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# THE ROLE OF PUBLIC GREEN OPEN SPACE IN SUPPORTING URBAN SUSTAINABILITY: A CASE STUDY OF AHMAD YANI PARK, GAJAHMADA PARK, AND USU URBAN FOREST IN MEDAN CITY

**Ramayani. M [1], Ruri Prihatini Lubis [2], Ruth Riah Ate Tarigan [3]**
Universitas Pembangunan Panca Budi, Medan, North Sumatera [1,2,3]
Corresponding email: ramayani76@gmail.com
Author email : ruriprihatinilubis@dosen.pancabudi.ac.id, , ruthriah@dosen.pancabudi.ac.id

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**ABSTRACT**

This study discusses the sustainability performance of public green open space (RTH) in Medan City through an integrated approach that includes environmental quality, social quality, and accessibility. The methods used include regression analysis, correlation, and ANOVA to test the influence of each variable on urban sustainability. The results showed that these three variables had a significant effect, with the regression model able to explain 68.4% of the sustainability variance. Social quality was the most dominant factor (β = 0.412; r = 0.74), followed by environmental quality (r = 0.68) and accessibility (r = 0.61). Spatially, USU Urban Forest shows the highest ecological performance with a canopy cover of 78%, an NDVI value of 0.72, and a lower average microclimate temperature (27.1°C) compared to Ahmad Yani Park (29.3°C) and Gajah Mada Park (30.1°C). However, Taman Ahmad Yani obtained the highest overall sustainability score (85/100) because it was supported by superior social perception (4.35) and accessibility (4.60). Meanwhile, Taman Gajah Mada showed moderate performance (75.3/100), and USU Urban Forest received a lower score (70/100) due to limited facilities and access range. The results of the ANOVA test showed a significant difference between locations (Sig = 0.000), which indicates that the Green Open Space typology affects sustainability. Ahmad Yani Park tends to excel in social and accessibility aspects, while USU's urban forests play a greater role in ecological stability. This study confirms that the sustainability of urban RTH will be optimal if ecological, social, and accessibility functions are developed synergistically and not partially.

## Introduction

High levels of urbanization and climate change have become major challenges for cities around the world, especially in developing countries, population growth and land conversion are putting increasing pressure on the quality of the urban environment and human well-being (Seto et al., 2012; UN-Habitat, 2020). With the expansion of urban areas, the reduction of green open space often leads to a decrease in environmental quality, an increase in surface temperature, a decrease in air quality to reduced opportunities for social interaction and recreation. Public green open spaces, such as city parks and urban forests, are increasingly recognized as essential components of sustainable urban infrastructure.

Public green open spaces serve as green infrastructure that provides a wide range of ecosystem services, including microclimate regulation, air pollution mitigation, carbon sequestration, rainwater management, and biodiversity conservation (Bolund & Hunhammar, 1999; Nowak et al., 2006). Many studies have shown that urban vegetation can reduce air temperature, reduce the effects of urban heat, and improve local air quality, thereby increasing the resilience of urban environments (Zhou et al., 2011; Lafortezza et al., 2013). green open spaces are also beneficial for recreation, sports, social interaction, and provide tranquility, providing urban well-being (Grahn & Stigsdotter, 2010; Houlden et al., 2019).

Urban sustainability focuses on environmental, social, and economic integration to ensure that cities meet current needs without sacrificing future generations (WCED, 1987; Elmqvist et al., 2018). Equitable access to public green space is an important indicator of a sustainable and equitable city, as unequal distribution can exacerbate social and health inequalities (Rigolon, 2016). There is still a lack of research in developing countries, limited integrated evaluations of ecological conditions, social perceptions, and accessibility (Sharifi & Yamagata, 2016; Sharifi, 2020).

In Indonesia, the provision of green open space is mandated in spatial planning policies, but its availability, quality, and function vary widely. The city of Medan faces challenges related to changes in land use, uneven distribution of green space, and suboptimal environmental performance (Putri et al., 2019; Sari & Lubis, 2021).

Therefore, it is important to conduct research by comparing between Ahmad Yani Park, Mada Elephant Park, and USU City Forest, as these three green open spaces represent different ecological, social, and accessibility characteristics in Medan City. Despite their strategic importance, comparative evaluation of their contribution to urban sustainability is still limited. By researching these parks simultaneously, it is hoped to generate evidence-based insights that support more effective green space planning, strengthen the resilience of urban environments, and encourage sustainable urban development.

## RESEARCH METHOD

### Research Design

This study uses a quantitative descriptive research method to evaluate the contribution of public green open space to urban sustainability. Quantitative approaches to the measurement of environmental conditions, user perception, and accessibility, while analytical methods facilitate relationships between sustainability indicators (Creswell, 2018).

## Research Location

This research was conducted in three public green open spaces in the city of Medan, Indonesia: Taman Ahmad Yani, Taman Gajah Mada, and Kota Forest USU. These locations were deliberately chosen because they represent different typologies of urban green spaces, central urban parks, community parks, and urban forests thus allowing for a comparative assessment of ecological, social, and spatial performance. Evaluation of green spaces is recommended to better understand its role in sustainable urban systems (Kabisch et al., 2017).

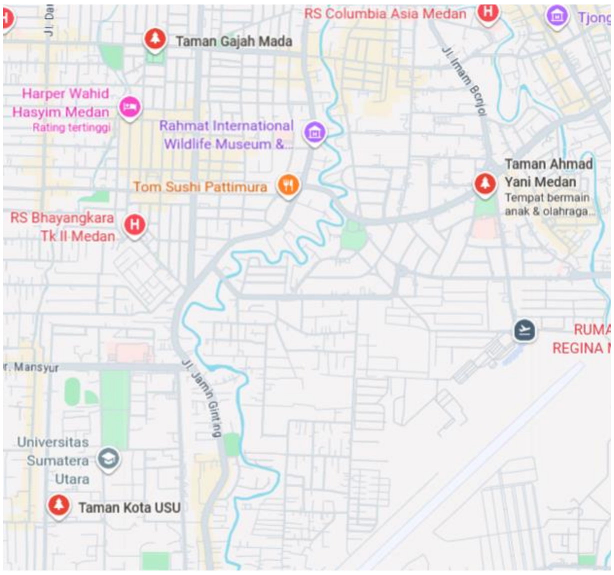


**Figure 1. Map of Ahmad Yani Park , Taman Gajah mada , USU City Forest**

## Variables and Measurements

This study integrates three independent variables and one dependent variable based on the urban sustainability framework (Elmqvist et al., 2018).

Environmental Quality (X1): assessed through vegetation cover, canopy density, microclimate temperature, and site conditions. Vegetation composition is strongly associated with a decrease in urban temperature and an improvement in air quality (Nowak et al., 2006; Zhou et al., 2011).

Environmental quality was assessed using vegetation cover, canopy density, microclimate temperature, and overall site conditions.

## Vegetation Cover (%)

Vegetation cover is calculated using the proportion of green areas in each park:

$$\text{Vegetation cover} = \frac{\text{Green ar}}{\text{Total park area}} \text{ X } 100$$

This formula is used to evaluate the service capacity of ecosystems, in particular urban temperature reductions and air purification (Nowak et al., 2006).

**Normalization Difference Vegetation Index (NDVI)**

NDVI is used to measure vegetation health:

$$NDVI = \frac{(NIR - red)}{(NIR + red)}$$

Higher NDVI values are associated with healthier vegetation and stronger thermal regulation (Zhou et al., 2011).

**Microclimate Temperature**

The ambient temperature was recorded at several sampling points and averaged:

$$Tavg = \frac{\sum Ti}{n}$$

Lower temperatures indicate a stronger cooling effect produced by vegetation (Nowak et al., 2006).

Calculating the environment index using a composite score:

$$\text{Environmental index} = \frac{\sum \text{indicator value}}{\text{Number of}}$$

Composite environmental indices are generally applied in urban ecological assessments (Elmqvist et al., 2018).

Social Quality (X2): measured using perceived comfort, safety, amenities, and recreational benefits. Exposure to well-planned green spaces has been shown to improve psychological recovery and social well-being (Grahn & Stigsdotter, 2010; Houlden et al., 2019).

Social quality was measured using a Likert scale questionnaire that included comfort, safety, amenities, and perceived social benefits.

Each indicator is scored from 1 (very poor) to 5 (very good) and counted as:

$$Mean\ Score = \frac{\sum X}{n}$$

To generate the overall social index:

$$Social\ Index = \frac{\sum Mean\ Indicator}{Total\ Indicators}$$

Liker-based perception assessment systems are widely recommended to evaluate psychological recovery and user satisfaction in green spaces (Grahn & Stigsdotter, 2010; Houlden et al., 2019).

Accessibility (X3): evaluated based on mileage, connectivity, transportation availability, and ease of access. Equitable access to green space is an important component of a sustainable and equitable city (Rigolon, 2016).

Accessibility is evaluated using mileage, connectivity, transportation availability, and ease of access.

Distance Index:

$$Distance\ Score = \frac{Actual\ Distance}{Maximum\ Distance}$$

(standardized to ensure comparability between sites).

The composite accessibility index is calculated as:

$$Accessibility\ Index = \frac{\sum Indicator\ Scores}{Number\ of\ Indicators}$$

Accessibility metrics are essential for measuring spatial equity in green infrastructure (Rigolon, 2016).

**Urban Sustainability (Y)**

Dependent variables reflect users' perceptions of environmental support, social benefits, and overall urban viability.

$$Sustainability\ Index = \frac{\sum Sustainability\ Indicators}{Total\ Indicators}$$

bility to meet current needs withc

The dependent variable, Urban Sustainability (Y), reflects the user's perception of the park's contribution to environmental carrying capacity, social benefits, and urban quality of life, in accordance with the sustainability principles outlined by WCED (1987).

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**Sampling and Data Collection**

The sample was park visitors aged 17 years and older selected using comfort sampling, a method that is widely applied in public space research due to its practicality in capturing the user experience in real-time (Lafortezza et al., 2013).

Data is collected through four main techniques:

a. Field observations, conducted to evaluate vegetation characteristics, facility conditions, and physical qualities of the site, follow the approach that has been established in urban ecology studies (Nowak et al., 2006).
b. Microclimate measurements, ambient temperatures are recorded at multiple sampling points during daylight hours to assess the cooling effects of vegetation, a standard method in urban heat studies (Zhou et al., 2011).
c. Survey Questionnaire, a structured Likert scale instrument is used to capture visitors' perceptions of social quality and accessibility. Perception-based surveys are commonly used in environmental behavior research (Grahn & Stigsdotter, 2010).
d. Spatial Accessibility Analysis, a digital mapping tool used to estimate distance and connectivity, supports the evaluation of green space equity (Rigolon, 2016).

**Data Analysis**

Data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics summarize ecological conditions and user perceptions, while Pearson's correlation examines the relationships between variables. Multiple linear regression was applied to determine the simultaneous effects of environmental quality, social factors, and accessibility on urban sustainability. In addition, one-way ANOVA is used to identify differences in sustainability performance between the three parks.

**Descriptive Statistics**

Used to summarize environmental conditions and perception scores:

$$Mean = \frac{\sum X}{n}$$

(Creswell & Creswell, 2018).

**Pearson Correlation**

To measure the relationship between variables:

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

Correlation analysis is generally used to examine the relationships between urban environmental indicators (Creswell & Creswell, 2018).

**Multiple Linear Regression**

Used to evaluate the simultaneous influence of independent variables:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e$$

Where:

**Y** = Urban sustainability
**a** = constant
**b** = Regression Coefficient
**e** = Error

Regression modeling is widely applied in sustainability research to explain multidimensional relationships (Elmqvist et al., 2018).

**One-Way ANOVA**

Used to identify differences in sustainability performance across different parks:

$$F = \frac{Between - group\ variance}{Within - group\ variance}$$

ANOVA is suitable for comparing averages across different groups (Creswell & Creswell, 2018).

**Validity, Reliability, and Ethics**

The validity of the instrument was assessed using item-total correlation, and reliability was confirmed via Alpha Cronbach, with values above 0.70 indicating acceptable internal consistency (Taber, 2018). All participants were informed of the research objectives, and responses were collected anonymously. Ethical principles—including voluntary participation, confidentiality, and non-interference—are strictly adhered to (Creswell & Creswell, 2018).

The validity of the instrument is tested using item-total correlation, while the reliability is evaluated with Alpha Cronbach:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

where k is the sum of items.

A value above 0.70 indicates acceptable internal consistency (Taber, 2018).

All respondents were informed of the purpose of the study, and responses were collected anonymously. Ethical principles, including voluntary participation, confidentiality, and non-interference and confidentiality of data are maintained (Creswell & Creswell, 2018).

## Results and Discussion

### Environmental characteristics of Green Open Spaces:

**Table 1. Vegetation Cover and Ecological Indicators**

| Indicator | USU City Forest | Ahmad Yani Park | Taman Gajah Mada |
|---|---|---|---|
| Canopy cover (%) | 78 | 52 | 38 |
| Trees per tile | 45 | 27 | 17 |
| NDVI Estimate | 0.62 | 0.41 | 0.32 |

USU's urban forest shows the highest ecological maturity, with a canopy cover of 78% and 45 trees per plot, while Taman Gajah Mada recorded the lowest vegetation density.

**Table 2. NDVI and Microclimate Conditions**

| Indicator | USU City Forest | Ahmad Yani Park | Taman Gajah Mada |
|---|---|---|---|
| NDVI | 0.72 | 0.48 | 0.41 |
| Micro temperature (°C) | 27.1 | 29.3 | 30.1 |
| Shadow (%) | 78 | 55 | 43 |
| Vegetation Density (1–5) | 4.7 | 3.2 | 2.8 |

Higher NDVI values correlate with lower microclimate temperatures, suggesting a strong negative correlation between vegetation health and thermal conditions.

### Social Perception

**Table 3. Social Perception Scores (Likert Scale 1–5)**

| Indicator | U SE | Ahmad Yani | Gajah Mada |
|---|---|---|---|
| Convenience | 3. | 4.3 | 3.7 |

| | | | |
|---|---|---|---|
| | 4 | | |
| Security | 3.3 | 4.2 | 3.8 |
| Facilities | 3.1 | 4.4 | 3.6 |
| Social Advantages | 3.5 | 4.5 | 3.9 |
| **Total Value** | **3.33** | **4.35** | **3.75** |

Ahmad Yani Park achieved the highest social score (4.35), while USU City Forest recorded the lowest score (3.33).

## Accessibility Performance

**Table .4. Accessibility Analysis**

| **Indicator** | **USE** | **Ahmad Yani** | **Gajah Mada** |
|---|---|---|---|
| Average distance | 3.2 | 4.6 | 4.0 |
| Transportation Access | 3.1 | 4.5 | 3.9 |
| Connectivity | 3.4 | 4.7 | 4.1 |
| Navigation | 3.3 | 4.6 | 4.0 |
| **Total Value** | **3.25** | **4.60** | **4.00** |

Ahmad Yani Park shows the highest accessibility rate (4.60), largely due to its central location and strong transportation network.

## Correlation and Regression Results

**Table 5. Pearson Correlation**

| **Variable** | **Correlation with Urban Sustainability** | **Interpretation** |
|---|---|---|
| Environment (X1) | 0.68 | Strong |

| | | |
|---|---|---|
| Social (X2) | 0.74 | Very Powerful |
| Accessibility (X3) | 0.61 | Strong |

Social perceptions show the strongest link with urban sustainability.

**Table 6. Multiple Linear Regression**

Model:
Y = 6.214 + 0.321X1 + 0.412X2 + 0.355X3

| Variable | Beta | Sig | Conclusion |
|---|---|---|---|
| Environment | 0.321 | 0.001 | Significant |
| Social | 0.412 | 0.000 | Significant |
| Accessibility | 0.355 | 0.002 | Significant |

$R^2$ = 0.684, indicating that 68.4% of the urban sustainability variance is explained by all three predictors.

The ANOVA test confirmed that the regression model was statistically significant (F = 45.33; Sig = 0.000).

Comparative Sustainability Contribution

Comparisons of ANOVA between parks showed significant differences (F = 14.22; Sig = 0.000).

The post-hoc Tukey test showed significant differences across all garden pairs.

Overall sustainability score:
1. Taman Ahmad Yani: 85/100
2. Taman Gagah Mada: 75.3/100
3. USU Urban Forest: 70/100

**Discussion**

This study confirms that urban sustainability is shaped by the interaction between ecological, social, and accessibility. The superior ecological conditions of the USU Urban Forest are demonstrated by the high NDVI and lower temperatures thus supporting the cooling effect theory, which states that dense vegetation significantly reduces urban heat (Zhou et al., 2011; Nowak et al., 2006).

However, ecological strength alone does not guarantee high sustainability results. The regression results identified social variables as the most dominant predictors (β = 0.412), suggesting that user comfort, safety, and recreational value strongly influence the perception of sustainability.

This is in line with urban well-being research that emphasizes that green spaces function as restorative environments that improve psychological health and social interaction (Lafortezza et al., 2013; Houlden et al., 2019).

Accessibility also plays a reinforcing role. More accessible parks result in greater public benefits, supporting spatial equity that states that equitable access determines the effectiveness of green infrastructure (Rigolon, 2016).

The comparative analysis highlights the importance of typological diversity in urban green space systems. Ahmad Yani Park excels because of its integration into everyday urban life, while USU's Urban Forest functions primarily as ecological infrastructure. This variation supports a multidimensional sustainability framework, which emphasizes the integration between environmental, social, and accessibility within resilient cities (Elmqvist et al., 2018).

Overall, the results of this study show that cities should avoid relying on one green space development model alone. Instead, a balanced network, the amalgamation of ecologically dense urban forests with socially dynamic and accessible parks can provide the strongest pathway to a sustainable urban environment.

## Conclusion

1. Environmental quality, social quality, and accessibility significantly affect the sustainability performance of public green open spaces in the city of Medan. The regression model explains 68.4% of the variance in urban sustainability, showing that an integrated approach provides a carrying capacity in assessing the effectiveness of green spaces.
2. USU's urban forest has the highest ecological performance, with canopy cover reaching 78%, NDVI values of up to 0.72, and lower average microclimate temperatures (27.1°C) compared to Ahmad Yani Park (29.3°C) and Gajah Mada Park (30.1°C). These results confirm that dense vegetation plays an important role in regulating urban thermal conditions and strengthening environmental resilience, as emphasized in ecosystem services research.
3. Taman Ahmad Yani achieved the highest overall sustainability score (85/100), supported by superior social perception (4.35) and accessibility (4.60). In contrast, USU's Urban Forest obtained a score of 70/100, reflecting the limitations of facilities and spatial reach despite having strong environmental capacity. Taman Gajah Mada obtained a moderate score (75.3/100), indicating a balanced but not optimal performance across all dimensions evaluated.
4. Further correlation analysis showed that social quality had the strongest association with urban sustainability ($r = 0.74$), followed by environmental quality ($r = 0.68$) and accessibility ($r = 0.61$). The regression results reinforce this pattern, identifying social factors as the most influential predictors ($\beta = 0.412$). These findings show that respondents' perceptions in terms of comfort, safety, and recreational infrastructure are determinants of the sustainability of urban green spaces.

5. The ANOVA test confirmed a statistically significant difference between the three parks (Sig = 0.000), suggesting that the typology of green spaces influences sustainability outcomes. Central urban parks tend to generate stronger social benefits and accessibility, while urban forests make a more substantial contribution to ecological stability.
6. This research shows that urban sustainability is maximized when ecological functions, social uses, and accessibility operate simultaneously, rather than separately.

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