**BIODIVERSITAS**
Volume 26, Number 6, June 2025
Pages: 2806-2820

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d260625

# Climatological aspects and visitors' comfort perceptions in green open spaces of Samarinda City, East Kalimantan, Indonesia

**KARYATI[1,♥], KARMINI[2], DIAH RAKHMAH SARI[1], YOSEP RUSLIM[1], MUNA KARHANI[3]**

[1]Faculty of Forestry and Tropical Environment, Universitas Mulawarman. Jl. Penajam, Kampus Gunung Kelua, Samarinda 75119, East Kalimantan, Indonesia. Tel.: +62-541-735089, Fax.: +62-541-735379, ♥email: karyati@fahutan.unmul.ac.id

[2]Faculty of Agriculture, Universitas Mulawarman. Jl. Pasir Balengkong, Kampus Gunung Kelua, Samarinda 75119, East Kalimantan, Indonesia

[3]Faculty of Educational Sciences and Psychology, Universitas Negeri Yogyakarta. Jl. Colombo, Depok, Sleman 55281, Yogyakarta, Indonesia

Manuscript received: 17 March 2025. Revision accepted: 29 May 2025.

**Abstract.** *Karyati, Karmini, Sari DR, Ruslim Y, Karhani M. 2025. Climatological aspects and visitors' comfort perceptions in green open spaces of Samarinda City, East Kalimantan, Indonesia. Biodiversitas 26: 2806-2820.* The trees in Green Open Spaces (GOS) play an important role in improving the microclimate, especially in urban areas. This research study aimed to analyze climatological aspects and determine visitor perceptions of GOS comfort in Samarinda City, East Kalimantan, Indonesia. Microclimate elements were measured for 30 days in nine GOS: Anang Hasyim Ecological Park, Cerdas Park, Segiri Park, Samarendah Park, Teluk Lerong Garden Park, Bebaya Park, Muso Salim GOS, RE Martadinata GOS, and Slamet Riyadi GOS. The comfort of these GOS was assessed based on their Temperature Humidity Index (THI) values and the perceptions of visitors to these locations. Visitors' perceptions of microclimate comfort were collected through interviews with 270 respondents (30 respondents in each of the nine GOS). The average light intensity in the nine GOS ranged from 586.3 to 1,117.1 lux, the average air temperature ranged from 28.4-29.1°C, and the average air humidity ranged from 78.1-82.3% during the study period. All of the GOS within this study had a THI of less than 29.0°C and were in the comfortable category, highlighting the positive impact of the microclimate. The analysis of these nine GOS shows that the majority of the 270 respondents have a good perception of their microclimate and comfort. Information about climatological aspects and perceptions of GOS visitors can be used to support databases and recommendations for GOS management related to regional spatial planning.

**Keywords:** Green open spaces, humidity index, microclimate, perception, temperature, visitor comfort

## INTRODUCTION

Local climate and thermal comfort, which are both influenced by the presence of Green Open Space (GOS) in urban areas (Dissanayake and Weerasinghe 2021; Sutapa et al. 2023), have been shown to improve the well-being of urban residents, including mental and physical health, happiness, satisfaction, and quality of life from a psychological and physiological perspective (Lai et al. 2020; Aram et al. 2022; Arrar et al. 2022; Bille et al. 2023; Dollah et al. 2023; Hunter et al. 2023). Several factors pose challenges and negatively impact human comfort, such as the declining availability of GOS, insufficient GOS coverage relative to population needs (Sihombing and Hutapea 2021; Penggayuh et al. 2023; Khaire et al. 2024), the inadequate quality and functional performance of GOS (Mohamed and Vadeveloo 2023), and typology limitations within GOS (Ischak et al. 2023).

Trees growing within GOS, such as urban forests, city parks, arboretums, road medians, sports fields, and public cemeteries, improve the microclimate since vegetation canopies reduce solar radiation and air temperature, increase air humidity, reduce wind, and noise, and increase comfort (Karyati et al. 2020, et al. 2021, et al. 2023; Taufiq and Wulandari 2022; He and Reith 2023; Sutapa et al. 2023; Baruti et al. 2024). Their effectiveness in these functions is influenced by spatial arrangement and vegetation density (Ambarwati et al. 2023). These vegetated areas play a multifaceted role in the economy, environment, and society. They have a significant impact on various aspects of human life, providing essential ecosystem functions, including climate regulation and carbon sequestration (Karyati and Isa 2023).

The combination of natural vegetation and infrastructure or industrial elements (Amores et al. 2023) has been shown to influence visitors' thermal comfort perceptions and sensory experiences within GOS (Nitidara et al. 2022; Huang et al. 2023). The facilities and infrastructure available in GOS should be thematically tailored for diverse age groups and user interests. This aesthetic diversity and visual appeal increase visits to GOS and improve user comfort during a variety of activities (Alfatih et al. 2018; Richo et al. 2022; Sutapa et al. 2023; Dollah et al. 2023; Hutabarat 2023).

Despite their significant potential and benefits, GOS has not been adequately optimized within the urban spatial planning frameworks of the city's government or local communities. This underutilization is evident in the continued vulnerability of 11,732 hectares within the region (16.36% of the total area of Samarinda City, East Kalimantan, Indonesia) to flooding. There are 80 GOS in Samarinda City, consisting of 70 GOS managed by the government and 10 GOS managed by private or community groups, representing a total GOS area of 369.83 ha and a GOS-to-total-area ratio of only 0.51%. According to Samarinda Mayor Regulation No. 660/291/HK-

KS/VIII/2018 regarding the Designation of Several City Forest Locations, 16 areas, totaling 338.0 hectares, have been officially designated as city forests.

Several prior studies on microclimate and comfort index in GOS have been conducted (Dursun and Yavaş 2018; Lai et al. 2020; Karyati et al. 2021; Taufiq and Wulandari 2022; Ambarwati et al. 2023; He and Reith 2023). However, research comprehensively exploring comfort levels based on comfort indices and visitors' perceptions of GOS remains limited. This study addresses this gap by examining the climatological aspects of GOS and offering recommendations to support policy development and management strategies. Specifically, this work analyzes climatological aspects and determines visitors' perceptions of comfort in GOS in Samarinda City. These findings hold particular strategic relevance for Samarinda City. They are anticipated to contribute to the systematic and comprehensive collection of GOS-related data, enhance existing databases, and serve as a valuable reference for GOS management practices in general.

## MATERIALS AND METHODS

### Study area

This study observed 9 GOS in Samarinda City, East Kalimantan Province, Indonesia, which were studied over six months (April-September 2024). The group comprised 6 city parks: Anang Hasyim Ecological Park, Segiri Park, Samarendah Park, Teluk Lerong Garden Park, Bebaya Park, and Cerdas Park (which was renamed Edu Park after renovations to its facilities and infrastructure in November 2024), along with three other green open spaces (Muso Salim GOS, Martadinata GOS, and Slamet Riyadi GOS).

### Vegetation survey

A vegetation survey was conducted to document the plant species present in the nine GOS. The frequency of different plant species' presence at trees, herbs, flowers, and understory levels was identified and recorded in a tally sheet. This was to identify the distribution of plants and the diversity of species planted in the GOS.

### Microclimate assessment

Measurements of microclimate elements (light intensity, air temperature, and relative humidity) within the study locations were carried out three times a day (morning, afternoon, and evening) for a total of 30 days (10 days each in June, July, and August 2024). Climate data collection was conducted from June to August 2024 with several considerations, including that weather conditions in Samarinda City were relatively more stable during this time, with lower rainfall and longer sunshine duration than other months of the year. These conditions are expected to support more accurate and representative data collection, as well as minimize disruption to research activities in the field. An environmental meter was used to record all measurements, with three repetitions taken at each time interval: morning (07:00-08:00), afternoon (12:00-13:00), and evening (17:00-18:00).

### Comfort index analysis

The comfort index or Temperature Humidity Index (THI) provides a quantitative measure of the comfort level of an area based on temperature and relative humidity values. The comfort index was calculated using the Nieuwolt formula (Penggayuh et al. 2023):

$$THI = 0.8\ T + [(RH \times T) / 500]$$

Where, THI: temperature humidity index (comfort index); T: air temperature (°C); RH: relative humidity (%).

Comfort index criteria were determined based on criteria outlined in prior work (Teodoreanu 2016); the descriptive analysis of the visitor perception data employed both quantitative and qualitative methods.

### Visitors' perception survey

Visitors' perceptions were collected via questionnaire-aided, structured interviews with 270 respondents (30 individuals for each of the 9 GOS studied). Visitor comfort was assessed based on several parameters: visitors' perceptions of microclimate comfort, presence of trees and other plants, adequacy of public facilities, and cleanliness and safety conditions.

## RESULTS AND DISCUSSION

### Description of study sites

The Green Open Spaces (GOS) in this study contained various types of vegetation, including woody and herbaceous, ranging from low-growing ground cover plants to trees. A total of 59 tree species were planted across the 9 GOS considered in this study. Furthermore, 85 ornamental plants, encompassing both herbaceous and floral species, as well as understory varieties, were identified within 8 out of the 9 GOS studied. Figure 1 presents a view of the 9 GOS studied.

Samarendah Park had the most extensive array of tree species, with 35 species recorded (Table 1). This was followed by Anang Hasyim Ecological Park, which had 22 tree species, Segiri Park (15 tree species), Slamet Riyadi GOS (15 tree species), Teluk Lerong Garden Park (15 tree species), and Bebaya Park (14 tree species). In contrast, the tree species composition in Cerdas Park, Muso Salim GOS, and RE Martadinata GOS was 12, 9, and 2 species, respectively. *Pterocarpus indicus* has been identified as the most prevalent tree species in 8 out of the 9 GOS studied. *Ficus benjamina* and *Terminalia catappa* were also prevalent tree species in 7 GOS. *Syzygium oleana* was found in 4 GOS, while *Mangifera indica, Mimusops elengi, Samanea saman*, and *Spathodea campanulata* were recorded in 5 of the 9 GOS studied. *Swietenia macrophylla* was the most abundant exotic tree on the Universitas Sumatera Utara (USU) campus, Indonesia, followed by *Polyalthia longifolia, Syzygium paniculatum, Tamarindus indica* and *P. indicus* (Susilowati et al. 2021).


**Figure 1.** View of study sites in GOS of Samarinda City, East Kalimantan, Indonesia. A. Anang Hasyim Ecological Park, B. Cerdas Park, C. Segiri Park, D. Samarendah Park, E. Teluk Lerong Garden Park, F. Bebaya Park, G. Muso Salim GOS, H. RE Martadinata GOS, I. Slamet Riyadi GOS

A study of the flora of six urban parks and urban forests in Kediri City revealed that the most prevalent tree species were *F. benjamina* (*beringin*) and *P. longifolia* (*glodokan tiang*). Fabaceae exhibited the most species richness, with 5 species, followed by Arecaceae, which contained 4 species (Afrianto et al. 2021). Dominant trees in GOS serve as foundational structural elements, contributing significantly to the visual coherence and aesthetic appeal of these areas. Their expansive canopies offer substantial shade, enhancing thermal comfort for visitors and mitigating the urban heat island effect by fostering cooler microclimates. Densely vegetated zones exhibit lower ambient temperatures and elevated humidity levels compared to sparsely vegetated areas. Furthermore, these trees play a pivotal role in environmental amelioration by sequestering carbon dioxide, releasing oxygen, filtering airborne pollutants, and attenuating urban noise levels.

All GOS studied were planted with understory species, with the exception of RE Martadinata GOS, which was exclusively planted with trees. The green open spaces with the most undergrowth, both herbaceous and floral, were Samarendah Park (45 species), Anang Hasyim Ecological Park (40 species), Cerdas Park (22 species), and Bebaya Park (21 species), as shown in Table 2. In contrast, the number of understory species documented in Segiri Park, Teluk Lerong Garden Park, Muso Salim GOS, and Slamet Riyadi GOS was 13, 6, 6, and 5 species, respectively. The most prevalent understory species (within 6 out of 9 of the GOS studied) was *Cordyline fruticosa. Codiaeum variegatum, Excoecaria cochinchinensis, Ixora coccinea, Justicia gendarussa*, and *Reullia simplex* were also identified among the understory species planted in 4 of the GOS studied. *Alternanthera brasiliana, Bougainvillea glabra, Chlorophytum comosum, Cuphea hyssopifolia, Dypsis lutescens, Euphorbia tithymaloides, Heliconia bihai, Hibiscus rosa-sinensis, Pandanus amaryllifolius, Sansevieria trifasciata, Saraca asoca, Tradescantia spathacea,* and *Turnera ulmifolia* were the most common understory species in 3 of the studied GOS. Of the 106 tree species identified in the Universitas Sebelas Maret area, Indonesia, *Bauhinia purpurea* (*kupu-kupu* tree), *T. indica* (*asam jawa*), and *Araucaria heterophylla* (*cemara norfolk*) had particularly noteworthy characteristics. These species are known for their attractive crown morphology, branched structures, foliage, and particularly beautiful flowers, characteristics that contribute to their high aesthetic appeal (Yulia et al. 2023).

**Table 1.** List of trees planted in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

| Species | Local Name | AHEP | CP | SP | SRP | TLG | BP | MSG | REM | SRG |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acacia mangium* | *Akasia* | | | ● | | | | ● | | |
| *Agathis alba* | *Damar* | | | | | ● | | | | |
| *Ailanthus altissima* | *Pohon surga* | | | | ● | | | | | |
| *Albizia saman* | *Trembesi* | | | | ● | ● | | ● | | |
| *Alstonia scholaris* | *Pulai* | ● | | | ● | | ● | | | |
| *Aquilaria malaccensis* | *Gaharu* | | | | ● | | | | | |
| *Areca catechu* | *Pinang* | | ● | | ● | | | | | |
| *Artocarpus communis* | *Sukun* | | | ● | | | | | | |
| *Artocarpus heterophyllus* | *Nangka* | | | ● | | | ● | | | |
| *Artocarpus integer* | *Cempedak* | | | ● | | | | | | |
| *Artocarpus lanceifolius* | *Keledang* | | | | ● | | | | | |
| *Baccaurea motleyana* | *Rambai* | ● | | | | | | | | |
| *Bambusa glaucescens* | *Bambu hias* | ● | | | | | | | | |
| *Calophyllum inophyllum* | *Nyamplung* | | | | ● | | | | | |
| *Casuarina equisetifolia* | *Cemara laut* | | | | | | ● | | | |
| *Cerbera manghas* | *Bintaro* | ● | | | ● | | ● | | | |
| *Cocos nucifera* | *Kelapa* | | | | | | | ● | | ● |
| *Cyrtostachys renda* | *Palem merah* | | | | | | ● | | | |
| *Delonix regia* | *Flamboyan* | ● | | | | | | | | |
| *Dimocarpus longan* | *Lengkeng* | | | | ● | | | | | |
| *Elaeis guineensis* | *Kelapa sawit* | | ● | | | | | | | ● |
| *Erythrina subumbrans* | *Dadap serep* | | | | | ● | | | | |
| *Eusideroxylon zwageri* | *Ulin* | ● | | | ● | | | | | |
| *Ficus benjamina* | *Beringin* | ● | | ● | ● | ● | ● | ● | | ● |
| *Filicium decipiens* | *Kerai payung* | ● | | ● | ● | | | | | |
| *Gmelina arborea* | *Jati putih* | | | | ● | ● | | | | |
| *Lagerstroemia speciosa* | *Bungur* | | | | ● | ● | | | | |
| *Leucaena leucocephala* | *Lamtoro* | ● | ● | ● | ● | | | | | |
| *Mangifera indica* | *Mangga* | ● | | ● | ● | | | ● | | ● |
| *Mimusops elengi* | *Tanjung* | | ● | | ● | | | ● | ● | ● |
| *Muntingia calabura* | *Kersen* | | | | ● | ● | | | | ● |
| *Nephelium lappaceum* | *Rambutan* | ● | | ● | ● | | | | | |
| *Peronema canescens* | *Sungkai* | | | | ● | | | | | |
| *Pinus merkusi* | *Pinus* | | ● | ● | | | | | | |
| *Plumeria acuminata* | *Kamboja* | ● | | | | | ● | | | |
| *Polyalthia longifolia* | *Glodokan tiang* | ● | ● | ● | | | | | | ● |
| *Pometia pinnata* | *Matoa* | ● | | | | | | | | |
| *Psidium guajava* | *Jambu biji* | | | ● | ● | | | | | |
| *Pterocarpus indicus* | *Angsana* | ● | ● | ● | ● | ● | | ● | ● | ● |
| *Rauvolfia caffra* | *Pohon kina* | | | | ● | | | | | |
| *Roystonea regia* | *Palem raja* | | | | | ● | ● | | | ● |
| *Samanea saman* | *Trembesi* | ● | ● | | ● | | | ● | | ● |
| *Senegalia pennata* | *Petai siam* | | | | | | ● | | | |
| *Senna siamea* | *Johar* | | | | | ● | | ● | | |
| *Shorea acuminate* | *Meranti merah* | | | | ● | | | | | |
| *Shorea assamica* | *Meranti putih* | | | | ● | | | | | |
| *Shorea laevis* | *Bangkirai* | | | | ● | | | | | |
| *Spathodea campanulata* | *Tulip afrika* | | ● | ● | | ● | ● | | | ● |
| *Swietenia macrophylla* | *Mahoni* | ● | | | ● | ● | | | | |
| *Swietenia mahagoni* | *Mahoni* | | | | ● | | | | | ● |
| *Syzygium aqueum* | *Jambu air* | | | | ● | | | | | |
| *Syzygium oleana* | *Pucuk merah* | ● | ● | | ● | | ● | | | |
| *Syzygium polyanthum* | *Salam* | ● | | | ● | | | | | ● |
| *Tabebuia heterophylla* | *Tabebuya* | ● | | | | ● | | | | |
| *Tamarindus indica* | *Asam jawa* | | ● | | ● | | | | | |
| *Terminalia catappa* | *Ketapang* | ● | ● | ● | ● | ● | ● | | | ● |
| *Terminalia mantaly* | *Ketapang kencana* | ● | | | ● | | ● | | | |
| *Vitex pinnata* | *Laban* | | | | | | ● | | | |
| *Ziziphus mauritiana* | *Bidara* | | | | | ● | | | | |

Note: AHEP: Anang Hasyim Ecological Park, CP: Cerdas Park, SP: Segiri Park, SRP: Samarendah Park, TLG: Teluk Lerong Garden Park, BP: Bebaya Park, MSG: Muso Salim GOS, REM: RE Martadinata GOS, SRG: Slamet Riyadi GOS

**Table 2.** List of herbs, flowers, and understory plants planted in eight green open spaces in Samarinda City, East Kalimantan, Indonesia

| Species | Local Name | AHEP | CP | SP | SRP | TLG | BP | MSG | SRG |
|---|---|---|---|---|---|---|---|---|---|
| *Acrostichum aureum* | *Paku laut* | ● | | | | | | | |
| *Agaphantus praecox* | *Lili afrika* | ● | | ● | | | | | |
| *Agave americana* | *Lidah buaya Amerika* | ● | | | ● | | | | |
| *Allamanda cathartica* | *Alamanda* | ● | | | | | ● | | |
| *Allium tuberosum* | *Kucai* | | ● | | | | | | |
| *Alternathera brasiliana* | *Bayam merah* | | ● | ● | ● | | | | |
| *Aphelandra squarrosa* | *Bunga zebra* | ● | | | ● | | | | |
| *Aucuba japonica* | *Kroton* | | | | ● | | | | |
| *Ayapana triplinervis* | *Daun panahan* | ● | | | | | | | |
| *Bougainvillea glabra* | *Kembang kertas* | ● | ● | | ● | | | | |
| *Brassica oleracea* | *Brokoli hijau* | ● | | | | | | | |
| *Brunfelsia uniflora* | *Melati mentomori* | | ● | | | | | | |
| *Cananga odorata* | *Kenanga* | ● | | | | | | | |
| *Canavalia gladiate* | *Kacang koro pedang* | ● | ● | | | | | | |
| *Canna discolor* | *Ganyong* | ● | | | | | ● | | |
| *Canna indica* | *Bunga kana* | | | | ● | | | | |
| *Canna lily* | *Bunga tasbih* | | | | ● | | | | |
| *Caprifolium paniculatum* | *Bunga pagoda* | | | | | | ● | | |
| *Carex morrowii* | *Kucai jepang* | | ● | | ● | | | | |
| *Catharanthus roseus* | *Tapak dara* | | ● | | ● | | | | |
| *Chamaerops humilis* | *Telapak kerdil* | | | | ● | | | | |
| *Chlorophytum comosum* | *Lili paris* | | ● | | ● | ● | | | |
| *Chrysanthemum indicum* | *Krisan* | ● | | | | | | | |
| *Codiaeum variegatum* | *Puring* | ● | ● | | ● | | | | ● |
| *Cordyline fruticosa* | *Hanjuang merah* | ● | ● | ● | ● | | ● | | ● |
| *Cornus alba* | *Derain putih* | | | | ● | | | | |
| *Costus spicatus* | *Pacing pentul* | | | | | ● | ● | | |
| *Costus spilaris* | *Jahe spiral* | ● | | | ● | | | | |
| *Cuphea hyssopifolia* | *Bunga ungu Taiwan* | ● | | | ● | | ● | | |
| *Dieffenbachia bowmannii* | *Blanceng* | ● | | | | | ● | | |
| *Dieffenbachia seguine* | *Sri rejeki* | | | | ● | | | ● | |
| *Dracaena marginata* | *Bunga manggar* | | | | ● | | | | |
| *Dracaena reflexa* | *Nyanyian india* | | | ● | | | | | |
| *Dypsis lutescens* | *Palem* | ● | | | ● | | | ● | |
| *Epipremnum aureum* | *Sirih gading* | | | | | | ● | | |
| *Euphorbia tirucall* | *Patah tulang* | | | | ● | | | | |
| *Euphorbia tithymaloides* | *Zig-zag* | ● | | ● | | | ● | | |
| *Excoecaria cochinchinensis* | *Sambang darah* | | | ● | ● | ● | ● | | |
| *Ficus microcarpa* | *Beringin dolar* | ● | | | | | | | |
| *Heliconia bihai* | *Palulu merah* | ● | ● | | ● | | | | |
| *Heliconia densiflora* | *Pisang-pisangan* | ● | | | | | ● | | |
| *Heliconia psittacorum* | *Supit udang* | ● | | | ● | | | | |
| *Heliconia variegata* | *Pisang hias* | | ● | | | | | | |
| *Hibiscus rosa-sinensis* | *Kembang sepatu* | ● | | | | | ● | | ● |
| *Hovenia dulcis* | *Pohon kismis Jepang* | | | | ● | | | | |
| *Hymenocallis littoralis* | *Bunga bakung* | ● | | | ● | | | | |
| *Impatiens balsamina* | *Pacar air* | | | | ● | | | | |
| *Iris domestica* | *Brojo lintang* | | | | | | | | ● |
| *Ixora coccinea* | *Soka* | ● | | ● | ● | | ● | | |
| *Ixora javanica* | *Soka jawa* | | | ● | | | | | |
| *Justicia gendarussa* | *Gandarusa* | ● | ● | | ● | | ● | | |
| *Lilium candidum* | *Bunga lili putih* | | ● | | ● | | | | |
| *Mussaenda erythrophylla* | *Nusa indah merah* | | | | | | ● | | |
| *Mussaenda frondosa* | *Kingkilaban* | ● | | | | | | | |
| *Mussaenda pubescens* | *Nusa indah putih* | | | | | | ● | | |
| *Nerium oleander* | *Bunga mentega* | | | | | | ● | | |
| *Pandanus ammaryllifolius* | *Pandan wangi* | ● | ● | | | ● | | | |
| *Pandanus odorifer* | *Sri rezeki* | | ● | | | ● | | | |
| *Passiflora foetida* | *Rambusa* | | ● | | | | | | |
| *Pedilanthus tithymaloides* | *Penawar lilin* | | | | ● | | | ● | |
| *Pennisetum purpureum* | *Rumput gajah mini* | | ● | | ● | | | | |
| *Persicaria odorata* | *Daun kesum* | | | | | | ● | | |
| *Phyllanthus pulcher* | *Meniran* | | | | | | | ● | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Plectranthus scutellarioides* | *Miana* | | | | | ● | | | | | | |
| *Pleomele angustifolia* | *Suji hijau* | | ● | | | | | | | | | |
| *Pluchea indica* | *Beluntas* | ● | | | | | | | | | | |
| *Plumeria obtusa* | *Kamboja cempaka* | | | | | ● | | | ● | | | |
| *Plumeria rubra* | *Kamboja merah* | | | | | ● | | | | | | ● |
| *Portulaca grandiflora* | *Krokot mawar* | ● | | | | ● | | | | | | |
| *Pseuderanthemum carruthersii* | *Melati jepang* | ● | | | | ● | | | | | | |
| *Reullia simplex* | *Kencana ungu* | ● | ● | ● | | ● | | | | | | |
| *Rhapis excelsa* | *Palem jari* | | | | | | | | | ● | | |
| *Sambucus javanica* | *Sangitan* | | | | | ● | | | | | | |
| *Sanchezia noblis* | *Cacak gading* | | | ● | | | | ● | | | | |
| *Sansevieria trifasciata* | *Lidah mertua* | ● | | | | ● | | | | ● | | |
| *Saraca asoca* | *Asoka* | ● | ● | | | | | | ● | | | |
| *Schefflera arboricola* | *Walisongo* | | | ● | | | | | | | | |
| *Spiraea japonica* | *Spiraea Jepang* | | | | | ● | | | | | | |
| *Strelitzia reginae* | *Bunga cendrawasih* | ● | | | | | | | | | | |
| *Tabernaemontana divaricata* | *Mondokaki* | | ● | | | ● | | | | | | |
| *Trachycarpus fortunei* | *Palem hijau* | ● | | | | ● | | | | | | |
| *Tradescantia spathacea* | *Nanas kerang* | ● | | ● | | ● | | | | | | |
| *Turnera ulmifolia* | *Bunga pukul delapan* | ● | | ● | | ● | | | | | | |
| *Yucca grandiflora* | *Tombak raja* | | | | | | | | ● | | | |
| *Zinnia elegans* | *Zinia anggun* | ● | | | | ● | | | | | | |

Note: AHEP: Anang Hasyim Ecological Park, CP: Cerdas Park, SP: Segiri Park, SRP: Samarendah Park, TLG: Teluk Lerong Garden Park, BP: Bebaya Park, MSG: Muso Salim GOS, REM: RE Martadinata GOS, SRG: Slamet Riyadi GOS

Salsabila et al. (2021) reported that *Pseuderanthemum reticulatum* exhibits a high tolerance level to air pollution, placing it within the "tolerant" category. It possesses a high level of water content, ascorbic acid, and other components of APTI (Air Pollution Tolerance Index), such as pH, water content, and chlorophyll, which are proportionally balanced. In contrast, *Canna indica* and *Syzygium myrtifolium* plants exhibited intermediate tolerance levels across all sectors. Furthermore, Muhlisin et al. (2021) found that vegetation planted in urban parks is predominantly ornamental, primarily serving aesthetic purposes rather than ecological functions, daily human needs, or other ecosystem services.

**The microclimate of green open spaces**

The light intensity in the study locations ranged from 586.3 to 1,117.1 lux, air temperature ranged from 28.4°C to 29.1°C, and air humidity ranged from 78.1% to 82.3%. The measurements collected from June to August of 2024 revealed significant variations in microclimate parameters within the studied GOS, including light intensity, air temperature, and air humidity. Light intensity exhibited substantial fluctuations throughout the observation period. Some GOS exhibited substantial increases in light intensity, particularly on specific days, which may be attributable to weather conditions or variations in vegetation composition across the various locations. Peaks in light intensity were observed on measurement days 5 and 17, with some sites experiencing drastic increases exceeding 2,500 lux. The variation in light intensity was found to be lower in gardens with denser vegetation, which likely provided a protective effect against direct sunlight. After day 20, fluctuations in light intensity appeared to be more stable, exhibiting lower average values compared to the initial measurement period (Figure 2.A).

The air temperature in nine GOS exhibited a more stable fluctuation pattern than light intensity. The temperature fluctuated within the range of 26.5°C to 30.5°C, exhibiting less extreme variations, as depicted in Figure 2.B. The overall trend in air temperature exhibited a repetitive upward and downward pattern, with a limited range of variation. Notably, a series of temperature spikes emerged during the measurement period, specifically between measurement days 15 and 20. These spikes were likely influenced by heightened light intensity and other meteorological factors. Sites with higher vegetation density exhibited lower temperatures compared to those with less vegetation cover. Air humidity exhibited a diverse fluctuation pattern at each location. Humidity levels ranged between 72% and 88%, exhibiting fluctuating trends that were not consistent across the study locations (Figure 2.C). On certain days, significant spikes in humidity were observed, which were primarily influenced by weather conditions, such as precipitation or alterations in wind patterns. The heightened humidity trend was particularly pronounced on the final days of measurement, a phenomenon that is likely attributable to diminished light intensity and more stable air temperatures.

Microclimatic factors, including light intensity, wind speed, and soil pH, play a pivotal role in the functioning of an ecosystem. A comprehensive study conducted in the Arroceros Forest Park revealed that air temperature, air humidity, soil temperature, percent organic matter, and soil moisture were found to be highly significant among the four quadrants studied (Berame et al. 2021). This study demonstrates that microclimates within GOS exhibit variations that are influenced by diverse environmental factors, including vegetation cover, light intensity, and local weather conditions. It is noteworthy that fluctuations in light intensity were more pronounced than those of air temperature and humidity, while air temperature remained relatively stable, exhibiting minimal variation. In contrast, air humidity displayed a high degree of variability, largely

due to external factors, such as precipitation and wind patterns, which play a significant role in shaping the microclimates.

**Comfort index of green open spaces**

Urban geometry and climate variables are the two most influential factors influencing perceptions of outdoor thermal comfort. Physical characteristics of urban environments, such as layout and vegetation cover, play a critical role in shaping microclimatic conditions that support thermal comfort (Dursun and Yavaş 2018). One of the functions of GOS is to regulate climate stability and environmental comfort (Kandari et al. 2024). The THI values in the nine GOS demonstrated variations in thermal comfort levels, as illustrated in Figure 3. THI serves as a metric for evaluating thermal comfort levels, with its calculation incorporating both air temperature and relative humidity. The findings reveal that the nine green open spaces and city parks under scrutiny exhibit a THI below 29.0, thereby indicating their classification as comfortable. This finding suggests that these areas offer a thermal environment conducive to visitor comfort. The Slamet Riyadi GOS, with a THI value of 27.3, is an example of a location that supports comfort. The low THI values (27.4) observed in Cerdas Park, Teluk Lerong Garden Park, Muso Salim GOS, and RE Martadinata GOS further substantiate the presence of thermal conditions conducive to visitor comfort. Segiri Park and Samarendah Park also have THI values of 27.7, which are within the comfortable range. Anang Hasyim Ecological Park and Bebaya Park exhibited a slightly higher THI (27.8), yet they remained within the comfortable range. The factors influencing thermal comfort in urban green spaces include vegetation density, the presence of tree canopies, and the presence of water elements, which have been observed to reduce temperatures and increase ambient air humidity. The presence of GOS has been demonstrated to contribute positively to thermal comfort in urban environments.

Accordingly, the comfort index in young secondary forests (THI: 26.47) and human settlements (THI: 26.99) is classified as comfortable, while that of open land (THI: 27.90) is classified as uncomfortable (Karyati et al. 2020). The microclimate characteristics in land cover types dominated by tree vegetation are more comfortable (THI: 26.5) and significantly different from the dominant land cover types of grass (THI: 31.8) and settlements (THI: 29.5) (Kandari et al. 2024). The concept of comfort is also evident across the varied topographies of Sejati Park in Samarinda City, which has a THI within the comfortable category. Specifically, THI values recorded at the peak (27.95), middle (28.14), and valley (28.95) indicate comfortable conditions (Karyati et al. 2021). As explained by Karyati et al. (2023), the strategic planting of trees in road medians has been shown to enhance the microclimate within urban areas. Furthermore, the THI values measured beneath the canopies and in the surrounding areas of *P. indicus* (angsana) and *P. longifolia* (glodokan) trees planted along road medians also fall within the comfortable range. A map of the comfort indices of the green open spaces evaluated in this work is presented in Figure 4.

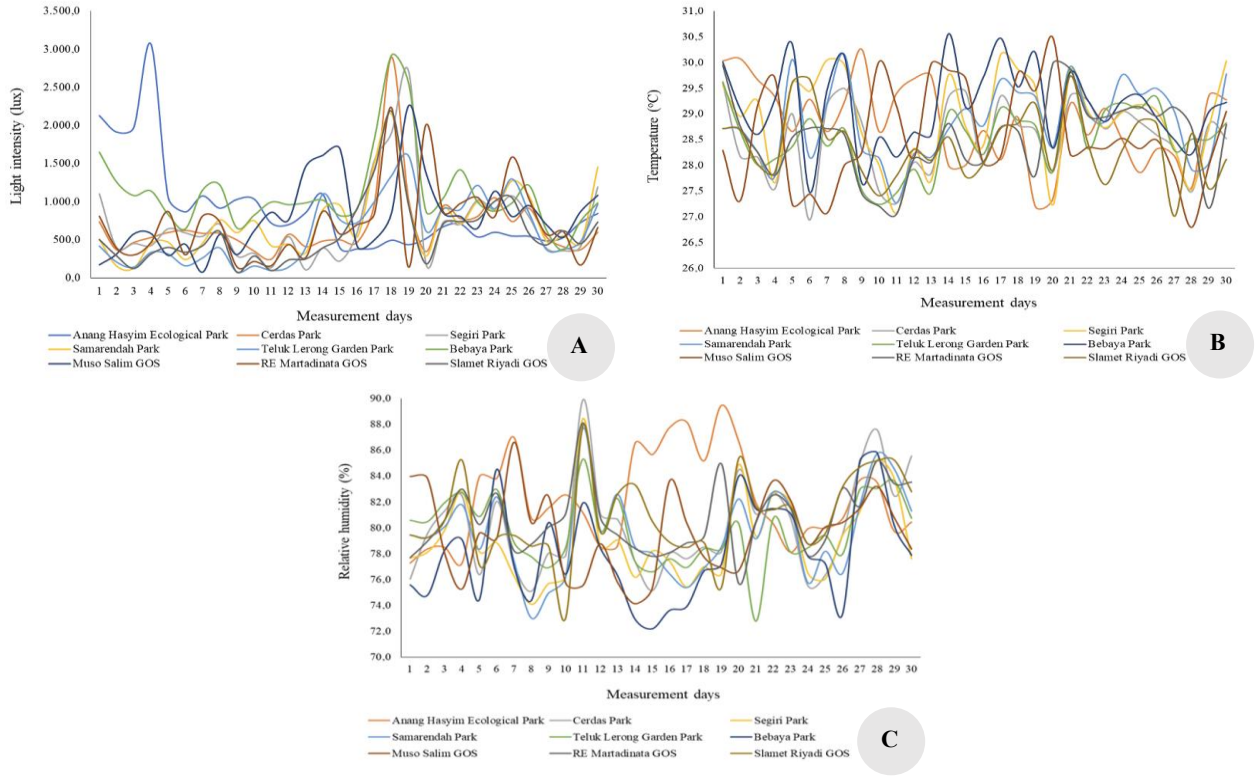


**Figure 2.** Fluctuations of: A. Light intensity, B. Temperature, C. Air humidity in nine green open spaces in Samarinda City, East Kalimantan, Indonesia, during June-August 2024

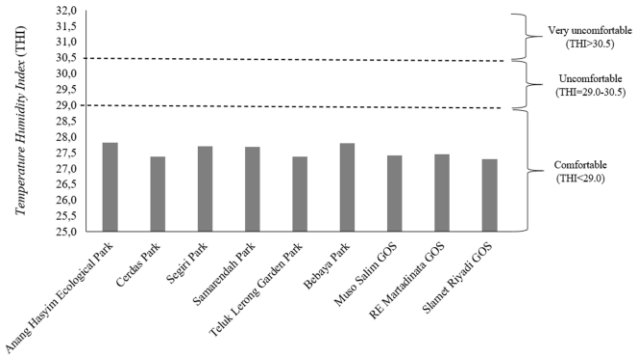


**Figure 3.** Comfort index (Temperature Humidity Index) in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

## Visitors' perceptions of microclimate comfort and facilities in green open spaces

The majority of respondents (60%) identified as female, while 40% identified as male (Figure 5). These data are derived from a total of 270 respondents across the 9 GOS. The majority of these respondents were between the ages of 21 and 30 (61%) and between 31 and 40 (27%). The proportion of respondents in the under-20 age group and above 40 years of age was 7% and 5%, respectively. The predominant purpose of respondents' visits to the GOS was for family leisure time, accounting for 46% of all visits. In addition, a significant proportion of respondents (44%) visited GOS for socializing, conducting business, and various other activities. A relatively small percentage of respondents (10%) reported visiting GOS for exercise.

The mean distance between respondents' places of residence and the GOS was 1 km (42%), with 39% of respondents indicating a distance of 1-3 km and 19% indicating a distance of more than 3 km. This suggests that most of the visitors to the studied GOS were individuals residing near the GOS. Responses to questions regarding the accessibility of the GOS revealed that 71% of respondents considered the GOS accessible by public transportation, while 26% indicated that they were best accessible through private transportation, and 3% indicated that the GOS was not easily accessible. The majority of respondents (55%) reported visiting the GOS one to two times per week. Conversely, 38% of respondents indicated that they only visit GOS occasionally or rarely. A relatively small percentage of respondents (7%) reported visiting the GOS more than three times per week.

Microclimate plays a significant role in human comfort. The assessment of thermal comfort level requires consideration of the perception of the local human population, given the variability in human adaptation across different geographical regions (Ambarwati et al. 2023). Many factors contribute to the comfort of a space, collectively influencing sensory experiences and perceptions of comfort. The optimization of open space design in densely populated areas should be guided by consideration of extreme microclimatic conditions and spatial behavior (Guo et al. 2018). Factors that influence outdoor thermal comfort may do so directly (for example, physical, physiological, and psychological factors) or indirectly (for example, behavioral, personal, social, and cultural factors, as well as thermal history and site characteristics) (Lai et al. 2020). Thermal comfort plays an important role in urban GOS since thermal conditions are related to the comfort and health of GOS users, and thermal conditions are linked to patterns of activity, intensity, and motivation to visit.

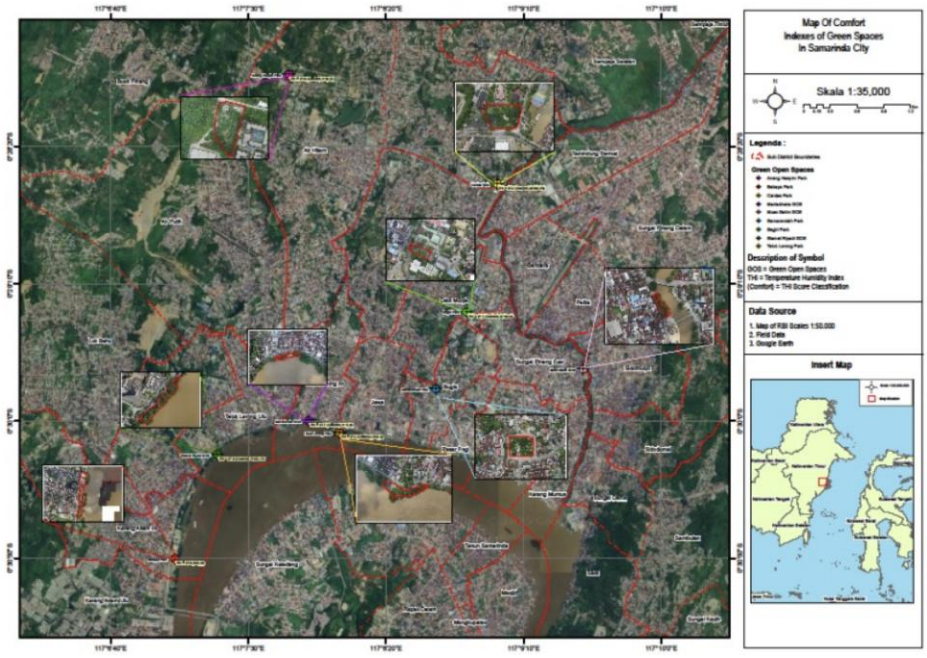


**Figure 4.** Map of the comfort index of green open spaces in Samarinda City, East Kalimantan, Indonesia

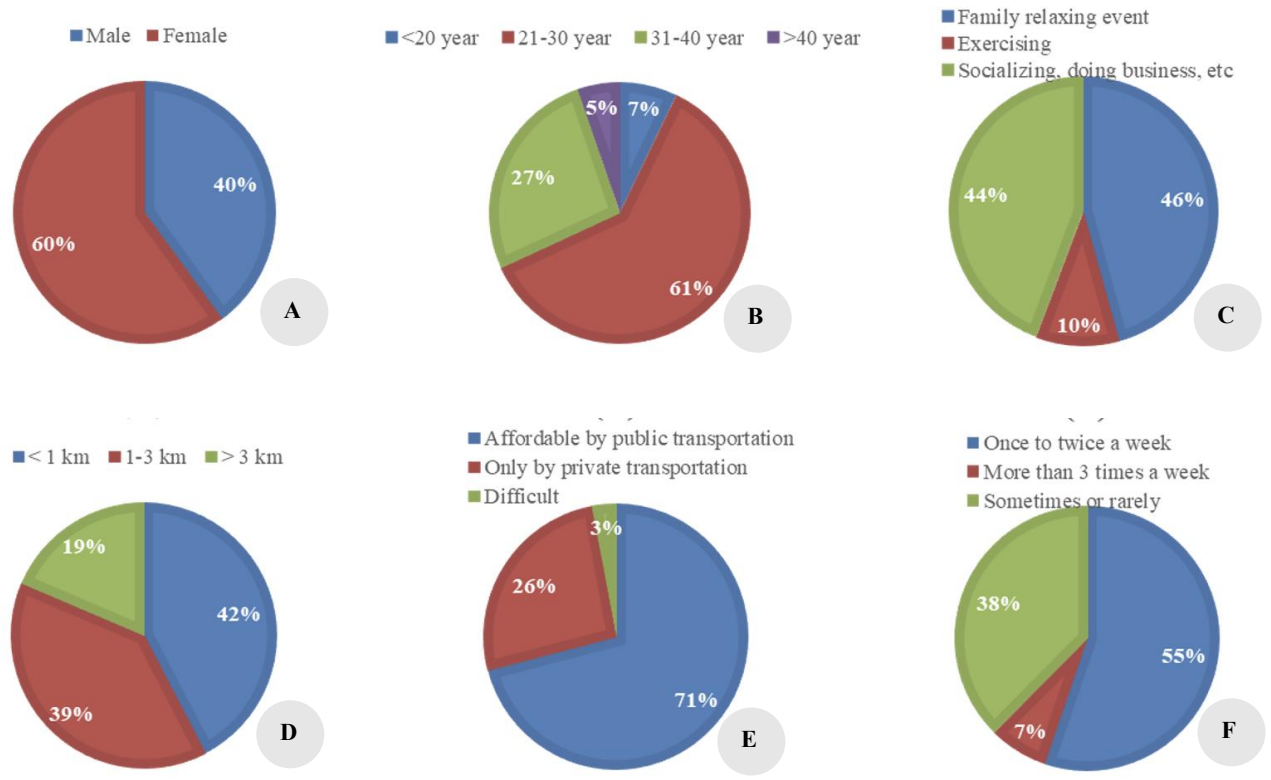


**Figure 5.** Background of respondents

This analysis of six city parks (Anang Hasyim Ecological Park, Cerdas Park, Segiri Park, Samarendah Park, Teluk Lerong Garden Park, and Bebaya Park) as well as three GOS, namely Muso Salim GOS, RE Martadinata GOS, and Slamet Riyadi GOS in Samarinda City, revealed that the majority of the 270 respondents had a favorable perception of the microclimate and comfort. Table 3 displays visitors' perceptions of microclimate comfort within the selected GOS in Samarinda City. Most respondents (>57%) rated the ability of most GOSs to reduce solar radiation as "good," except for Bebaya Park and RE Martadinata GOS. This is consistent with the finding that the GOS were generally perceived as effective temperature moderators by most respondents (>57%). Most respondents (>73%) also felt that GOS were effective wind reducers, except for Teluk Lerong Garden Park (70% thought it was moderate). Most visitors also perceived GOSs as effective in mitigating air pollution (>60% of respondents) and promoting air circulation (>56% of respondents), except for RE Martadinata GOS. Most respondents (97%) expressed the opinion that RE Martadinata GOS possessed the capacity to reduce air pollution to a moderate extent. In comparison, the ability of RE Martadinata GOS to neutralize air circulation was rated as "poor" by most visitors (63%). RE Martadinata is situated along the roadside and on the riverbank of the Mahakam River. The limited number of trees planted, and their specific type reduce the ability of this site to function effectively as an air pollution reducer and air circulation regulator. This assertion is substantiated by the observation that only two tree species were planted, namely *M. elengi* and *P. indicus*, and no understory species were planted, as described in Tables 1 and 2.

Several indicators related to the perception of microclimatic comfort influence the duration of visitor activity and led most respondents (>54%) to report that they felt comfortable engaging in activities for durations ranging between 1 and 3 hours in Anang Hasyim Ecological Park, Cerdas Park, Muso Salim GOS, Teluk Lerong Garden Park, RE Martadinata GOS, Slamet Riyadi GOS, and Bebaya Park. Notably, most respondents (43%) for Cerdas Park reported being able to engage in activities for more than 3 hours comfortably. This can be attributed to several key features of Cerdas Park, such as its strategic location, its abundance of trees and plants, which make the park shady and cooler, adequate game, and sports areas, as well as the numerous food vendors at this site, which are also one of the main attractions of Cerdas Park. Culinary tourism at this location is significant, particularly at the end of the day and week. Most of the respondents (47%) visiting Segiri Park indicated that they were able to engage in activities for less than one hour comfortably. This is partly because although Segiri Park is quite strategically placed and easy to access, many city residents are unfamiliar with it, it occupies a relatively small area (+0.6 ha) featuring few trees and plants, and there is an absence of play areas and sports facilities. However, most respondents (47%) in Samarendah Park stated that they

could be comfortably active for 1-3 hours. The pattern and density of vegetation determine the influence of GOS on the microclimate.

All the GOS studied had THI values ranging from 27.3 to 27.8, which were categorized as "comfortable". This is consistent with most visitors' perceptions of microclimate comfort in the GOS as shown in Table 4. All respondents (100%) at Cerdas Park, Samarendah Park, and Muso Salim GOS felt comfortable, although the THI was not too different from other locations. Most respondents at Bebaya Park (97%), RE Martadianta GOS (93%), and Slamet Riyadi GOS (93%) also stated that GOS has a comfortable microclimate. The perception of comfort was also felt by most visitors to Segiri Park, Teluk Lerong Garden Park, and Anang Hasyim Ecological Park, with 83%, 80%, and 77%, respectively. Visitors who felt less comfortable at GOS ranged from 3% to 20%. In comparison, those who feel uncomfortable are only a small percentage (3%) of visitors, namely at Anang Hasyim Ecological Park and Teluk Lerong Garden Park. Although THI is one indicator of the level of thermal comfort of a place, the perception of visitor comfort is not only influenced by THI value. Other factors, such as the presence of trees and other vegetation, public facilities, cleaning facilities, security facilities, and surrounding activities, are also likely to influence overall comfort perception.

**Table 3.** Visitors' perceptions (%) of microclimate comfort in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

| Indicators | Anang Hasyim Ecological Park | Cerdas Park | Segiri Park | Samarendah Park | Teluk Lerong Garden Park | Bebaya Park | Muso Salim GOS | RE Martadinata GOS | Slamet Riyadi GOS |
|---|---|---|---|---|---|---|---|---|---|
| | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) |
| Reduction of solar radiation | | | | | | | | | |
| a. good | 87 | 93 | 67 | 57 | 57 | 47 | 93 | 10 | 93 |
| b. moderate | 13 | 7 | 33 | 40 | 43 | 53 | 7 | 90 | 7 |
| c. poor | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Reduction of high temperature | | | | | | | | | |
| a. good | 77 | 97 | 80 | 80 | 80 | 57 | 90 | 57 | 87 |
| b. moderate | 23 | 3 | 20 | 20 | 20 | 40 | 10 | 43 | 13 |
| c. poor | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Reduction of wind speed | | | | | | | | | |
| a. good | 100 | 97 | 73 | 76 | 30 | 83 | 87 | 73 | 93 |
| b. moderate | 0 | 3 | 27 | 17 | 70 | 17 | 13 | 27 | 7 |
| c. poor | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 |
| Reduction of air pollution | | | | | | | | | |
| a. good | 100 | 87 | 97 | 60 | 80 | 73 | 90 | 3 | 93 |
| b. moderate | 0 | 13 | 0 | 30 | 20 | 27 | 10 | 97 | 7 |
| c. poor | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 0 |
| Air circulation regulator | | | | | | | | | |
| a. good | 100 | 90 | 77 | 60 | 87 | 56 | 90 | 0 | 87 |
| b. moderate | 0 | 0 | 0 | 7 | 0 | 7 | 0 | 37 | 0 |
| c. poor | 0 | 10 | 23 | 33 | 13 | 37 | 10 | 63 | 13 |
| Duration of activity comfortably | | | | | | | | | |
| a. <1 jam | 36 | 3 | 47 | 43 | 40 | 33 | 23 | 43 | 7 |
| b. 1-3 jam | 57 | 54 | 33 | 47 | 60 | 64 | 64 | 54 | 73 |
| c. >3 jam | 7 | 43 | 20 | 10 | 0 | 3 | 13 | 3 | 20 |

**Table 4.** Comfort index and visitor comfort perception in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

| Location | Comfort Index | | Total Respondent | Visitor Comfort Perception | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Comfortable | | Less comfortable | | Uncomfortable | |
| | THI | Category | | Respondent | (%) | Respondent | (%) | Respondent | (%) |
| Anang Hasyim Ecological Park | 27.8 | Comfortable | 30 | 23 | 77 | 6 | 20 | 1 | 3 |
| Cerdas Park | 27.4 | Comfortable | 30 | 30 | 100 | 0 | 0 | 0 | 0 |
| Segiri Park | 27.7 | Comfortable | 30 | 25 | 83 | 5 | 17 | 0 | 0 |
| Samarendah Park | 27.7 | Comfortable | 30 | 30 | 100 | 0 | 0 | 0 | 0 |
| Teluk Lerong Garden Park | 27.4 | Comfortable | 30 | 24 | 80 | 5 | 17 | 1 | 3 |
| Bebaya Park | 27.8 | Comfortable | 30 | 29 | 97 | 1 | 3 | 0 | 0 |
| Muso Salim GOS | 27.4 | Comfortable | 30 | 30 | 100 | 0 | 0 | 0 | 0 |
| RE Martadinata GOS | 27.4 | Comfortable | 30 | 28 | 93 | 2 | 7 | 0 | 0 |
| Slamet Riyadi GOS | 27.3 | Comfortable | 30 | 28 | 93 | 2 | 7 | 0 | 0 |

Note: THI: Temperature Humidity Index

Most respondents evaluated the tree canopy cover in Anang Hasyim Ecological Park (100%), Cerdas Park (80%), and Slamet Riyadi GOS (73%) as "good." Most respondents in Bebaya Park (83%) assessed the shade as "moderate" (as presented in Table 5). Conversely, most respondents who visited Samarendah Park (53%), Segiri Park (60%), Teluk Lerong Garden Park (63%), Muso Salim GOS (67%), and RE Martadinata GOS (63%) found the trees to be less shady. Most respondents provided favorable ratings for the physiognomy of vegetation and trees in Anang Hasyim Ecological Park (80%), Cerdas Park (93%), Samarendah Park (70%), Teluk Lerong Garden Park (57%), Muso Salim GOS (100%), and RE Martadinata GOS (60%). In contrast, the physiognomy of vegetation and trees received a "moderate" rating from respondents in Segiri Park (47%), Bebaya Park (87%), and Slamet GOS (70%).

Most respondents thought the trees and plants at Anang Hasyim Ecological Park (93%), Samarendah Park (87%), Bebaya Park (93%), and RE Martadinata GOS (90%) were "good." However, visitors at Segiri Park (67%), Teluk Lerong Garden Park (77%), and Slamet Riyadi GOS (93%) thought they were "moderate." Meanwhile, respondents visiting Cerdas Park (57%) and Muso Salim GOS (63%) said that there was a lack of enrichment of trees and other vegetation. Park vegetation can improve the local climate by reducing heat and air temperature, increasing air humidity, and reducing noise (Suripto et al. 2021). The presence of dense and shady vegetation in urban parks and forests provides substantial ecological benefits, offering essential environmental services to the surrounding community and visitors. The transformation of GOS into a suitable recreational space can be achieved through the implementation of ecological interventions, such as the strategic planting of new vegetation and the revitalization of existing vegetation (Oktavia et al. 2023).

A large proportion of respondents (>60%) stated that all the GOS studied were strategically located and well managed, as described in Table 6. Most respondents who visited Segiri Park (70%), Teluk Lerong Garden (77%), RE Martadinata GOS (73%), and Slamet Riyadi GOS (93%) stated that the GOS could be visited during both the dry and rainy seasons. However, respondents stated that visits to Anang Hasyim Ecological Park (57%), Bebaya Park (53%), and Muso Salim GOS (90%) could only be made during the dry season. A total of 43% of respondents visited Cerdas Park, Samarendah Park, and Bebaya Park at specific times, such as morning and evening only. Anang Hasyim Ecological Park and Samarendah Park provide numerous amenities, such as play facilities, sports facilities, and areas for relaxation. Play and sports facilities are also available at the Segiri Park and Muso Salim GOS, while Cerdas Park, RE Martadinata GOS, and Slamet Riyadi GOS provide facilities for play and relaxation. However, Teluk Lerong Garden Park and Bebaya Park only provide facilities for relaxation. Most respondents gave a rating of "good" for questions related to visitor activity accommodation (>67%) and the design or conditions of the facilities provided (>83%) at the nine GOS studied.

Most respondents (more than 83%) thought the design or condition of the facilities at the nine GOS studied was "good." Additionally, most respondents rated the availability of supporting facilities, such as places of worship and places to relax, as "good" at Cerdas Park (77%) and Bebaya Park (100%). In comparison, respondents rated the availability of these facilities at Anang Hasyim Ecological Park (100%), Segiri Park (100%), Teluk Lerong Garden Park (73%), and Slamet Riyadi GOS (100%) as "moderate." Muso Salim GOS (63%) and RE Martadinata GOS (93%) were rated as "poor" in providing supporting facilities. There was consensus among respondents regarding the adequate accessibility of weather information boards at Anang Hasyim Ecological Park (100%), Segiri Park (70%), Muso Salim GOS (93%), and Slamet Riyadi GOS (63%). Conversely, most respondents at Cerdas Park (53%), Teluk Lerong Garden Park (80%), Bebaya Park (63%), and RE Martadinata GOS (60%) assessed the availability of weather information boards as "poor." Each park must be designed and maintained to a high standard to enhance the accessibility of recreational opportunities for residents. The design and layout of parks directly influence the recreational experience of their users (Ahirwal 2020).

The majority of visitor respondents (77% or more) at Cerdas Park, Samarendah Park, Segiri Park, Bebaya Park, and Slamet Riyadi GOS evaluated the waste bin facilities at these locations as "good" (Table 7). Conversely, respondents who visited Anang Hasyim Ecological Park (90%) and Teluk Lerong Garden Park (67%) assessed the waste bin facilities as "poor." Meanwhile, most respondents who visited Muso Salim GOS (67%) and RE Martadinata GOS (70%) assessed the availability of waste bins as "moderate." Furthermore, most respondents (>57%) expressed satisfaction with the cleanliness of Anang Hasyim Ecological Park, Cerdas Park, Samarendah Park, Segiri Park, Bebaya Park, and Slamet Riyadi GOS. Then, the three other GOS was rated as "moderate".

A significant proportion of respondents (>57%) who visited Cerdas Park, Segiri Park, Teluk Lerong Garden Park, Bebaya Park, and Slamet Riyadi GOS expressed satisfaction with the security facilities, rating them as "good." Conversely, most respondents (60% or more) assessed the security at Anang Hasyim Ecological Park, Samarendah Park, and Muso Salim GOS as "poor," whereas the security at RE Martadinata was regarded as "moderate" by the majority of respondents (83%).

The quality of assistance provided by staff was regarded as "good" by most respondents (57% or more) at Anang Hasyim Ecological Park, Samarendah Park, Muso Salim GOS, RE Martadinata GOS, and Slamet Riyadi GOS. In contrast, the ratings given by respondents who visited Cerdas Park, Segiri Park, and Teluk Lerong Garden Park were predominantly "moderate" (>67% of respondents). Conversely, a substantial majority (97%) of respondents evaluated the assistance to visitors as "poor." The majority of respondents (>67%) provided a favorable evaluation of the maintenance of facilities and the surrounding environment at all the GOS studied, with the exception of Muso Salim GOS. Furthermore, 63% of respondents assessed the standard of maintenance of the facilities and the surrounding environment as "moderate.".

**Table 5.** Visitors' perceptions (%) of the presence of trees and other vegetation in 9 green open spaces in Samarinda City, East Kalimantan, Indonesia

| Indicator | Anang Hasyim Ecological Park | Cerdas Park | Samarendah Park | Segiri Park | Teluk Lerong Garden Park | Bebaya Park | Muso Salim GOS | RE Martadinata GOS | Slamet Riyadi GOS |
|---|---|---|---|---|---|---|---|---|---|
| | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n-30) | (n: 30) | (n: 30) |
| The shade of the planted trees | | | | | | | | | |
| a. good | 100 | 80 | 30 | 10 | 0 | 7 | 33 | 0 | 74 |
| b. moderate | 0 | 3 | 17 | 30 | 37 | 83 | 0 | 37 | 3 |
| c. poor | 0 | 17 | 53 | 60 | 63 | 10 | 67 | 63 | 23 |
| Physiognomy of vegetation and trees | | | | | | | | | |
| a. good | 80 | 93 | 70 | 40 | 57 | 13 | 100 | 60 | 27 |
| b. moderate | 20 | 7 | 30 | 47 | 43 | 87 | 0 | 40 | 70 |
| c. poor | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 3 |
| Enrichment of trees and other vegetation | | | | | | | | | |
| a. good | 93 | 3 | 86 | 30 | 23 | 93 | 23 | 90 | 7 |
| b. moderate | 7 | 40 | 7 | 67 | 77 | 7 | 14 | 10 | 93 |
| c. poor | 0 | 57 | 7 | 3 | 0 | 0 | 63 | 0 | 0 |

**Table 6.** Visitors' perceptions regarding the comfort of public facilities available in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

| Indicator | Anang Hasyim Ecological Park | Cerdas Park | Sama-rendah Park | Segiri Park | Teluk Lerong Garden Park | Bebaya Park | Muso Salim GOS | RE Marta-dinata GOS | Slamet Riyadi GOS |
|---|---|---|---|---|---|---|---|---|---|
| | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) |
| Location and arrangement | | | | | | | | | |
| a. strategic and well-organized | 70 | 90 | 77 | 60 | 93 | 100 | 80 | 100 | 100 |
| b. less strategic with good arrangement | 30 | 10 | 23 | 33 | 7 | 0 | 20 | 0 | 0 |
| c. arrangement is not good | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 |
| Possibility of dry and rainy season visits | | | | | | | | | |
| a. both seasons throughout the day | 13 | 23 | 43 | 70 | 77 | 3 | 10 | 73 | 93 |
| b. only the dry season all day long | 57 | 33 | 13 | 20 | 3 | 53 | 90 | 17 | 0 |
| c. only certain times, for example, morning and afternoon | 30 | 43 | 43 | 10 | 20 | 43 | 0 | 10 | 7 |
| Facilities provided | | | | | | | | | |
| a. play facilities | 30 | 60 | 20 | 0 | 0 | 0 | 10 | 3 | 3 |
| b. sports facilities | 27 | 0 | 30 | 7 | 0 | 0 | 90 | 0 | 0 |
| c. relaxing facilities, etc | 43 | 40 | 50 | 93 | 100 | 100 | 0 | 97 | 97 |
| Accommodation of visitor activities | | | | | | | | | |
| a. good | 77 | 83 | 80 | 67 | 83 | 90 | 100 | 100 | 90 |
| b. moderate | 23 | 17 | 20 | 33 | 17 | 10 | 0 | 0 | 10 |
| c. poor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| The design or shape of the facilities provided | | | | | | | | | |
| a. good | 83 | 97 | 100 | 90 | 93 | 93 | 100 | 100 | 97 |
| b. moderate | 17 | 3 | 0 | 10 | 7 | 7 | 0 | 0 | 3 |
| c. poor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Supporting facilities such as prayer rooms and restrooms | | | | | | | | | |
| a. good | 0 | 77 | 50 | 0 | 3 | 100 | 10 | 7 | 0 |
| b. moderate | 100 | 17 | 43 | 100 | 73 | 0 | 27 | 0 | 100 |
| c. poor | 0 | 7 | 7 | 0 | 23 | 0 | 63 | 93 | 0 |
| Weather information board | | | | | | | | | |
| a. good | 100 | 47 | 47 | 70 | 20 | 37 | 93 | 37 | 63 |
| b. moderate | 0 | 0 | 17 | 7 | 0 | 0 | 0 | 3 | 0 |
| c. poor | 0 | 53 | 37 | 23 | 80 | 63 | 7 | 60 | 37 |

**Table 7.** Visitors' perceptions (%) of the comfort of cleanliness and safety facilities available in nine green open spaces in Samarinda City, East Kalimantan, Indonesia

| Indicator | Anang Hasyim Ecological Park | Cerdas Park | Samarendah Park | Segiri Park | Teluk Lerong Garden Park | Bebaya Park | Muso Salim GOS | RE Martadinata GOS | Slamet Riyadi GOS |
|---|---|---|---|---|---|---|---|---|---|
| | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n: 30) | (n-30) | (n: 30) | (n: 30) |
| Waste disposal facilities | | | | | | | | | |
| a. good | 0 | 93 | 93 | 77 | 7 | 100 | 13 | 13 | 83 |
| b. moderate | 10 | 7 | 3 | 23 | 27 | 0 | 67 | 70 | 13 |
| c. poor | 90 | 0 | 3 | 0 | 67 | 0 | 20 | 17 | 3 |
| Cleanliness of public open spaces | | | | | | | | | |
| a. good | 73 | 57 | 70 | 90 | 10 | 100 | 40 | 37 | 73 |
| b. moderate | 27 | 43 | 30 | 10 | 87 | 0 | 53 | 63 | 23 |
| c. poor | 0 | 0 | 0 | 0 | 3 | 0 | 7 | 0 | 3 |
| Security facilities | | | | | | | | | |
| a. good | 0 | 70 | 7 | 57 | 57 | 97 | 27 | 17 | 63 |
| b. moderate | 0 | 27 | 33 | 30 | 43 | 3 | 10 | 83 | 10 |
| c. poor | 100 | 3 | 60 | 13 | 0 | 0 | 63 | 0 | 27 |
| Staff are helpful to visitors | | | | | | | | | |
| a. good | 57 | 30 | 83 | 33 | 27 | 0 | 57 | 57 | 73 |
| b. moderate | 43 | 67 | 17 | 67 | 73 | 3 | 43 | 43 | 27 |
| c. poor | 0 | 3 | 0 | 0 | 0 | 97 | 0 | 0 | 0 |
| Maintenance of facilities and the surrounding environment | | | | | | | | | |
| a. good | 67 | 87 | 97 | 73 | 100 | 93 | 37 | 97 | 97 |
| b. moderate | 33 | 13 | 3 | 23 | 0 | 7 | 63 | 3 | 3 |
| c. poor | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |

Azzahra et al. (2023) identifies 7 key approaches to ecotourism development: engaging and collaborating with local communities, promoting active community involvement, creating tour packages, improving facilities and infrastructure, and providing effective promotion and visitor services. Visitors' safety and health standards must be satisfied to improve the quality of life and public spaces in urban parks (Ahmadinejad 2021). The incorporation of elements such as unobstructed sightlines, passive and active surveillance, permeable boundaries, and clear signage and lighting is also crucial in enhancing the perception of safety among visitors (Ahirwal 2020).

The highest microclimatic comfort level indicators based on visitor perceptions were received from visitors to Cerdas Park, Muso Salim GOS, and Slamet Riyadi GOS, which received high ratings for aspects related to mitigating or reducing solar radiation, high temperature, and wind speed. Meanwhile, RE Martadinata GOS and Bebaya Park received lower ratings on several aspects of microclimate, especially in air circulation regulation. Anang Hasyim Ecological Park and Muso Salim GOS received high ratings for their tree shade, vegetation structure, and plant diversity. In contrast, Segiri Park and Teluk Lerong Garden Park received unfavorable ratings for their vegetation density, indicating a lack of sufficient tree cover to maximize comfort. Bebaya Park and RE Martadinata GOS received high ratings for facility design and visitor activity accommodation. However, visitors noted that Samarendah Park and Segiri Park do not have many supporting facilities, such as places of worship and weather information boards. Visitors to Muso Salim GOS and Bebaya Park said they were happy with the cleanliness and safety of these locations. However, there is room for improvement at Anang Hasyim Ecological Park and Segiri Park with respect to waste management and staff support for visitors.

Overall, GOSs that have dense and shady vegetation, trees, and adequate facilities tend to receive more positive reviews from visitors regarding comfort. However, some GOS need improvement in terms of supporting infrastructure and cleanliness. Organizations responsible for the management of GOS must prioritize the maintenance of a comfortable microclimate balance for visitors and the sustainability of the ecosystem within to ensure the well-being of all stakeholders. Although this study has focused on Samarinda City, the findings from this exploration of the climatological and comfort aspects in the nine GOS considered are generally useful for the development of a comprehensive database and recommendations for GOS management and related regional spatial planning in various types of GOS. The findings of this study are of particular importance in supporting more environmentally friendly and sustainable urban planning. By encouraging the development and maintenance of green spaces, which have been demonstrated to improve human quality of life, this research can significantly influence future planning practices.

## ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia, which provided financial support for this research through Fundamental Research-

Regular, Decree No.: 061/E5/PG.0200.PL/2024, dated June 11, 2024 and derivative contract No.: 621/UN17.L1/HK/2024. The authors also extend their deep appreciation to the Institute for Research and Community Service (LP2M) of Universitas Mulawarman, Samarinda City Environmental Service (DLH Kota Samarinda), Indonesia, as well as the students, respondents, and all other individuals and organizations who cannot be mentioned individually but whose contributions during the field data collection were invaluable.

## REFERENCES

Afrianto WF, Wati SI, Hidayatullah T. 2021. The suitability assessment of the tree species in the urban parks and urban forest in Kediri City, East Java, Indonesia. Nusantara Biosci 13 (2): 131-139. DOI: 10.13057/nusbiosci/n130201.

Ahirwal AA. 2020. Recreational aspects of open green spaces in neighbourhood. Intl J Res Sci Innov 7 (6): 60-67.

Ahmadinejad P. 2021. Parks design and environmental health and safety: The degree of compliance with standards. Pak J Med Health Sci 15 (1): 626-632.

Alfatih A, Sartika DD, Enh DH. 2018. Public policy on green open space development in Palembang City, Indonesia. Intl J Social Sci Hum 8 (2): 55-58. DOI: 10.18178/ijssh.2018.8.2.933.

Ambarwati N, Faida LRW, Marhaento H. 2023. The effects of green open spaces on microclimate and thermal comfort in three integrated campus in Yogyakarta, Indonesia. GeoPlann J Geomat Plann 10 (1): 31-44. DOI: 10.14710/geoplanning.10.1.37-44.

Amores TRP, Romos JS, Delgado MG, Medina DC, Cerezo-Narva´ez A, Domínguez SA. 2023. Effect of green infrastructures supported by adaptative solar shading systems on livability in open spaces. Urban For Urban Green 82: 127886. DOI: 10.1016/j.ufug.2023.127886.

Aram F, Solgi E, Baghaee S, García EH, Mosavi A, Band SS. 2022. How parks provide thermal comfort perception in the metropolitan cores: A case study in Madrid Mediterranean climatic zone. Clim Risk Manag 30: 100245. DOI: 10.1016/j.crm.2020.100245.

Arrar FH, Kaoula D, Matallah ME, Abdessemed-Foufa A, Taleghani M, Attia S. 2022. Quantification of outdoor thermal comfort levels under sea breeze in the Historical City Fabric: The case of Algiers Casbah. Atmosphere 13 (575): 1-30. DOI: 10.3390/atmos13040575.

Azzahra PR, Sumarga E, Sholihah A. 2023. Mangrove ecotourism development at Karimunjawa National Park, Indonesia. Biodiversitas 24 (8): 4457-4468. DOI: 10.13057/biodiv/d240827.

Baruti MM, Yahia MW, Johansson E. 2024. Spatial and temporal variations of microclimate and outdoor thermal comfort in informal settlements of warm humid Dar es Salaam, Tanzania. Heliyon 10: e23160. DOI: 10.1016/j.heliyon.2023.e23160.

Berame JS, Elazegui EP, Arenas MC, Orozco JA. 2021. Microclimatic factors and soil characteristics of Arroceros Forest Park in the City of Manila, Philippines. Biodiversitas 22 (11): 4956-4962. DOI: 10.13057/biodiv/d221130.

Bille RA, Jensen KE, Buitenwerf R. 2023. Global patterns in urban green space are strongly linked to human development and population density. Urban For Urban Green 86: 127980. DOI: 10.1016/j.ufug.2023.127980.

Dissanayake C, Weerasinghe UGD. 2021. Urban microclimate and outdoor thermal comfort of public spaces in warm-humid cities: A comparative bibliometric mapping of the literature. Am J Clim Change 10: 433-466. DOI: 10.4236/ajcc.2021.104023.

Dollah AS, Nirwana, Mustafa M, Putri AMJ. 2023. The social performance of the green open space (GOS) in Karebosi Field Complex. Soc Sci Hum Open 8 (1): 1-9. DOI: 10.1016/j.ssaho.2023.100540.

Dursun D, Yavaş M. 2018. Microclimate analysis of different urban forms in cold climates and the effect of thermal comfort. Intl Arch Photogramm Remote Sens Spatial Inf Sci 42 (4): 155-160. DOI: 10.5194/isprs-archives-XLII-4-155-2018.

Guo Z, Setoguchi T, Watanabe, Huo K. 2018. Public open space design study on the basis of microclimate and spatial behavior in hot and cold weather conditions in downtown area. Modern Appl Sci 12 (2): 128-141. DOI: 10.5539/mas.v12n2p128.

He Q, Reith A. 2023. A study on the impact of green infrastructure on microclimate and thermal comfort. Pollack Periodica 18 (1): 42-48. DOI: 10.1556/606.2022.00668.

Huang C, Wei F, Qiu S, Cao X, Chen L, Xu J, Gao J, Lin Q. 2023. Interpreting regenerated post-industrial lands as green spaces: Comparing public perceptions of post-industrial landscapes using human factor design framework. Ecol Indic 157: 111282. DOI: 10.1016/j.ecolind.2023.111282.

Hunter RF, Nieuwenhuijsen M, Fabian C, Murphy N, O´Hara K, Rappe E, Sallis JF, Lambert EV, Duenas OLS, Sugiyama T, Kahlmeier S. 2023. Advancing urban green and blue space contributions to public health. Viewpoint 8: e735-e742. DOI: 10.1016/S2468-2667(23)00156-1.

Hutabarat J. 2023. Evaluation a sitting position on public space based ergonomic approach. Intl J Curr Res Appl Stud 2 (5): 1-15.

Ischak M, Pratiwi SN, Winandari MIR, Wijayanto P, Olivia D. 2023. The typology of public open space in peri-urban unplanned settlement. Case study: Kampong of Kalipaten, Tangerang, Indonesia. Indones J Urban Environ Technol 6 (1): 36-48. DOI: 10.25105/urbanenvirotech.v6i1.15829.

Kandari AM, Marwah S, Kasim S, Indriyani L, Albasri, Mando LOA, Nurdin A, Syamsuddin, Munadi LOM, Fahyuddin. 2024. Microclimate impacts of land cover types in Halu Oleo University Botanical Garden and its surroundings. J Sylva Lestari 12 (2): 258-278. DOI: 10.23960/jsl.v12i2.829.

Karyati, Assholihat NK, Syafrudin M. 2020. Iklim mikro tiga penggunaan lahan berbeda di Kota Samarinda Provinsi Kalimantan Timur. Agrifor 19 (1): 11-22. DOI: 10.31293/af.v19i1.4576. [Indonesian]

Karyati, Cahyaningprastiwi SR, Sarminah S. 2021. Karakteristik iklim mikro di Taman Sejati Kota Samarinda. Jurnal Penelitian Ekosistem Dipterokarpa 7 (1): 11-22. DOI: 10.20886/jped.2021.7.1.11-22. [Indonesian]

Karyati, Isa IB. 2023. The Floristic Dynamics of Tropical Secondary Forests in Sarawak. Mulawarman University Press, Samarinda. [Indonesian]

Karyati, Yusak MY, Syafrudin M. 2023. Iklim mikro di bawah tegakan pohon kombinasi angsana (*Pterocarpus indicus*) dan glodokan (*Polyalthia longifolia*) di median Jalan Mayor Jenderal S. Parman di Kota Samarinda. Agrifor 22 (1): 43-54. DOI: 10.31293/agrifor.v22i1.6331. [Indonesian]

Khaire JD, Madrigal LO, Lanzarote BS. 2024. Outdoor thermal comfort in built environment: A review of studies in India. Energy Build 303: 1-16. DOI: 10.1016/j.enbuild.2023.113758.

Lai D, Lian Z, Liu W, Guo C, Liu W, Liu K, Chen Q. 2020. A comprehensive review of thermal comfort studies in urban open spaces. Sci Total Environ 742: 140092. DOI: 10.1016/j.scitotenv.2020.140092.

Mohamed N, Vadeveloo T. 2023. Diversifying local government funding in implementing green open space for green city development: A systematic literature review. Intl J Acad Res Account Financ Manag Sci 13 (2): 946-961. DOI: 10.6007/IJARAFMS/v13-i2/18067.

Muhlisin, Iskandar J, Gunawan B, Cahyandito MF. 2021. Vegetation diversity and structure of urban parks in Cilegon City, Indonesia, and local residents' perception of its function. Biodiversitas 22 (7): 2589-2603. DOI: 10.13057/biodiv/d220706.

Nitidara NPA, Sarwono S, Suprijanto S, Soelami FXN. 2022. The multisensory interaction between auditory, visual, and thermal to the overall comfort in public open space: A study in a tropical climate. Sustain Cities Soc 78: 103622. DOI: 10.1016/j.scs.2021.103622.

Oktavia RCD, Oktovianus, Siregar H, Sunarminto T, Hermawan R. 2023. Green open space management strategy for recreation in DKI Jakarta. Media Konservasi 28 (2): 235-243. DOI: 10.29244/medkon.28.2.235-243.

Penggayuh D, Munibah K, Ardiansyah M. 2023. The impact of changes in land use on green open space and comfort index in Semarang City, Indonesia. J Natl Resour Environ Manag 13 (4): 683-693. DOI: 10.29244/jpsl.13.4.683-693.

Regulation of the Mayor of Samarinda Number 660/291/HK-KS/VIII/2018 regarding the Designation of Several City Forest Locations within the City Area. [Indonesian]

Richo Y, Rizky D, Pemadani D. 2022. Product design of Surabaya City Park bench with the development of the concept of 5 ergoncomic attributes. J Civil Eng Plann Design 1 (2): 104-111. DOI: 10.31284/j.jcepd.2022.v1i2.3608.

Salsabila SH, Kurniadie D, Withaningsih S. 2022. Evaluation of several plant species for the sustainability of green open spaces in three sectors. Biodiversitas 23 (8): 3861-3868. DOI: 10.13057/biodiv/d230801.

Sihombing T, Hutapea D. 2021. Implementation of green open space policy in the utilization of public space in City of Medan. Adv Soc Sci Educ Hum Res 642: 363-369. DOI: 10.2991/assehr.k.220204.055.

Suripto, Jupri A, Farista B, Virgota A, Ahyadi H. 2021. Ecological valuation of city parks (Case study for Mataram City). Jurnal Biologi Tropis 21 (3): 1003-1012. DOI: 10.29303/jbt.v21i3.3026.

Susilowati A, Rachmat HH, Rangkuti AB, Iswanto AH, Elfiati D, Rambey R, Ginting IM, Larekeng SH. 2021. Tree biodiversity in USU green space: Exotic plant and its risk to native species. IOP Conf Ser Earth Environ Sci 886: 012035. DOI: 10.1088/1755-1315/886/1/012035.

Sutapa IDA, Mbarep DPP, Hasibuan HS, Zalewski M. 2023. Ecohydrology approach to strengthen public green open space management towards comfortable common space and playground in Kalijodo Area - Jakarta Province, Indonesia. Ecohydrol Hydrobiol 23 (4): 518-531. DOI: 10.1016/j.ecohyd.2023.04.005.

Taufiq A, Wulandari C. 2022. Comfort level of green open space in bandar lampung based on climate and humidity. Jurnal Belantara 5 (1): 847. DOI: 10.29303/jbl.v5i1.847.

Teodoreanu E. 2016. Thermal comfort index. Present Environ Sustain Dev 10 (2): 105-118. DOI:10.1515/pesd-2016-0029.

Yulia IT, Permatasari DP, Igustita, Berlin GE, Safira RN, Sugiyarto, Nazar IA, Himawan W, Sunarto, Pradhan P, Setyawan AD. 2023. Assessing the suitability of tree species for urban green space in a tropical university campus in Surakarta, Indonesia. Biodiversitas 24 (3): 1713-1723. DOI: 10.13057/biodiv/d240345.