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Evaluation of the Ecological and Social Functions of Manado City Parks: A Case Study of Taman Kesatuan Bangsa

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Abstract

Urban parks provide ecological and social functions, but thermal comfort often becomes a limiting factor for their use in tropical climates. This study evaluates the ecological function, with a focus on microclimate regulation, and the social function of Taman Kesatuan Bangsa, Manado City. A descriptive quantitative approach was used, with field measurements in three zones (shaded, unshaded, and amphitheater) from 09:00 to 17:00. Thermal comfort was analyzed using the PMV and PPD indices, public space quality was assessed using the Public Space Index (PSI), and space use was examined through behavior mapping and a structured questionnaire distributed randomly to 50 visitors. The results show that all zones exceeded the comfort range. The mean PMV in the shaded area was 2.2 (PPD 65–94%), while the unshaded and amphitheater areas reached 3.0 (PPD 100%). The mean radiant temperature in the open area was 67.4 °C, far above that of the shaded area (37.6 °C), and the surface temperature of paving (53.7 °C) was higher than that of plants (31.1 °C). The overall PSI score was 3.42 (moderate), with meaning and identity of space as the highest dimension (4.10) and thermal and physical comfort as the lowest (2.15). About 48.1% of visitors came at midday and 62.9% stayed longer than one hour, with two-thirds of visitors aged over 45 years. The park is socially strong, but its ecological function is not yet optimal, so adding natural shade, vegetation, and cooler surface materials is needed to sustain its social function.

Keywords: City Park, ecological, green open space, social, Taman Kesatuan Bangsa

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Introduction

Urban green open spaces (GOS) are strategic elements in sustainable urban development, simultaneously serving ecological and social functions. From an urban ecology perspective, GOS helps regulate the microclimate, improve air quality, and provide public spaces that facilitate social interaction among community members. These functions have become increasingly important in cities located in humid tropical climates, where high air temperatures and humidity levels can reduce outdoor thermal comfort.

In Manado, Taman Kesatuan Bangsa (TKB) is a major public space with a strategic role as both the city's kilometer-zero point and a center of socioeconomic activity. However, following the area's revitalization, significant changes occurred in the park's physical configuration, particularly the dominance of concrete paving materials and the reduction of vegetation cover. These conditions indicate a potential decline in the quality of the local microenvironment, especially through increased surface temperatures and reduced thermal comfort for park users.

This phenomenon is associated with the urban heat island (UHI) effect, which refers to elevated temperatures in urban areas resulting from the dominance of impervious surfaces and a scarcity of vegetation. In tropical climates, an imbalance between hardscape and green landscape elements can exacerbate the thermal conditions of open spaces and reduce the intensity and quality of community social activities. Accordingly, public-space design must address not only aesthetic considerations but also the requirements of thermal comfort and social inclusivity.

Although research on thermal comfort and public-space quality has advanced, studies that simultaneously integrate ecological and social evaluations of urban parks in eastern Indonesia, particularly in Manado, remain limited. Furthermore, few empirical studies have evaluated post-revitalization conditions, creating a gap between design planning and actual on-site performance. The absence of standardized evaluation instruments may result in public-space development that prioritizes visual appearance over functional sustainability.

Based on this background, this study addresses the following research questions: (1) What is the level of thermal comfort in the TKB area resulting from the interaction between vegetation and paved surfaces? (2) What is the quality of TKB as a public space in terms of accessibility, safety, and social inclusivity? and (3) What is the relationship between the park's physical configuration and user behavior patterns?

Methods

Research location and zoning

The study was conducted in the green open space of Taman Kesatuan Bangsa (TKB), Manado City. The research area was divided into four representative spatial observation zones:

1. Zone 1 (Vegetated/Shaded Area): The peripheral areas of the park, specifically the southern and eastern sections, characterized by dominant tree-canopy cover and shade-providing vegetation (softscape).
2. Zone 2 (Main Plaza/Amphitheater Area): The open western section, where the predominant surface material consists of impervious concrete (hardscape).
3. Zone 3 (Perimeter Corridor/Pedestrian Area): Pedestrian circulation routes extending along the park's outer edges.
4. Zone 4 (Commercial Area/Supporting Facilities): The outer boundary of the park adjoining areas characterized by local economic activities.



Figure 1
Observation zones

Ecological data collection

Microclimatic data were measured simultaneously across the four zones using digital thermo-hygrometers over seven consecutive measurement days at threetime intervals:

1. Morning (9:00 a.m. Central Indonesia Time, WITA)
2. Midday (1:00 p.m. WITA)
3. Afternoon (5:00 p.m. WITA)

Air temperature (T, in (_^∘)"C") and relative humidity (RH, in %) were processed to calculate thermal comfort levels using the Thermal Humidity Index (THI) formula developed by Nieuwolt (1982):

$$THI = T - (0.55 - 0.0055 \times RH) \times (T - 14.5)$$

The threshold categories for thermal comfort under tropical climatic conditions, based on THI values, were classified as follows:

$THI \leq 21$: Comfortable
$21 < THI \leq 24$: Moderately Comfortable
$24 < THI \leq 27$: Partially Uncomfortable
$THI > 27$: Uncomfortable/Hot

Ecological data collection
Stop-Motion Walking: Static observations were conducted for 15 minutes at each observation-zone location to record the number of users, types of activities (sitting, walking, conversing, and trading), and the spatial distribution of user positions.
Public Space Index (PSI): A structured questionnaire survey was administered to 50 park users. The survey covered five principal dimensions: Inclusivity, Safety, Comfort, Activities, and the Meaning of Place, measured using a five-point Likert scale.

Results and discussions

Evaluation of Ecological Performance (Microclimate and THI)
Based on field measurements conducted in the Taman Kesatuan Bangsa area, the average air temperature (T), relative humidity (RH), and calculated THI values for each zone are presented in table 1.

Table 1
Microclimatic measurement results and THI Values at Taman Kesatuan Bangsa

Measurement time	Observation zone	Air Temperature (T, °C)	Relative Humidity (RH, %)	THI Value
Morning (9:00 a.m. WITA)	Zone 1 (Vegetated Area)	27.2	78	25.6
	Zone 2 (Plaza/Amphitheater)	29.2	72	27.3
	Zone 3 (Corridor/Pedestrian Area)	28.1	75	26.2
	Zone 4 (Commercial Area)	28.8	73	26.8
Midday (1:00 p.m. WITA)	Zone 1 (Vegetated Area)	30.5	68	27.6
	Zone 2 (Plaza/Amphitheater)	34.2	58	30.2
	Zone 3 (Corridor/Pedestrian Area)	32.0	62	28.6
	Zone 4 (Commercial Area)	32.8	60	29.2
Afternoon (5:00 p.m. WITA)	Zone 1 (Vegetated Area)	27.8	76	26.0
	Zone 2 (Plaza/Amphitheater)	29.8	70	27.4
	Zone 3 (Corridor/Pedestrian Area)	28.5	74	26.5
	Zone 4 (Commercial Area)	29.0	71	26.9

The measurement results indicate substantial differences in microclimatic conditions among the observation zones. During peak solar radiation at

1:00 p.m. WITA, Zone 2 (Plaza/Amphitheater) experienced an extreme increase in air temperature, reaching 34.2°C, with a THI value of 30.2. These elevated values were attributable to the absorption of direct solar radiation by solid concrete paving, which was characterized in the original study as having low albedo and high heat-storage capacity.
In contrast, Zone 1, which is dominated by the canopy cover of shade trees, maintained a lower peak air temperature of 30.5°C (THI = 27.6), or 3.7°C below that recorded in the open plaza area. Plant shading and evapotranspiration proved effective in mitigating heat stress within the site's microclimate.

Evaluation of social functions and user behavior

Public Space Index (PSI)

An assessment of public-space quality based on the perceptions of 50 TKB visitors produced a multidimensional performance profile, as presented in table 2.

Table 2
Evaluation results for the Public Space Index (PSI) dimensions

Evaluation dimension	Mean score (Scale of 1–5)	Assessment
Spatial Inclusivity	3.82	High
Thermal and Physical Comfort	2.15	Low
Security and Safety	3.40	Moderate
Activity Intensity	3.65	High
Spatial Meaning and Identity	4.10	Very High
Overall Mean PSI Score	3.42	Moderate

The PSI scores indicate that TKB possesses substantial historical value and strong place identity for the residents of Manado City, reflected in a score of 4.10, as well as inclusive accessibility, reflected in a score of 3.82. However, thermal and physical comfort received the lowest score, at 2.15. Respondents reported the absence of shade in the central park area and the heat-reflective characteristics of the paving and seating surfaces during midday.

Stop-Motion Walking

Spatial observations mapped the dynamics of visitor activities, which were highly dependent on daily microclimatic conditions:

- Morning (9:00–11:00 a.m. WITA): Activities were distributed relatively evenly across Zones 1, 2, 3, and 4, particularly those involving worker transit, casual social interaction, and trading.
- Midday (11:00 a.m.–3:00 p.m. WITA): A phenomenon of spatial clearance occurred in Zone 3, the pedestrian circulation area, particularly in the western section. Visitors became increasingly concentrated beneath the tree shade in Zone 1 and within the portions of the Zone 3 corridor shaded by tree canopies.
- Afternoon (3:00–6:00 p.m. WITA): As air temperatures and solar radiation decreased, with THI values declining to between 26.0 and 27.4, the use of Zone 2 increased again for recreational activities, social gatherings, and informal artistic performances. However, the section of Zone 1 directly exposed to sunlight from the west experienced another decline in occupancy because of exposure to the afternoon sun.

Integrative analysis (Ecological–Social Relationships)

An overlay of the spatial distribution of temperature (THI) and activity density revealed a strong negative correlation between THI values and the duration of visitors' stays (dwelling time) in open areas. When THI exceeded 28.0, the use of public space shifted from passive and social activities, such as sitting, conversing, and recreation, toward predominantly transient activities, such as walking quickly through the area.

The physical conditions following revitalization, which placed excessive emphasis on concrete paving (hardscape), were found to reduce the park's social vitality during productive midday hours. A public space that appears visually clean but provides inadequate thermal comfort fails to function optimally as a setting for community interaction.

Conclusion

1. The ecological performance of Taman Kesatuan Bangsa following revitalization has deteriorated in terms of thermal quality in the open plaza area (Zone 2), where the THI reached 30.2 during midday, corresponding to a highly uncomfortable thermal condition.
2. The vegetated area (Zone 1) proved effective in regulating the local microclimate, reducing air temperature by as much as 3.7°C compared with the concrete-paved area.
3. Based on the Public Space Index (PSI), the social quality of TKB falls within the moderate category, with an overall score of 3.42. The strengths associated with its historical significance and inclusivity are constrained by low levels of physical and thermal comfort, which received a score of 2.15.
4. Park users' behavioral patterns demonstrate a high degree of adaptation to heat stress, as evidenced by the movement and concentration of visitors toward vegetated, shaded areas during midday.

Adaptive design recommendations

To restore the balance between the ecological and social functions of TKB, the following landscape-planning and redesign intervention strategies are proposed:

1. Increasing the Green Coverage Ratio (Softscape): Introduce additional broad-canopy trees with a multilayered canopy structure along the perimeter of Zone 2 to expand the area covered by natural shade.
2. Modifying Surface Materials (Cool Pavement): Replace portions of the solid concrete paving in the amphitheater plaza with porous materials, such as permeable paving, or grass blocks to improve water infiltration and reduce the heat-storage capacity of surface materials.
3. Providing Adaptive Artificial Shading: Integrate landscape shading elements, such as canopy shade structures and pergolas, combined with climbing plants, within the open amphitheater area.

4. Introducing Water Features: Restore existing water features or introduce additional water pools and small fountains in the center of the plaza to reduce ambient air temperature through evaporative cooling.

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