widely used in UHI studies to derive LST and assess spatial thermal patterns in densely built environments.

Supporting spatial data included administrative boundaries and land-use maps obtained from the Bogor City Housing and Settlement Agency. Google Earth imagery was used as auxiliary data for visual interpretation and ground verification of land use and vegetation conditions. Spatial data processing and analysis were conducted using GIS software, while tabular data were processed using spreadsheet applications to support statistical analysis and data visualization.

2.2 Research Procedures

This study employed an integrated spatial, biophysical, and social research design to formulate a public green open space development plan for UHI mitigation in Tanah Sareal District, Bogor City. The research was conducted through sequential stages, including data collection, spatial and thermal analysis, social analysis, and multi-criteria spatial synthesis.

Primary data were collected through field surveys and questionnaire-based social surveys conducted between November 2023 and March 2024. The social survey involved [jumlah] respondents, selected purposively to represent residents living in high-density areas with limited access to public green open space. The questionnaire addressed thermal comfort perception, green space usage patterns, landscape preferences, and community expectations and was validated through expert review and pilot testing.

Spatial and thermal analysis was conducted using Geographic Information System (GIS) techniques. Land Surface Temperature (LST) was derived from Landsat 8 OLI/TIRS imagery, while spatial overlay analysis integrated land use, built-up density, vegetation cover, population density, accessibility, and proximity to existing green open spaces. All spatial variables were classified and normalized to enable comparative suitability analysis.

Land suitability assessment was performed using a Multi-Criteria Decision Analysis (MCDA) approach. Each criterion was weighted by its relevance to UHI mitigation and green open space functionality, and combined through a GIS-based overlay to generate a composite suitability map.

Social survey results were analyzed using descriptive statistical methods and integrated into the spatial suitability assessment by aligning community preferences and activity patterns with the MCDA outputs. This integration ensured that the proposed green open space locations and landscape elements addressed both thermal mitigation needs and local social demands.

3. RESULTS AND DISCUSSION

3.1 Green Open Space Deficit and Its Impact on UHI

Tanah Sareal District has a minimum requirement of 20% of its total area for public green open space, equivalent to approximately 377 hectares. However, to date, only approximately 45 hectares of public green open space have been provided, resulting in a substantial deficit (Zakaria, 2020). This condition reflects an imbalance between ecological carrying capacity and the intensity of built-up land use, which continues to increase in line with population growth and urban activity, a pattern commonly observed in rapidly urbanizing cities in developing countries (Seto et al., 2012; Firman, 2014). The limited availability of public green open space has direct implications for the degradation of urban environmental quality, including reduced ecological functions, decreased rainwater infiltration capacity, and diminished public spaces that serve as ecosystem regulators and platforms for social interaction (Kabisch et al., 2016).

Insufficient vegetation cover increases the dominance of impervious surfaces, which absorb and store solar radiation, leading to higher land surface temperatures. Several studies have reported that surface temperatures in densely built areas can be 3–4°C higher than in areas with adequate vegetation cover (Wardhana, 2003; Tike et al., 2020; Zhou et al., 2017). Consistent with these findings, this study found that areas with high building density and limited green open space in Tanah Sareal District exhibit higher land surface temperatures than areas with relatively better vegetation cover, with temperature differences reaching approximately [X–Y]°C in Landsat-derived LST analyses.

These findings are consistent with previous research by Fandeli et al. (2004), which highlighted the critical role of green open space in reducing air temperature, improving air quality, and enhancing urban environmental comfort. International studies further confirm that urban vegetation mitigates UHI effects through shading and evapotranspiration processes, thereby improving thermal comfort and overall urban livability (Bowler et al., 2010; Santamouris, 2015). Therefore, the provision, protection, and optimization of public green open space constitute essential strategies for UHI mitigation and environmental quality improvement in Tanah Sareal District.

3.2 Physical/Biophysical Conditions

Spatial analysis of classified land cover data reveals significant changes in Tanah Sareal District, characterized by the increasing dominance of built-up areas and the continued reduction of green space. This trend reflects rapid urban development that is not adequately balanced by sufficient green open space, a common phenomenon in rapidly urbanizing cities (Seto et al., 2012; Firman, 2014). The conversion of vegetated land into impervious surfaces reduces the capacity of urban areas to regulate microclimate conditions and exacerbates thermal stress (Weng et al., 2004).

Based on Landsat 8 OLI/TIRS imagery from 2013 and 2023, land surface temperature (LST) was derived from thermal infrared bands to examine spatial–temporal variations in urban thermal conditions. The results indicate an average increase in LST of approximately 2.1°C across Tanah Sareal District, reflecting a clear intensification of urban heat conditions over the ten-year period. Landsat-based LST analysis has been widely recognized as an effective approach for identifying UHI dynamics at the urban scale (Voogt & Oke, 2003; Zhou et al., 2017).

Spatial analysis further shows that high-temperature hotspots are predominantly concentrated in Sukaresmi and Kayumanis Villages, areas characterized by high building density and limited vegetation cover. This spatial configuration highlights the strong relationship between land cover characteristics and the distribution of surface temperatures. Similar thermal patterns have been documented in other dense urban environments, where building concentration and surface materials significantly influence local thermal regimes (Li et al., 2019).

This spatial pattern demonstrates the typical characteristics of the UHI phenomenon, in which built-up surfaces such as concrete and asphalt absorb substantial amounts of solar radiation during the daytime and slowly release stored heat at night, resulting in persistently elevated ambient temperatures (Howard, 1988; Oke, 1982; EPA, 2020). The lack of vegetative shading and evapotranspiration further amplifies heat accumulation, reinforcing the need for strategic green open space planning as a key component of UHI mitigation (Santamouris, 2015).

3.3 Analysis of the Causes of the Urban Heat Island in Tanah Sareal District

The UHI phenomenon in Tanah Sareal District is primarily driven by rapid urbanization, which has accelerated the conversion of vegetated land into built-up areas. Spatial analysis indicates that built-up land cover increased substantially between 2013 and 2023, accompanied by a marked reduction in vegetated areas. This land cover transformation corresponds with an average increase in land surface temperature of approximately 2.1°C across the district, with the highest temperature values concentrated in areas characterized by high building density and limited green open space.

Artificial surfaces such as asphalt, concrete, and building roofs dominate urban landscapes and have high heat-absorption and storage capacities. These materials absorb solar radiation during the day and slowly release the stored heat at night, keeping urban areas warmer than surrounding vegetated or rural areas. This mechanism is a fundamental characteristic of the UHI phenomenon (Oke, 1982; Voogt & Oke, 2003). Analysis of Landsat 8 OLI/TIRS satellite imagery from 2013 to 2023 (Figures 1-6). indicates an average increase in land surface temperature of approximately 2.1°C across all urban villages in Tanah Sareal District, with the most intense thermal hotspots occurring in densely built-up areas such as Sukaresmi and Kayumanis. These findings are consistent with early observations by Howard (1818) and more recent assessments by the United States Environmental Protection Agency (EPA, 2020), which highlight a strong correlation between UHI intensity, building density, and reduced vegetation cover.

Furthermore, the relatively low proportion of public green open space in Bogor City—only 4.18% of the total area, far below the 20% target stipulated in Regional Regulation No. 8 of 2020—has further exacerbated the UHI phenomenon (Zakaria, 2020). Insufficient vegetation limits the effectiveness of green spaces in providing shading, regulating microclimatic conditions, and enhancing thermal comfort for urban residents (Simonds, 1983; Fandeli et al., 2004).

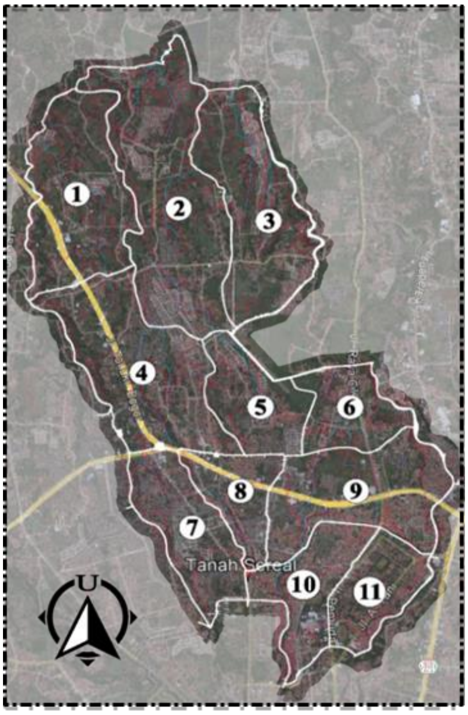

Figure 1. Aerial view of Tanah Sareal District in 2013.

Source: Google Earth (2024)

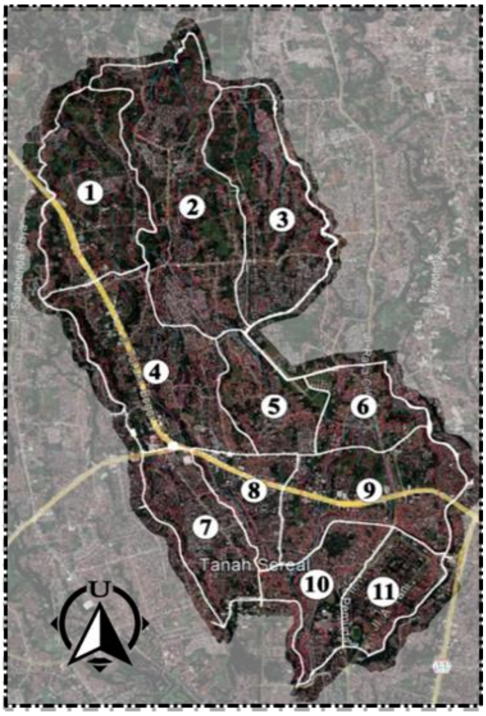

Figure 2. Aerial view of Tanah Sareal District in 2023.

Source: Google Earth (2024)

Village Description:

1. Kayumanis
2. Mekarwangi
3. Kencana
4. Cibadak
5. Sukadamai
6. Sukaresmi
7. Kedung Waringin
8. Kedung Jaya
9. Kedung Badak
10. Kebon Pedes
11. Tanah Sareal

Legends:

- Administrative boundaries
- Residential buildings
- Public buildings
- Green open space (RTH)
- Roads
- BORRS *Flyover*
- Contours
- Rivers

Scale: 1:100.000

Anthropogenic heat emissions are also recognized as an important contributing factor to the intensification of UHI effects in urban areas. Increased energy consumption for air conditioning and emissions from fossil-fueled transportation have been widely reported to contribute additional heat to the urban atmosphere, thereby widening the temperature gap between urban and non-urban areas (Sailor, 2011; Tike et al, 2020). Although this study did not directly quantify local-scale anthropogenic heat emissions, the high building density and the intensity of urban activities observed in Tanah Sareal District suggest that anthropogenic heat release may further exacerbate existing thermal conditions.

High population density in Tanah Sareal District accelerates land conversion, a process further constrained by the limited utilization of vacant land due to private ownership. This condition contributes to the degradation of microenvironmental quality and increases energy consumption and greenhouse gas emissions. The deficit of public green open space, amounting to approximately 3.32 km² compared to the minimum 20% requirement stipulated by regulations, exacerbates local thermal conditions and intensifies the UHI phenomenon. Therefore, effective UHI mitigation in Tanah Sareal District requires adaptive ecological landscape planning strategies that optimize idle land and promote a more equitable and functional distribution of public green open space.

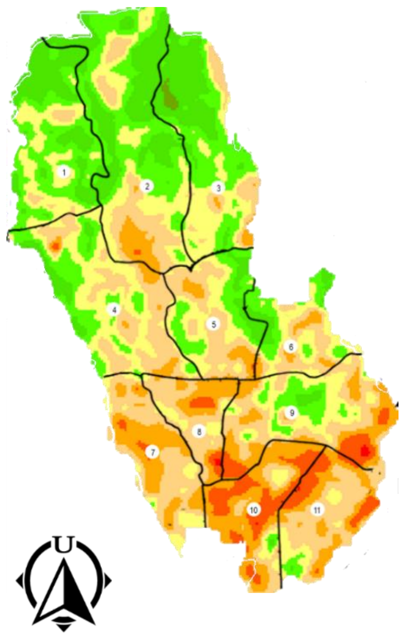

Figure 3. Land surface temperature Mapping in 2013.
Source: Landsat 8 OLI/TIRS (2013)

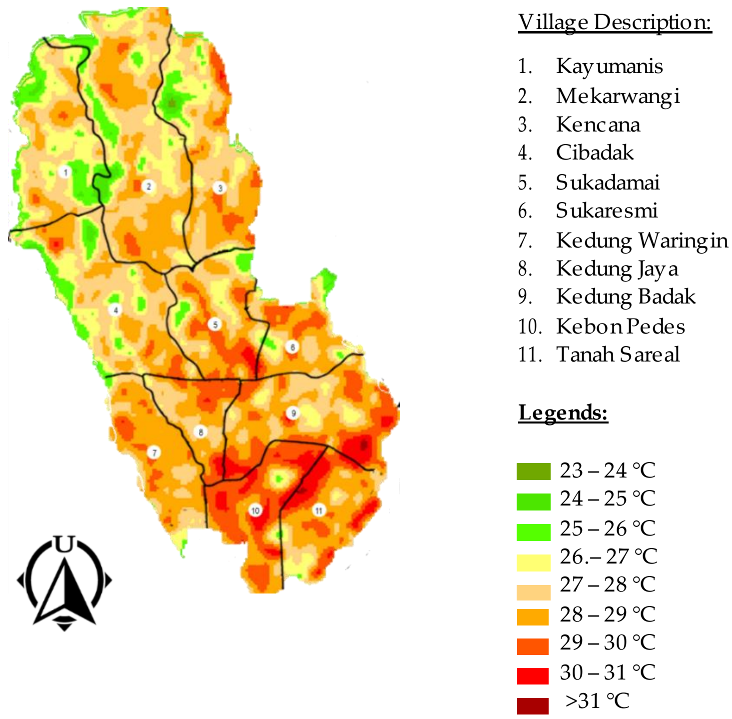

Figure 4. Land surface temperature Mapping in 2023.
Source: Landsat 8 OLI/TIRS (2023)

Scale: 1:100.000

Figure 5. Map of land cover in 2013.
Source: Sentinel 2A Satellite (2013)

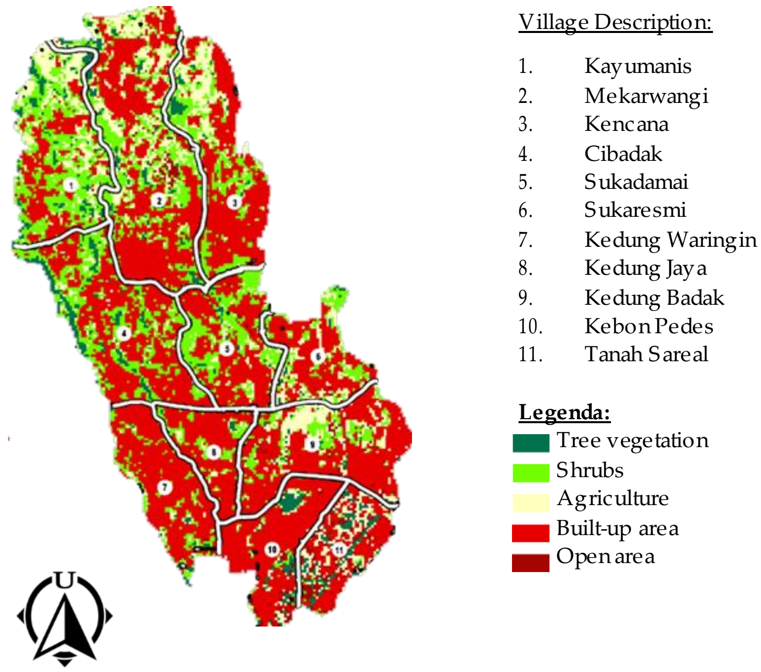

Figure 6. Map of land cover in 2023.
Source: Sentinel 2A Satellite (2023)

Scale: 1:100.000

3.4 Analysis of Community Perceptions and Preferences Regarding Activities in Public Green Space

Survey results indicate that the majority of residents in Tanah Sareal District perceive the availability of public green open space as very limited, both in quantity and quality. Based on responses to structured questionnaire items addressing accessibility and facility adequacy, approximately 72% of respondents reported that access to public parks is difficult, while 68% stated that existing facilities do not adequately support recreational and sports activities. Similar perceptions have been widely reported in dense urban areas, where limited green space availability reduces accessibility and functional diversity (Haaland & van den Bosch, 2015; Kabisch et al., 2016).

The dominant activities in existing green spaces include light exercise and social interaction, with respondents expressing a strong preference for shaded, clean environments with supporting facilities, such as pedestrian paths and seating areas. These preferences are consistent with previous findings showing that physical comfort and basic amenities strongly influence the use intensity of urban green spaces (Giles-Corti et al., 2005; Cohen et al., 2007).

Respondents also emphasized the socio-economic functions of public green open spaces, including their roles as community gathering areas, spaces for environmental education, and locations for small-scale economic activities. Such multifunctional roles of green spaces have been increasingly recognized in urban planning literature, particularly in relation to social cohesion, informal economic activities, and community well-being (Peters et al., 2010; Wolch et al., 2014). This perception aligns with earlier conceptual frameworks proposed by Simonds (1983) and Hakim (2002), which highlighted that public green open spaces function not only as ecological infrastructure but also as arenas for social interaction and local economic activities.

Overall, community perceptions underscore the urgency of developing multifunctional, inclusive, and responsive public green open spaces that respond to local socio-cultural needs. Integrating community preferences into green space planning is essential to ensure usability, sustainability, and long-term public support, particularly in densely populated urban districts such as Tanah Sareal (Brown & Kyttä, 2014; Kabisch & Haase, 2014).

3.5 Multi-Criteria Analysis of Potential Locations

The location for public green open space development in Tanah Sareal District was determined using the Multi-Criteria Decision Analysis (MCDA) method, which integrates biophysical, spatial, and social aspects into a structured decision-making framework. MCDA has been widely applied in urban environmental and landscape planning to support transparent and systematic site selection processes (Malczewski, 2006; Geneletti & van Duren, 2008). In this study, six main criteria were considered, namely land availability, accessibility, environmental conditions, ecological connectivity, social support, and cultural values, reflecting a holistic approach to sustainable green space planning (Kabisch et al., 2016).

Each criterion was operationalized into measurable indicators derived from spatial and social datasets, and these indicators were subsequently standardized to enable comparison across different data types. Land availability was assessed based on the spatial extent and distribution of vacant or underutilized land parcels, while accessibility was measured through proximity to residential areas and the existing road network. Environmental conditions were evaluated using land surface temperature intensity and vegetation cover, whereas ecological connectivity was assessed based on the continuity of green patches and proximity to existing green open spaces. Social support and cultural values were derived from questionnaire results reflecting community preferences, acceptance, and anticipated use of public green open spaces.

All criteria were reclassified into standardized suitability scores using a common ordinal scale, allowing heterogeneous spatial and social data to be integrated into a single analytical framework. Criteria weights were assigned based on their relative importance for UHI mitigation and green space functionality, informed by literature review and landscape planning objectives. A weighted overlay analysis was then performed using GIS to generate a composite suitability index for potential public green open space locations.

The analysis results indicate that Sukaresmi Village achieved the highest suitability score, with a total potential land area of approximately 0.305 km², exceeding the minimum green open space requirement by about 20%. This outcome reflects the combined influence of high land availability, favorable accessibility, strong community support, and its strategic location within areas experiencing high UHI intensity. Spatially, Sukaresmi possesses relatively extensive, evenly distributed vacant land closely integrated with densely populated residential areas, a configuration identified as a key determinant of effective green space provision in high-density urban settings (Haaland & van den Bosch, 2015; Zhou et al., 2017).

From a social perspective, questionnaire results reveal strong community support for public green open space development in Sukaresmi, including preferences for community gardens, social interaction spaces, and sports facilities. Ecologically, the village also plays a critical role in stabilizing the local thermal environment, given its location in an area characterized by high surface-temperature intensity. Prioritizing green space development in such thermal hotspots is recognized as an effective strategy for maximizing UHI mitigation benefits (Norton et al., 2015; Santamouris, 2015). Therefore, Sukaresmi Village is identified as a priority location for public green open space development that is both representative and replicable at the sub-district scale. These findings are consistent with criteria-based landscape planning principles proposed by Malczewski (1999) and supported by subsequent GIS–MCDA studies, which emphasize that site selection integrating ecological, social, and spatial dimensions leads to more adaptive and sustainable urban planning outcomes (Malczewski, 2006; Geneletti, 2010).

3.6 Spatial Planning Implications for UHI-Oriented Public Green Space

Public green open space landscape planning in Tanah Sareal District is grounded in a comprehensive inventory of existing physical, biophysical, and socio-spatial conditions, which reveals the dominance of private land ownership, fragmented vacant land, and an uneven distribution of public green open spaces. Rising land surface temperatures and strong community aspirations further reinforce the urgency of developing green open spaces as a strategic measure for UHI mitigation and environmental quality improvement. Similar findings in other compact cities highlight that green space planning must prioritize spatial efficiency and multifunctionality (Haaland & van den Bosch, 2015; Kabisch & Haase, 2014).

The expected outputs of this planning process include land potential mapping, innovative strategies for utilizing limited urban space, sustainable landscape design concepts, and strengthened multi-stakeholder collaboration frameworks. Adaptive planning approaches such as pocket parks, vertical gardens, green rooftops, and partnerships with private landowners are increasingly recognized as effective solutions for expanding green infrastructure in high-density urban environments (Bowler et al., 2010; Davies et al., 2008). These approaches promote the creation of greener, healthier, and more inclusive urban environments while addressing spatial limitations and competing land-use demands.

Ultimately, integrating community preferences, spatial analysis, and policy alignment within green open space landscape planning enhances the capacity of Tanah Sareal District to achieve sustainable urban development and climate adaptation goals (Kabisch et al., 2016; Santamouris, 2015).

The public green open space planning concept in Tanah Sareal District is developed based on a synthesis of ecological, social, economic, and cultural dimensions. The core principle is to establish public green open spaces as multifunctional, inclusive, and adaptable urban spaces capable of addressing the challenges posed by the Urban Heat Island (UHI) phenomenon while responding to diverse community needs. Multifunctionality in green space planning is increasingly emphasized as a key strategy for enhancing urban resilience and sustainability (Wolch et al., 2014; Kabisch et al., 2016).

- Ecological aspect. Public green open spaces are designed to reduce microclimate temperatures by increasing vegetation cover for shading, implementing green infrastructure elements such as bioswales, rain gardens, and infiltration wells, and restoring ecological connectivity among fragmented green spaces. Numerous studies have demonstrated that green infrastructure enhances evapotranspiration, improves stormwater management, and effectively mitigates UHI impacts (Gill et al., 2007; Norton et al., 2015; Santamouris, 2015).
- Social aspect. Public green open spaces function as community interaction areas, family recreation spaces, and sports facilities that are easily accessible and inclusive, including for people with disabilities. Accessibility, comfort, and safety are fundamental determinants of green space utilization and social well-being (Giles-Corti et al., 2005; Peters et al., 2010). Inclusive design principles ensure that green spaces support social cohesion and equitable access to urban environmental benefits (Kabisch & Haase, 2014).
- Economic aspect. Public green open spaces are also envisioned as platforms for microeconomic activities, such as plant kiosks, small business spaces, and community-managed markets. Integrating small-scale economic functions within green spaces has been shown to enhance management sustainability, strengthen local livelihoods, and increase community stewardship (Peters et al., 2010; Wolch et al., 2014).
- Cultural and educational aspects. Public green open spaces are positioned as media for environmental education and local cultural preservation, for instance through thematic gardens featuring local flora and open spaces for community arts and cultural activities. Cultural landscape approaches highlight the importance of embedding local identity and knowledge into urban green space planning to foster a sense of place and long-term community engagement (Simonds, 1983; Jim & Chen, 2006).

This planning concept is consistent with Simonds' (1983) assertion that landscape planning should integrate ecological and social functions, as well as with international recommendations advocating the incorporation of green infrastructure into climate change mitigation and adaptation strategies (UNEP, 2018; Geneletti et al., 2020). Through this approach, public green open spaces in Tanah Sareal District are intended to become green, healthy, productive, and sustainable urban environments.

Public green open space landscape planning in Tanah Sareal District focuses on revitalizing and optimizing limited urban land through adaptive and context-sensitive design. Spatial planning is tailored to site-specific characteristics, integrating ecological, social, and aesthetic functions within a compact urban fabric. Adaptive strategies such as the utilization of residual spaces, greenways, linear parks, and community gardens are increasingly recognized as effective solutions for expanding green infrastructure in high-density cities (Davies et al., 2008; Haaland & van den Bosch, 2015).

A participatory planning approach is adopted to support long-term sustainability, mitigate UHI emissions, and improve urban quality of life. Community involvement in planning and management has been shown to enhance social acceptance, maintenance effectiveness, and environmental outcomes of public green spaces (Brown & Kyttä, 2014; Kabisch et al., 2016).

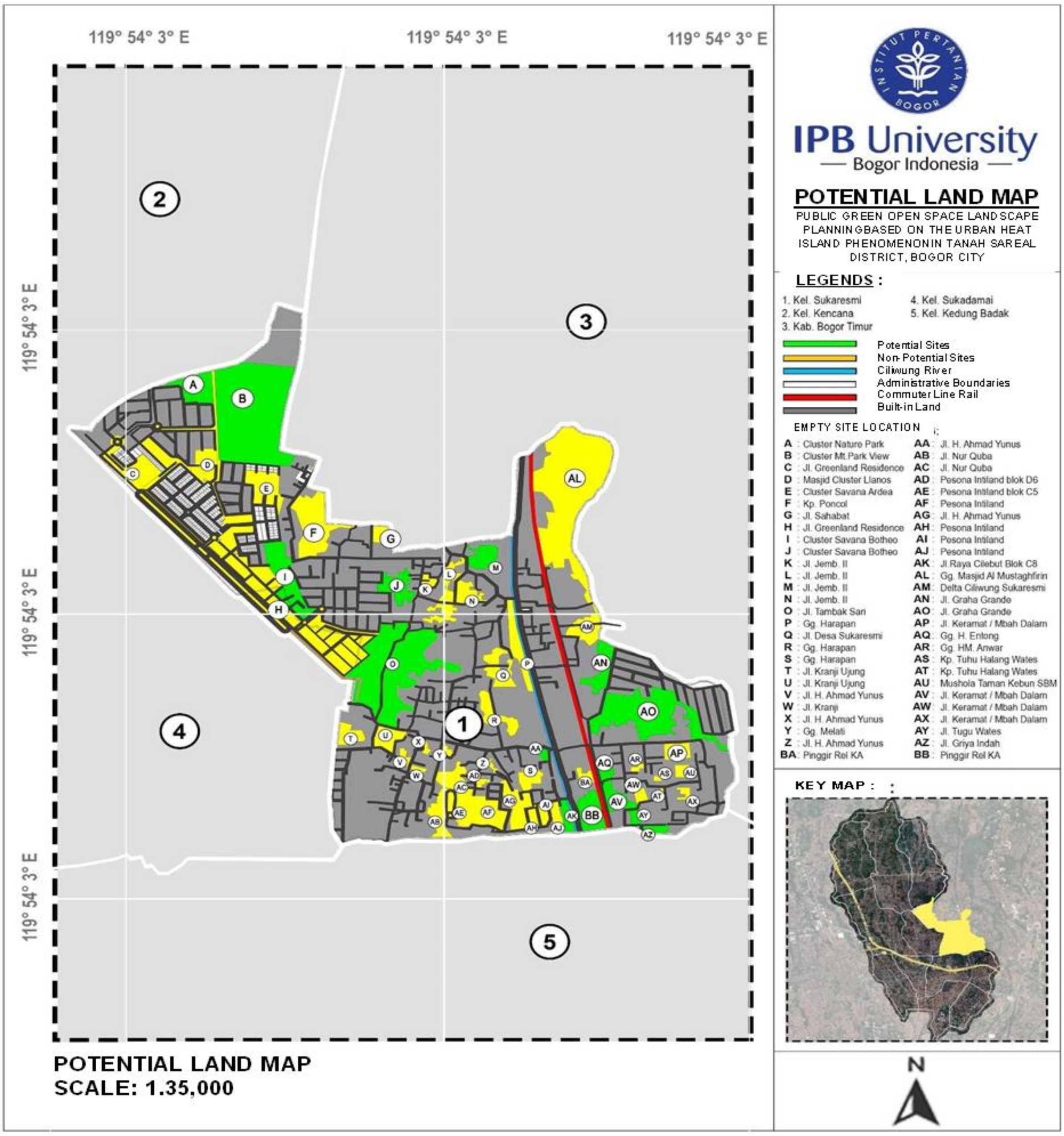

Figure 7. Mapping of potential land in Sukaresmi Village, Tanah Sareal District.

Sukaresmi Village was selected as a pilot location for public green open space development because it meets comprehensive feasibility indicators across the physical, ecological, social, economic, and cultural dimensions. This area exhibits high environmental vulnerability, complex urban challenges, and conditions that necessitate planned ecological landscape interventions. Similar pilot-based approaches have proven effective in generating replicable models for urban green space development at local scales (Geneletti & van Duren, 2008; Norton et al., 2015).

Furthermore, Sukaresmi Village is considered representative and replicable for public green open space development at the sub-district level, supporting integrated, sustainable improvements in environmental quality in densely populated urban areas (Figure 7). This approach reinforces the role of landscape planning as a strategic instrument for climate-responsive and socially inclusive urban development (Santamouris, 2015; Wolch et al., 2014).

Based on the weighted MCDA approach, a site is considered potentially suitable for public green space development if it scores between 3.50 and 5.00 (≥70% of the maximum score). Of the 56 sites that met the basic feasibility criteria, 15 potential sites were selected based on land availability, cultural value, demonstrative value, and equitable spatial distribution (Tabel 1). In Sukaresmi Village, with an area of approximately 1.37 km², the minimum requirement for public green space of approximately 0.276 km² can be met, and even exceeded, as the total potential land area is approximately 0.305 km². This demonstrates the area's feasibility for public green space development based on UHI mitigation and increased ecological accessibility for the community.

Table 1. List of potential sites to be developed as public green open space based on site location planning aspects for public green open space in Sukaresmi subdistrict

No.	Land	LA	Acc	EC	Eco	SS	Nil	Total Score (%)	Area (km²)	Site Location
1.	A	5	5	1	5	4	5	3,65	0,010	Cluster Nature Park
2.	B	5	5	1	5	4	5	3,65	0,079	Cluster Mt. Park View
3.	I	5	5	1	5	3	5	3,55	0,019	Cluster Savana Botheo
4.	J	5	4	3	2	4	5	3,65	0,009	Cluster Savana Botheo
5.	M	5	4	2	3	4	3	3,50	0,017	Jl. Jemb. II
6.	O	5	5	1	5	4	5	3,65	0,059	Jl. Tambak Sari
7.	AA	5	5	2	4	2	3	3,60	0,001	Jl. H. Ahmad Yunus
8.	AK	5	5	1	5	4	4	3,65	0,002	Jl. Raya Cilebut Blok C8
9.	AN	5	4	2	5	3	4	3,60	0,010	Jl. Graha Grande
10.	AO	5	5	1	4	4	5	3,55	0,044	Jl. Graha Grande
11.	AQ	5	5	2	3	3	3	3,60	0,003	Gg. H. Entong
12.	AV	5	5	2	5	3	5	3,80	0,008	Jl. Keramat/Mbah Dalam
13.	AY	5	5	2	2	4	5	3,60	0,002	Jl. Tugu Wates
14.	AZ	5	5	2	4	4	5	3,80	0,002	Jl. Griya Indah
15.	BB	4	5	2	3	5	5	3,50	0,011	Jl. Raya Cilebut
TOTAL LAND AREA									0.305	

Description
LA : Land Availability
Acc : Accessibility
EC : Environmental Conditions
Eco : Ecological Connectivity
SS : Social Support
Nil : Cultural & Demonstrative Values

Public green space in Tanah Sareal District serves as essential green infrastructure for maintaining ecological balance, mitigating the impacts of climate change, and improving environmental quality amidst the pressures of urbanization. This role is realized through strengthening ecological functions, implementing sustainable spatial planning, and multi-stakeholder collaboration in managing green open space.

Sites A–B in Sukaresmi Village are designed as public green open spaces with recreational and educational functions, through the integration of shade, air-filtering, directional, aesthetic-ecological, and productive vegetation (Figure 8 and 9). Spatial zoning includes pedestrian corridors, key visual areas, and participatory urban farming involving the community. Sites I–J, meanwhile, emphasize socio-community functions with shade vegetation on circulation paths and open fields, as well as additional aesthetic and air-filtering vegetation. Both sites feature microclimate-adaptive and participatory designs, making them models of contextual and sustainable public green open spaces.

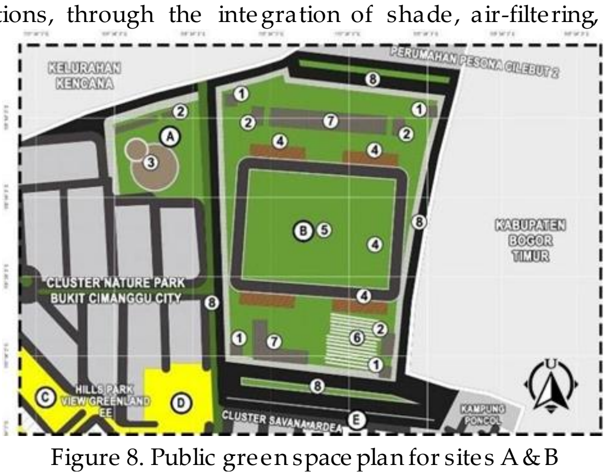

Figure 8. Public green space plan for sites A & B

Legends:
Non-Potential Area
Potential Area
Built-Up Area
Grass
Old Asphalt Road
New Asphalt Road

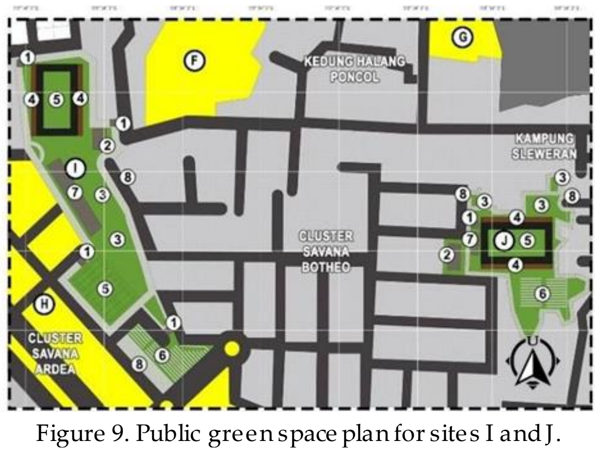

Figure 9. Public green space plan for sites I and J.

Legends:
1. Security post
2. Public restroom
3. Town Square Park
4. Spectator bleachers
5. Sports field
6. Urban Farming
7. Canteen/Vendor Area
8. Parking Area

Site M is designed as a micro-park with visual-educational functions, leveraging its strategic location and high visibility. Shading, aesthetic, air-filtering vegetation, and directional elements are used to support thermal comfort, air quality, and spatial order. It also functions as a demonstration space to promote public ecological awareness (Figure 10). Meanwhile, Site O (Figure 11) was developed as a neighborhood-scale urban forest with ecological transition and educational roles. Extensive canopy vegetation, pollutant absorbers, and bioswales were placed to increase water absorption and strengthen the natural hydrological cycle. The addition of interpretive trails and community spaces makes it a center for ecological learning while simultaneously strengthening the city's ecological function

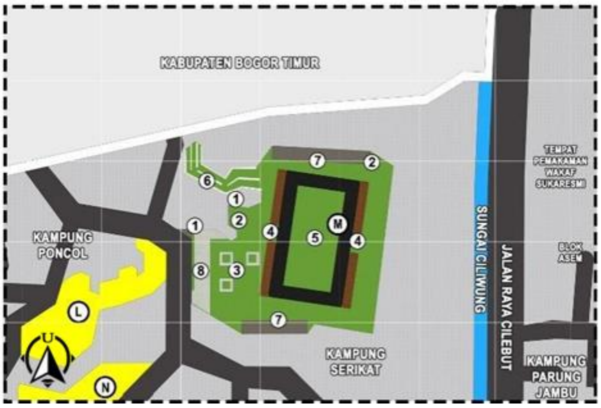

Figure 10. Public green space plan for site M

Legends:

Non-Potential Area	Grass
Potential Area	Old Asphalt Road
Built-Up Area	New Asphalt Road

Figure 11. Public green space plan for site O

Legends:

1. Security post
2. Public restroom
3. Town Square Park
4. Spectator bleachers
5. Sports field
6. Urban Farming
7. Canteen/Vendor Area
8. Parking Area

Sites AA, AK, and BB (Figure 12) , located along the main road, are designed as green frontages dominated by columnar shade vegetation and aesthetic elements. This green corridor serves as a buffer against vehicle pollution while strengthening the visual-ecological identity of the area, making it a representative and pedestrian-friendly open space. Meanwhile, Sites AQ, AV, AY, and AZ (Figure 13) are developed as a modular-integrated green space system that bridges the spatial separation caused by the railway and arterial roads. Sites AQ and AV are focused on shade vegetation and aesthetics, while Sites AY and AZ function as community spaces and environmental education. The integration of productive vegetation, signage, and vegetation markings strengthens visual connectivity between sites, creating a micro-green network that is adaptive to dense settlements while acting as active green infrastructure for UHI mitigation and improving micro-environmental quality.

Figure 12. Public green space plan for sites AA, AK, and BB

Legends:

Non-Potential Area	Grass
Potential Area	Old Asphalt Road
Built-Up Area	New Asphalt Road

Figure 13. Public green space plan for sites AQ, AV, AY, and AZ

Legends:

1. Security post
2. Public restroom
3. Town Square Park
4. Spectator bleachers
5. Sports field
6. Urban Farming
7. Canteen/Vendor Area
8. Parking Area

Sites AN and AO (Figure 14), located along the Ciliwung River, are designed as vertical green corridors and semi-open community spaces that adapt to the land's contours. At Site AO, the concave shape is utilized as a landscape amphitheater with gradual vegetation following the contours to support social activities, education, and water conservation. Shading and pollution-absorbing vegetation strengthen ecological functions while supporting the village's green network. Both sites serve as microclimate coolers and interactive spaces that enhance ecological connectivity and improve the community's quality of life

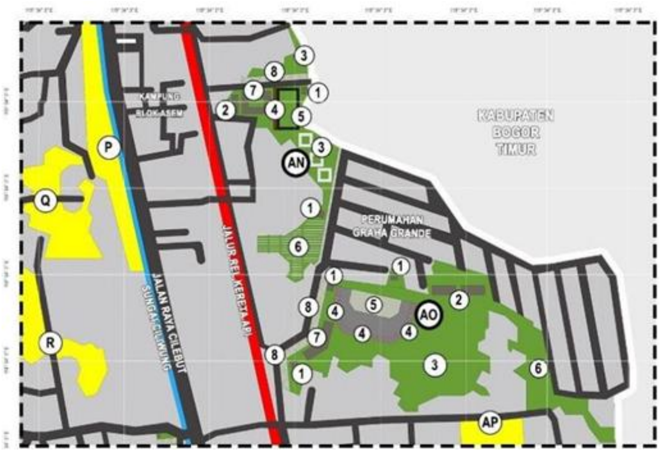

Figure 14. Public green open space plan on the AN and AO sites.

Legends:
- Public space
- Potential Area
- Built-Up Area
- Grass
- Old Asphalt Road
- New Asphalt Road

1) Security post
2) Public restroom
3) Town square park
4) Spectator bleachers
5) Sport field
6) Urban farming
7) Canteen Area
8) Parking area

The landscape planning for public green open space in Sukaresmi Village was formulated by considering the spatial characteristics, ecological potential, and social needs of the community. Each site has a specific function: Sites A–B as recreational and educational spaces, Sites I–J as community-oriented and hybrid, Site M as a micro-park, Site O as an urban forest, Sites AA–BB as a green frontage, Sites AN–AO as a landscape amphitheater, and Sites AQ–AZ as a space with an integrated modular system. All these sites need to be connected through an ecological and social circulation plan, which will form an adaptive green network that supports UHI mitigation, improves quality of life, and strengthens the sustainability of dense residential areas.

4. CONCLUSION

This study demonstrates that rapid urbanization in Tanah Sareal District, Bogor City, has led to a substantial loss of vegetation cover of approximately 364.67 ha and a deficit of about 3.32 km² of public green open space, resulting in increased microclimatic stress and the intensification of the Urban Heat Island (UHI) phenomenon. The dominance of residential land use, the development of major infrastructures such as the BORR flyover, and weak enforcement of spatial regulations have accelerated the conversion of vegetated land into impervious surfaces, thereby exacerbating surface temperature increases.

Although public awareness of the importance of public green open space is relatively high, limitations in land availability, inadequate facilities, and restricted community participation remain major barriers to effective implementation. These findings confirm that awareness alone is insufficient without institutional support and integrated spatial planning mechanisms. Therefore, adaptive and solution-oriented landscape planning is required, emphasizing the optimization of idle or privately owned vacant land, the application of vertical greening strategies such as green roofs and green walls, and the development of linear public green open spaces along rivers, road corridors, and urban infrastructure networks.

The integration of horizontal and vertical green infrastructure, supported by comprehensive spatial planning policies, continuous environmental education, and strengthened institutional collaboration, is essential to ensure inclusive, functional, and sustainable public green open space development. Such an approach is critical for enhancing urban resilience and mitigating UHI impacts in densely populated districts under conditions of land scarcity.

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REFERENCES

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning, 97(3), 147–155. https://doi.org/10.1016/j.landurbplan.2010.05.006

Brown, G., & Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Applied Geography, 46, 122–136. https://doi.org/10.1016/j.apgeog.2013.11.004

Carpenter, S. R., & Just, R. E. (1975). Ecosystem structure and function. Annual Review of Ecology and Systematics, 6, 1–21.

Cohen, D. A., McKenzie, T. L., Sehgal, A., Williamson, S., Golinelli, D., & Lurie, N. (2007). Contribution of public parks to physical activity. American Journal of Public Health, 97(3), 509–514. https://doi.org/10.2105/AJPH.2005.072447

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). Sage Publications.

EPA. (2020). Reducing urban heat islands: Compendium of strategies. United States Environmental Protection Agency.

Fandeli, C., Kaharuddin, & Mukhlison. (2004). Perencanaan lanskap kota. Gadjah Mada University Press.

Firman, T. (2014). The continuity and change in mega-urbanization in Indonesia: A survey of Jakarta–Bandung Region development. Habitat International, 41, 327–339. https://doi.org/10.1016/j.habitatint.2013.08.005

Geneletti, D. (2010). Combining stakeholder analysis and spatial multi-criteria evaluation to select and rank inert landfill sites. Waste Management, 30(2), 328–337. https://doi.org/10.1016/j.wasman.2009.09.039

Geneletti, D., & van Duren, I. (2008). Protected area zoning for conservation and use: A combination of spatial multicriteria and multiobjective evaluation. Landscape and Urban Planning, 85(2), 97–110. https://doi.org/10.1016/j.landurbplan.2007.10.004

Geneletti, D., Zardo, L., Cortinovis, C., Sperandii, M. G., & Adem Esmail, B. (2020). Planning for ecosystem services in cities. Springer. https://doi.org/10.1007/978-3-030-20024-4

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A., & Donovan, R. J. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? American Journal of Preventive Medicine, 28(2), 169–176. https://doi.org/10.1016/j.amepre.2004.10.018

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: The role of green infrastructure. Built Environment, 33(1), 115–133.

Haaland, C., & van den Bosch, C. K. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. Urban Forestry & Urban Greening, 14(4), 760–771. https://doi.org/10.1016/j.ufug.2015.07.009

Hakim, R., & Utomo, H. S. (2004). Komponen perancangan arsitektur lanskap. Bumi Aksara.

Howard, L. (1988). The climate of London. Cambridge University Press.

Kabisch, N., Qureshi, S., & Haase, D. (2016). Human–environment interactions in urban green spaces: A systematic review of contemporary issues and prospects for future research. Environmental Impact Assessment Review, 50, 25–34. https://doi.org/10.1016/j.eiar.2014.08.007

Li, X., Zhou, Y., Asrar, G. R., Zhu, Z., & Li, W. (2019). Developing a consistent global urban land surface temperature dataset. Remote Sensing of Environment, 230, 111263. https://doi.org/10.1016/j.rse.2019.111263

Malczewski, J. (1999). GIS and multicriteria decision analysis. John Wiley & Sons.

Malczewski, J. (2006). GIS-based multicriteria decision analysis: A survey of the literature. International Journal of Geographical Information Science, 20(7), 703–726. https://doi.org/10.1080/13658810600661508

Malczewski, J., & Rinner, C. (2015). Multicriteria decision analysis in geographic information science. Springer. https://doi.org/10.1007/978-3-540-74757-4

Norton, B. A., Coutts, A. M., Livesley, S. J., Harris, R. J., Hunter, A. M., & Williams, N. S. G. (2015). Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landscape and Urban Planning, 134, 127–138. https://doi.org/10.1016/j.landurbplan.2014.10.018

Oke, T. R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, 108(455), 1–24.

Sailor, D. J. (2011). A review of methods for estimating anthropogenic heat and moisture emissions in the urban environment. International Journal of Climatology, 31(2), 189–199. https://doi.org/10.1002/joc.2106

Santamouris, M. (2015). Regulating the damaged thermostat of the cities—Status, impacts and mitigation challenges. Energy and Buildings, 91, 43–56. https://doi.org/10.1016/j.enbuild.2015.01.027

Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences, 109(40), 16083–16088. https://doi.org/10.1073/pnas.1211658109

Tike, A., Pratiwi, R., & Nugroho, S. (2020). Urban heat island analysis using land surface temperature in tropical cities. IOP Conference Series: Earth and Environmental Science, 447, 012056. https://doi.org/10.1088/1755-1315/447/1/012056

Voogt, J. A., & Oke, T. R. (2003). Thermal remote sensing of urban climates. Remote Sensing of Environment, 86(3), 370–384. https://doi.org/10.1016/S0034-4257(03)00079-8

Wardhana, W. A. (2003). Dampak pembangunan kota terhadap perubahan iklim mikro. Jurnal Teknik Lingkungan, 4(2), 89–96.

Weng, Q., Lu, D., & Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. Remote Sensing of Environment, 89(4), 467–483. https://doi.org/10.1016/j.rse.2003.11.005

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Landscape and Urban Planning, 125, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Zakaria, R. (2020). Evaluasi ketersediaan ruang terbuka hijau publik di Kecamatan Tanah Sareal, Kota Bogor. Jurnal Perencanaan Wilayah dan Kota, 31(2), 135–146.

Zhou, D., Xiao, J., Bonafoni, S., Berger, C., Deilami, K., Zhou, Y., Frolking, S., Yao, R., Qiao, Z., & Sobrino, J. A. (2017). Satellite remote sensing of surface urban heat islands: Progress, challenges, and perspectives. Remote Sensing, 9(1), 1–30. https://doi.org/10.3390/rs9010023