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Forest Environment Characteristics for Health Therapy in Bunder Grand Forest Park, Gunungkidul, Special Region of Yogyakarta

Karakteristik Lingkungan Hutan untuk Terapi Kesehatan di Taman Hutan Raya Bunder, Gunungkidul, Daerah Istimewa Yogyakarta

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ABSTRACT

Healing forests maintain health through preservative practices, allowing benefits to emerge when site conditions support the practices. Therefore, this research aimed to identify the biophysical components and physical elements of the healing forests in Bunder Grand Forest Park (GFP). This research adopted observation methods and spatial analysis to characterize the healing forests' biophysical components and physical elements. The results showed that Bunder GFP had a diverse biodiversity and a distinctive landscape with the potential to provide comfort for visitors. It also met the criteria outlined in SNI 9006:2021, with medium thermal comfort levels. This research suggested vegetation enrichment to enhance the park's therapeutic potential, decrease noise, and increase thermal comfort. Additionally, the existing water features, karst rocks, and mixed forest vegetation can be used as media for sensory stimulation, further supporting health therapy.

INTISARI

*Penelitian ini bertujuan untuk mengetahui karakteristik komponen biofisik bentang alam dan elemen fisik lingkungan, khususnya iklim mikro, serta jenis vegetasi digunakan untuk mengidentifikasi lokasi hutan penyembuhan (*healing forest*) di Taman Hutan Raya Bunder. Identifikasi karakteristik lingkungan menggunakan metode observasi lapangan dan analisis spasial. Hasil analisis menunjukkan bahwa Tahura Bunder mempunyai keragaman hayati yang tinggi dan bentang alam yang khas sehingga berpotensi untuk memberikan kenyamanan bagi pengunjung dalam melakukan wisata hutan untuk terapi kesehatan. Tahura Bunder juga memenuhi kriteria biofisik lingkungan yang sesuai dengan SNI 9006:2021 dengan tingkat kenyamanan sedang. Pengayaan vegetasi perlu ditingkatkan untuk mengurangi tingkat kebisingan dan meningkatkan kenyamanan termal di kawasan Tahura Bunder. Unsur air, batuan karst, dan vegetasi hutan campuran dapat dimanfaatkan sebagai media stimulasi pancaindra untuk terapi kesehatan.*

Introduction

The forest ecosystem supports human life and enhances human health (Miyazaki 2018). The forest environment affects a range of sensory responses, engaging touch (skin), smell (nose), hearing (ears), sight (eyes), and taste (tongue) (Li 2018). Nature tourism is gaining popularity as public awareness rises regarding a new lifestyle after the COVID-19 pandemic, emphasizing physical and mental well-being through outdoor activities. Indonesia's Ministry of Environment and Forestry (MoEF) reported a remarkable 200% increase in visits to conservation areas in 2022, compared to the 5.29 million visitors recorded the previous year. As awareness grows, further visits to these conservation areas are anticipated.

Healing forest as a health therapy activity has been developed in various Asian countries, including Japan, China, and Korea, and has provided significant results on the human body's physiological response (Hong et al. 2021; Zhang & Ye 2022). The therapy prioritizes the connection between humans and nature, such as forests. Furthermore, it requires a forest location with a comfortable physical environment that helps cure diseases or improve physiology and psychology (Li 2018). Kang et al. (2024) identified forest biophysical characteristics suitable for forest therapy with indicators of predominant tree species, forest area, and water presence, which is considered to be the focus of forest therapy activities in the future. Therefore, a *healing forest* location should possess physical qualities that can provide healing services (Ramdan et al. 2021). Indonesia's extensive forest conservation areas have the potential for healing forest development, particularly in promoting ecotourism or nature tourism within conservation areas. The *healing forest* falls into the *cultural* category of environmental services.

Researchers have conducted numerous analyses on the biophysical potential of the healing forest environment across Indonesia. Baroqah et al. (2021) studied the protected forest area of Perum Perhutani in West Java. Similarly, Ramdan et al. (2021) studied the Cisamaya village area within Gunung Ceremai National Park. Both studies aimed to identify potential healing forest sites, which involved a spatial examination of the physical environment and an evaluation of health responses at the surveyed locations. According to SNI 9006:2021, the physical environment parameters of the forest ecosystem include slope vegetation density, temperature and relative humidity, wind speed, noise, and air negative ion content. Bunder Grand Forest Park (GFP), a conservation forest in the Special Region of Yogyakarta, is known for its rich and unique biodiversity and is a crucial tourist attraction (Suwandoko et al. 2022). Efforts to enhance forestry potential in the region include developing forest areas based on cultural ecosystem services. The healing forest concept offers a promising alternative as a specialized tourism concept to support the potential of Bunder GFP. Therefore, this research aimed to identify the biophysical components and physical elements of the healing forests in Bunder GFP, specifically the microclimate and vegetation types.

Materials and Methods

Location

The research location was Bunder Grand Forest Park, Gunungkidul, Special Region of Yogyakarta, with an area of 634.1 ha geographically and coordinates of 110 ° 32'55'' - 110 ° 34'35'' BT and 7 ° 53'25'' - 7 ° 55'10'' LS. Administratively, the area was bordered on the north by Ngelegi and Ngalang Villages in the Patuk and Gedangsari Sub-districts, respectively. It was also bothered to the east by Gading Village in the Playen Sub-district, the south by Gading and the Banaran Villages, Playen Sub-district, and the west by Bunder Village, Patuk Sub-district. Furthermore, the location was 100-240 meters above sea level, classified as climate type C based on the Schmidt and Ferguson climate classification system. The region experiences dry months annually, with rainfall falling below 60 mm for two to six months. The average number of rainy days was 80 annually between October and April, with an average rainfall of 200 mm/month.

Data and Tools

This research used primary data from field observation and secondary data from various sources. Primary data collection occurred in May-June 2023 in randomly selected 15 observation points. These include temperature, humidity, wind speed, noise level, negative ion content, sunlight intensity, and vegetation type. The sample collection across utilization, protection, collection, and traditional blocks referred to in the document on the restructuring of the Bunder GFP management blocks, outlined in the Decree of the Director General of Natural Resources and Ecosystem Conservation Number SK.57/KSDAE/RKK/KSA.0/3/2023. Over four weeks, we measured temperature and humidity by taking readings every 10 minutes for 24 hours. Other physical environment parameters were measured 10 times with three repetitions at intervals during the morning, afternoon, and evening under sunny weather conditions.

The secondary data includes administrative maps of Gunungkidul Regency (scale 1:25,000), DEMNAS data, and Landsat 8 and 9 imageries (path 120 row 065) recorded on April 22, 2022. Additional resources included the GFP Bunder area map 2023, the Bunder GFP Flora and Fauna Inventory Report, and the Long-Term Plan for Area Development and Management. The measurement instruments were temperature and humidity data loggers (Elitech RC-4HC), digital hand sound level meters (Uni-T UT 353), digital hand anemometers (Uni-T UT 363), digital hand lux meters (Uni-T UT 383), air ion tester K401, smartphones, tally sheets, stationery, and laptops equipped with Quantum GIS software and Microsoft Office.

Analysis

Vegetation Density

The standard Normalized Difference Vegetation Index (NDVI) method was applied to analyze the vegetation density levels, using Landsat 8 and 9 satellite imageries recorded on April 22, 2022. The NDVI values range from -1, representing non-vegetation, to 1, showing vegetation objects. According to the Ministry of Forestry (2003), the NDVI values -1 to 0.32, 0.32 to 0.42, and 0.42 to 1 signified sparse, medium, and high density, respectively. The NDVI calculation used Equation 1 (Huete et al. 2002; Li et al. 2021).

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad \text{......} \quad (1)$$

Description:
NDVI = vegetation density index value
NIR = value of near-infrared spectral channel
RED = value of red spectral channel

Slope

Land slope level data was processed using DEM data analyzed by Quantum GIS software (Figure 1). The slope was classified using Arsyad (2010) classification, as depicted in Table 1.

Figure 1. DEMNAS data processing process

Table 1. Slope classification based on slope angle

Slope classification	Slope gradient (%)
Flat	≤3
Gentle/wavy	4-7
Slightly sloping/wavy	8-15
Sloping/hilly	16-30
Slightly steep/mountainous	31-45
Steep	46-65
Very steep	>65

Source: Arsyad (2010)

Noise Level, Wind Speed, Sunlight Intensity, Negative Ion Content

Measurements of noise levels, wind speed, light intensity, and negative ion content were conducted at the following times: 7—9 am (morning), 11 am—1 pm (afternoon), and 3—5 pm (evening). These observations adhered to the area's operational hours and were carried out exclusively on sunny days. A total of 10 observations were recorded for each time slot, conducted three times throughout the study period. The average measurements for wind speed, light intensity, noise level, and harmful ion content will be compared to standard wind speed values in a healing forest environment, as detailed in SNI 9006:2021. The determination in the healing forest environmental criteria followed SNI 9006:2021, as presented in Table 2.

Temperature and Humidity

This research calculated and classified the level of environmental thermal comfort in tropical climates using the Thermal Comfort Index (THI) formula proposed by Nieuwolt (1975) in Equation 2 and Table 3.

$$THI = 0{,}8\,T + \left\{ \frac{(RH \times T)}{500} \right\} \qquad (2)$$

Description:
THI = *Thermal Humidity Index*
RH = Relative humidity (%)
T = Air temperature (°C)

Flora and Fauna

This research employed a counting method to analyze the flora and fauna data from secondary sources and field verification in the research area.

Nature and Artificial Objects

Natural interpretation is an art that involves area managers elucidating the state of the environment to visitors, encompassing aspects such as flora, fauna, geological processes, and both biotic and abiotic factors. The aim is to inspire innovation and encourage thoughtful engagement, enabling visitors to become more aware, educated, and motivated to participate in environmental protection or further explore ecological topics (Rachmawati et al. 2021). This research investigated physical objects as interpretive elements for healing forests by examining flora and fauna surrounding designated observation points, conducting literature reviews of previous studies, and performing field validations to assess the current condition of these objects.

Results and Discussion

Vegetation Density

The vegetation index, determined using a mathematical combination of red and NIR (Near-Infrared Radiation) channels, indicated vegetation health by representing the level of greenness. Active photosynthetics reflected near-infrared wavelengths and absorbed most of the red wavelengths of sunlight. In contrast, dead or stressed vegetation (less healthy)

Table 2. Forest environmental criteria for health therapy

Criteria	Description
Vegetation density	Medium to dense density
Temperature and relative humidity	Provides a comfortable effect for the body. Temperature ranges from ± 10% of the standard temperature above sea level (asl)
Slope level	0% to 15% (flat to sloping)
Noise	< 50 dB
Wind speed	< 1 m/s
Negative ion content in the air	>1.000 ion/cm^3

Source: SNI 9006:2021

Table 3. Classification of comfort based on THI

THI (°C)	Comfort level classification
< 27°C	Comfortable
27-29 °C	Somewhat uncomfortable
> 29 °C	Uncomfortable

Source: Nieuwolt, 1975

reflected less near-infrared wavelengths and absorbed less infrared wavelengths (Lillesand & Kiefer 1997; Prasetyo et al. 2016). The NDVI values of Bunder GFP ranged between 0.0199 and 0.4661, indicating low to high vegetation density (Figure 2). The size of the medium to high-density area was 576.18 ha, or around 90.87% of the area, while the low-density area was 57.92 ha. This result is in line with the results of Panuntun (2022), where the Bunder GFP area was dominated by moderate to dense vegetation index values. The Flora Inventory in 2021 indicated that cajuput (*Melaleuca leucadendron* L.) species dominated the sapling and pole levels, while cajuput (*Melaleuca leucadendron* L.), mahogany (*Swietenia mahagoni*), acacia (*Acacia* sp.), and teak (*Tectona grandis*) species dominated the tree level.

Slope

The SNI 9006:2021 required flat to gentle slopes (0-15%) for *healing forests*. Around 291.86 ha, or 46.03% of Bunder GFP, met the requirement, while 43.97% featured unsuitable slopes ranging from moderately sloping to steep (Figure 3). Bunder GFP is part of the Batur Agung Mountains and has a karst geomorphology.

Temperature and Humidity

Elevation, or altitude above sea level, is the most significant climate-controlling factor in tropical regions, particularly rainfall and air temperature (Lesik et al. 2020). Altitude influences the variation in air temperature in Indonesia. The average altitude of the Bunder GFP area is 180 meters above sea level, and the altitude of the Special Region of Yogyakarta (DIY) is 115 meters above sea level. The average temperature in DIY in May 2023 is 26.6°C with a humidity of 40-95% (Badan Perencanaan dan Pembangunan Daerah Istimewa Yogyakarta, 2023). According to SNI 9006:2021, a comfortable body temperature effect ranges from ± 10% of the standard temperature above sea level. In the Bunder GFP area, the standard comfort temperature is 27 ± 2.7 °C, which means the comfortable temperature range is between 24.3 °C and 29.7 °C. The average daily temperature in the Bunder GFP area exhibited a relatively stable pattern, ranging from 24.1ºC to 27.7ºC. This daily variation is considered

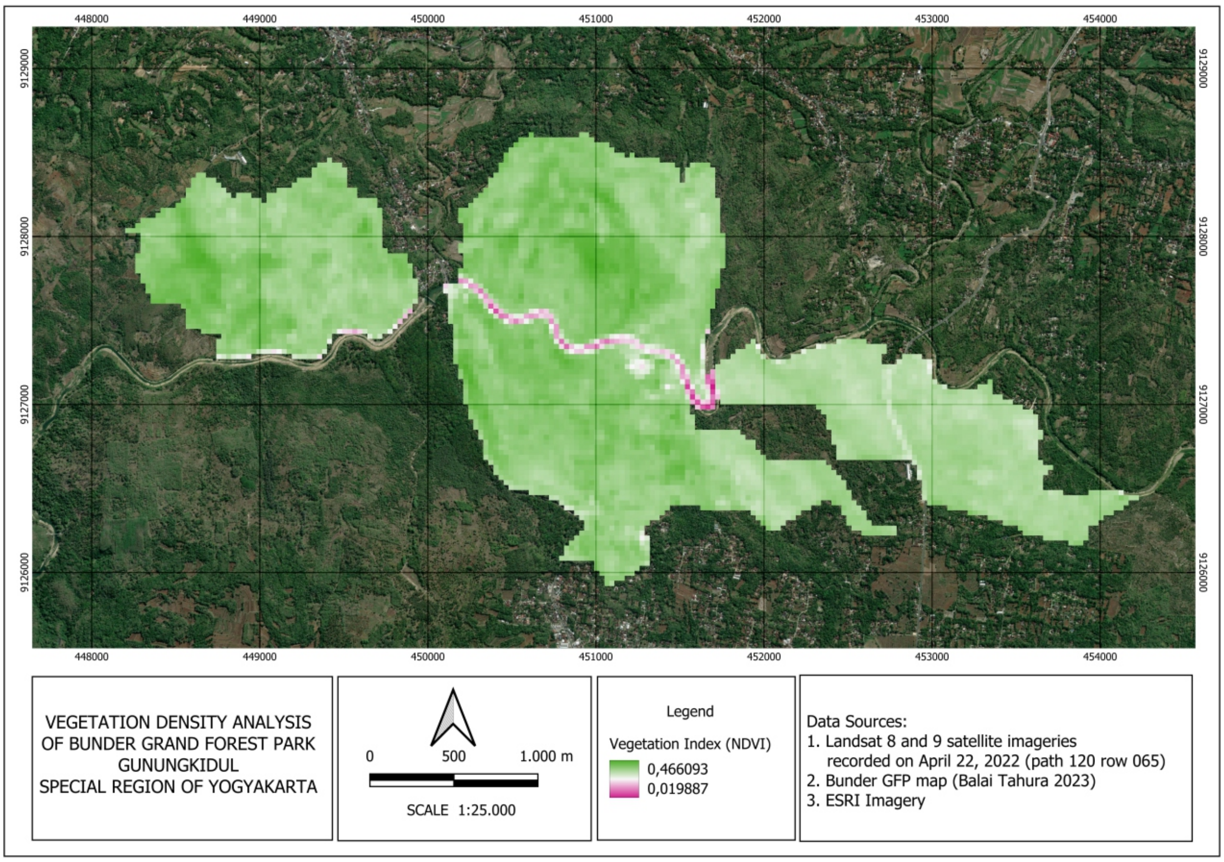

Figure 2. Distribution of NDVI in the Bunder Grand Forest Park (source: Landsat Image Analysis)

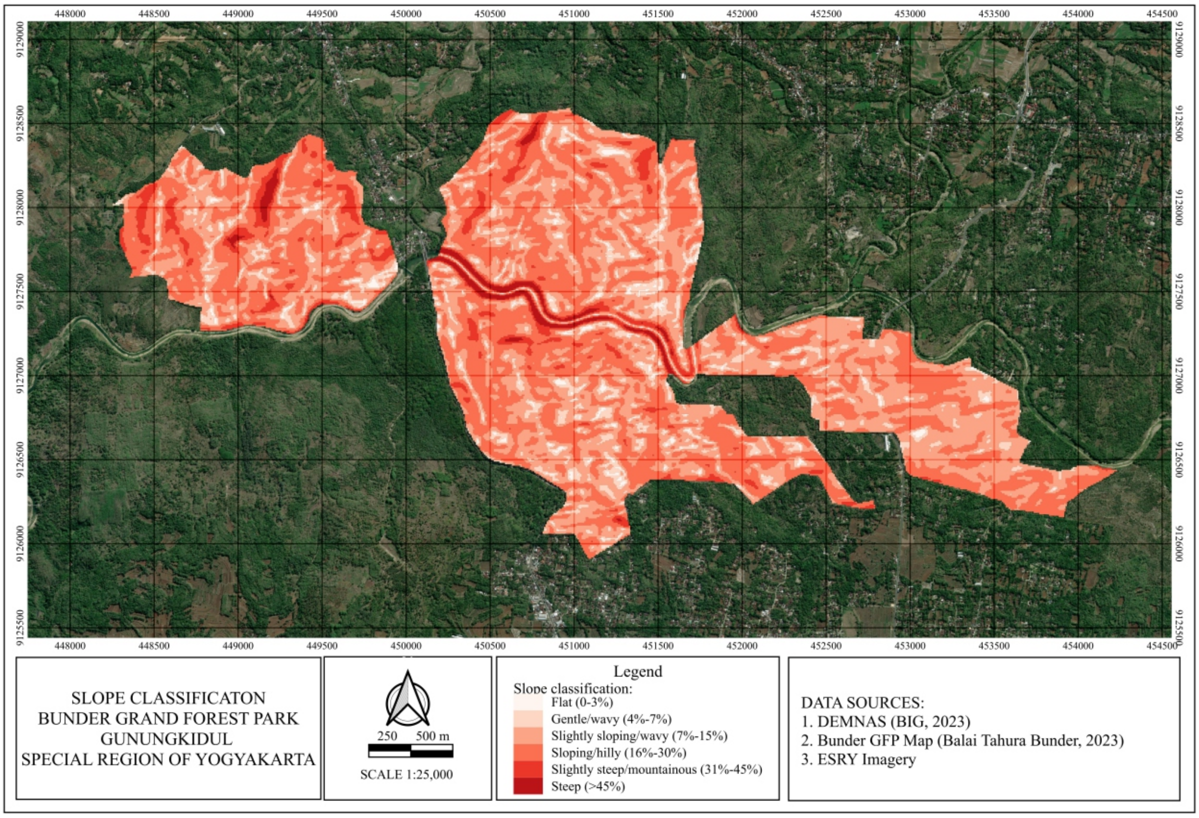

Figure 3. Slope classification of the Bunder Grand Forest Park area (source DEMNAS Analysis)

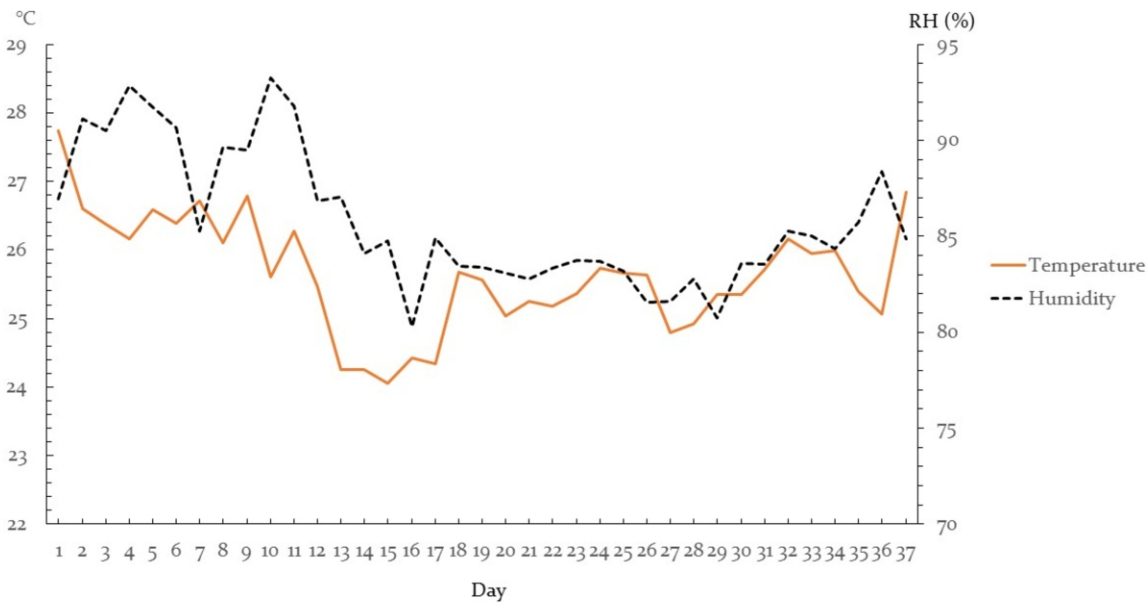

Figure 4. Observed average temperature and humidity in Bunder Grand Forest Park

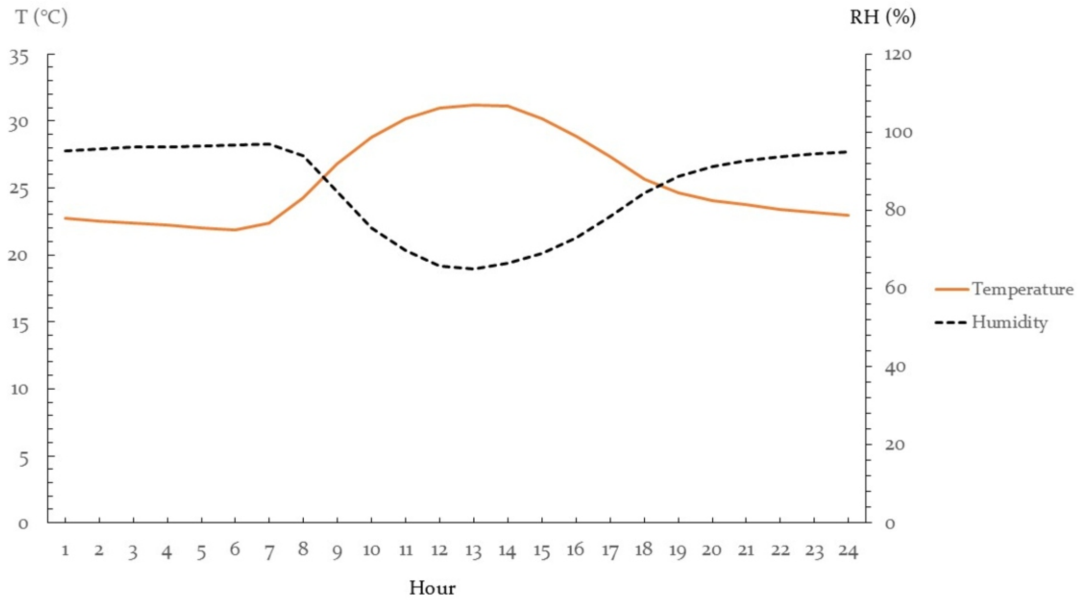

Figure 5. Observed average temperature and humidity fluctuations within 24 hours in Bunder Grand Forest Park

optimal for thermal comfort in tropical regions. The daily relative humidity in the Bunder GFP area varied significantly, ranging from 80.3% to 93.3% (Figure 4). Typically, lower temperatures are recorded in the morning, gradually increasing throughout the day to a peak of 31.2ºC at noon before declining in the afternoon. Humidity levels also fluctuate throughout the day, with peaks in the morning and afternoon. The lowest recorded humidity, 65.1%, occurred at noon (Figure 5). These observations aligned with Wiweka (2014), who indicated that maximum temperatures are reached during the day due to the highest intensity of sunlight, particularly when sunlight strikes perpendicularly at noon. Gases and particles in the atmosphere effectively absorb most solar radiation, increasing air temperature as they capture light energy. Furthermore, energy exchange within the atmosphere significantly influences air temperature (Anuar & Karyati 2019). As sunlight intensifies throughout the day, the resulting increase in air temperature contributes to a reduction in relative water content.

Noise Level

The highest average noise levels recorded were between 49.6 and 54.3 dB in the morning, which then decreased to a range of 49.0 to 54.1 dB during the day. The lowest noise levels occurred in the afternoon, registering between 47.2 and 53.0 dB, as illustrated in Figure 6. The collection block exhibited the highest average noise level at 53.8 dB. In contrast, the utilization, protection, and traditional blocks maintained noise levels that adhered to the SNI 9006 2021 standards, ranging from 49.3 to 50.0 dB. The noise levels in the Bunder GFP showed significant variability; while the central region remained within acceptable limits, the edges of the area exceeded the threshold. The composition of vegetation in the forests plays a crucial role in determining the noise level and enhancing comfort by absorbing and blocking sound (Putra et al. 2018). Factors such as vegetation type, density, lushness, location, and sound frequency influence the capacity for noise reduction. Trees absorb sound waves through their leaves, branches, and twigs. Notably, plants with thick canopies and broad leaves are particularly effective at sound reduction, with absorption rates reaching up to 95%. Furthermore, combining broadleaf trees or a mix of broadleaf and coniferous trees should have a minimum density of 0.25 trees per m^2, significantly reducing noise levels (Defrance et al. 2021). This finding aligned with Dzhambov et al. (2018), who revealed that areas with higher vegetation density experience lower noise disturbances. Instead, the larger spacing between trees can diminish their noise-reducing ability (Zhao et al. 2021).

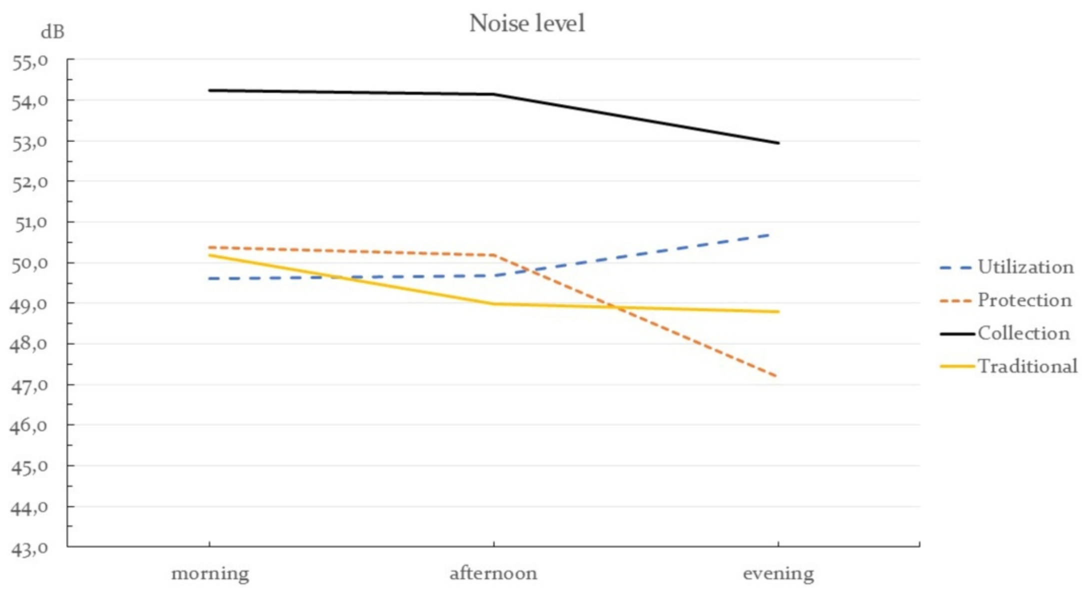

Figure 6. Observed average noise levels in Bunder Grand Forest Park

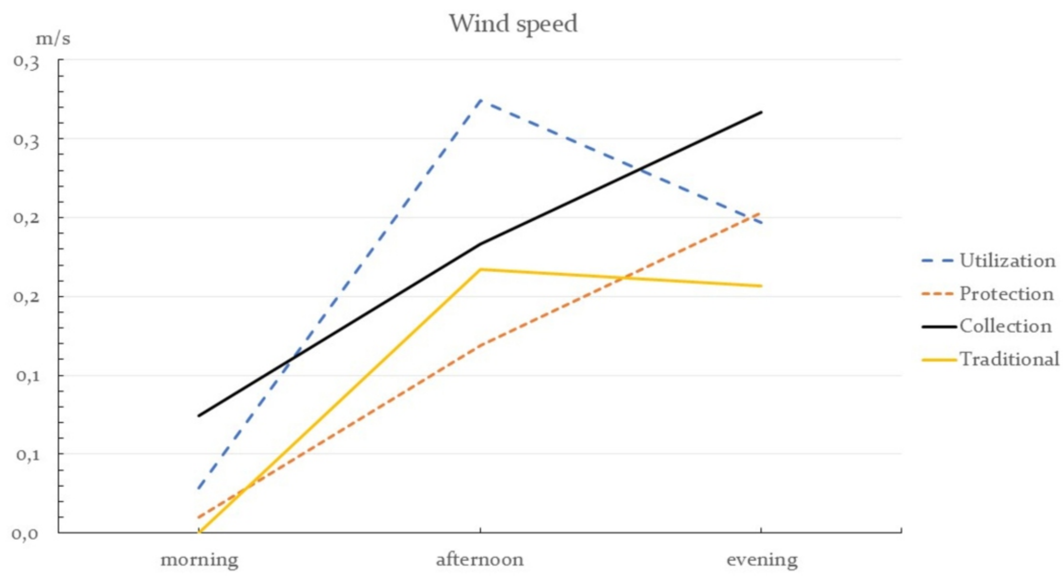

Figure 7. Observed average wind speed in Bunder Grand Forest Park

Cajuput (*Melaleuca leucadendron* L.) species were prevalent at the pole and stake levels. In contrast, cajuput (*Melaleuca leucadendron* L.), mahogany (*Swietenia mahagoni*), acacia (*Acacia* sp.), and teak (*Tectona grandis*) dominated the tree level. The cajuput (*Melaleuca leucadendron* L.) species featured narrow leaf areas with thin leaves, facilitating sound energy transmission. The Bunder GFP is situated along the main Yogyakarta – Wonosari road and is directly adjacent to community settlements, elevating noise levels due to vehicle traffic during peak mobility hours. The natural sounds from the nearby river and rustling leaves also contributed to the noise. The presence of animals, such as chirping birds, insects, and deer (*Rusa timorensis*), also increased the noise levels in the Bunder GFP area.

Wind Speed

The highest average wind speed in the Bunder GFP area occurred from day to evening, averaging 0.2 m/s. The speeds across all blocks tended to increase during the day, with the highest recorded in the utilization

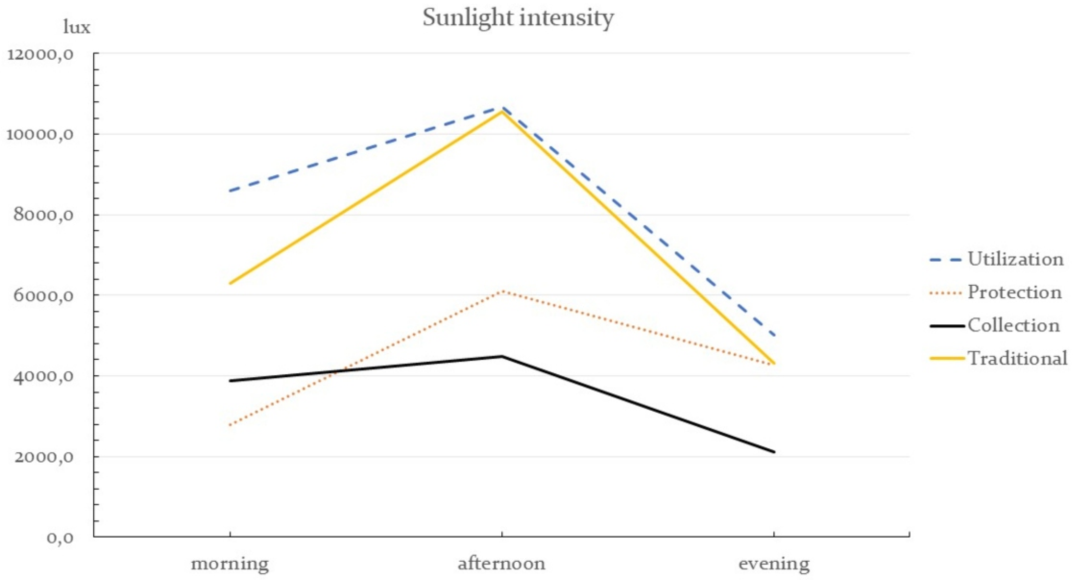

Figure 8. Observed average sunlight intensity in Bunder Grand Forest Park

block due to its location in the adjacent Oyo River, where vegetation density was low, intensifying wind gusts (Figure 7). With this average wind speed, the Bunder GFP area met the biophysical criteria of a *healing forest* environment according to SNI 9006:2001, which set a wind speed of <1 m/second.

Sunlight Intensity

The utilization block exhibited the highest average light intensity, ranging from 5,027 to 10,681 lux, whereas the collection block recorded the lowest intensity, falling between 2,102 and 3,887 lux (Figure 8). Sunlight intensity typically increases throughout the day and diminishes in the afternoon. Topography, slope, and aspect significantly influence the daily microclimate. Uneven land surfaces heighten variations in the microclimate both spatially and temporally. The configuration of slopes and aspects determines the angle at which sunlight strikes the terrain. As a result, uneven terrain varies in the amount of radiation it receives, leading to temporal differences. Areas with aspects oriented towards incoming sunlight generally absorb more radiation. This variation in received light energy results in differences in emitted energy and thermal flux within forest ecosystems. Theoretically, forests with undulating topography possess a more diverse microclimate than those with flat terrain (Medellu 2012).

Negative Ion Content

The highest average concentration of negative ions in Bunder GFP was observed during the day, ranging from 27,250 to 44,583 ions/cm^3. The concentrations in the morning and afternoon were 21,667 to 34,883 ions/cm^3 and 18,750 to 23,208 ions/cm^3, respectively (Figure 9). The utilization block recorded the highest peak of negative ion content at 39,708 ions/cm^3, while the collection block had the lowest value at 24,458 ions/cm^3. The negative ion levels in Bunder GFP exceeded the threshold of >1,000 ions/cm^3 specified in SNI 9006:2021. Negative ions are known to benefit air quality and human health.

The interaction of water, air, sunlight, and Earth's radiation forms negative air ions increased during the day and decreased in the afternoon (Ulfa & Muslimin 2022; Pan et al. 2011; Zhang et al. 2016). Temperature and humidity had a positive correlation and significantly influenced the concentration of negative ions. Notably, the levels of negative ions rose considerably within the temperature range of 30ºC to 40ºC (Li et al. 2022), peaking at 78.8% humidity (Pan et al. 2012). Higher temperatures increase atomic and molecular motion, resulting in more collisions and the ionization of negative air ions (Miao et al. 2018).

In addition to temperature and humidity, vegetation significantly affects the concentration of negative ions in the air. According to Feng et al. (2023)

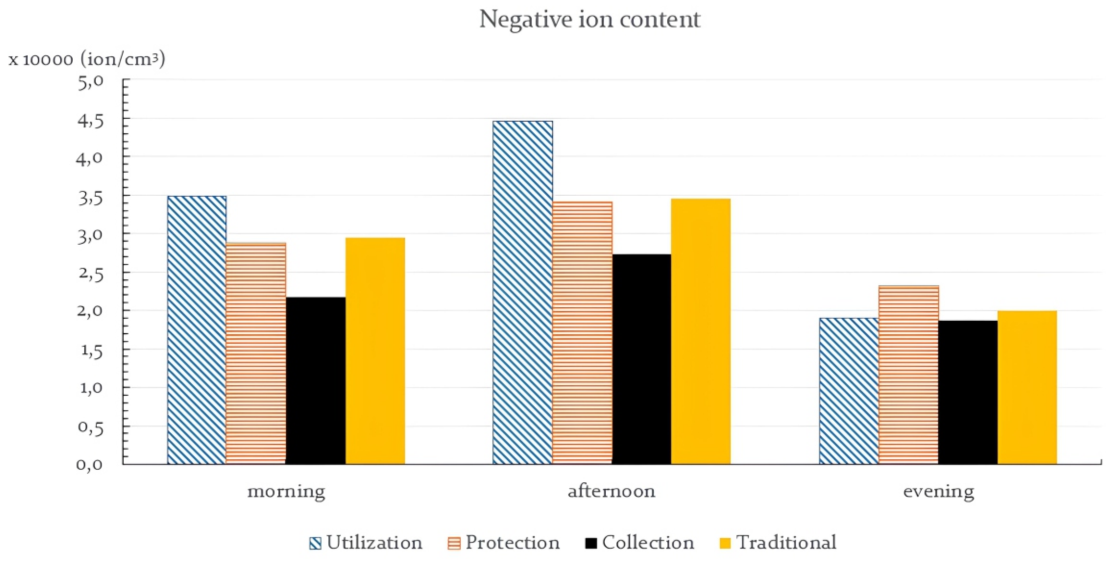

Figure 9. Observed negative ion content in Bunder Grand Forest Park

deciduous trees have greater water transport efficiency and photosynthetic capacity. Thus, they have a greater potential to produce negative ions in the air, which greatly impacts ecological health. Moreover, the type of tree-shrub-herb community also demonstrated lower levels of atmospheric air particles and higher concentrations of negative air ions compared to other plant communities. The Bunder GFP area exhibited moderate vegetation diversity, ranging from shrubs to trees. Specifically, plots 11, 19, 21, and 22 recorded moderate diversity values, while plots 15, 23, and 24 displayed lower diversity at the pole level. Additionally, plot 15 was noted for its low diversity at the tree level (Balai Tahura 2021).

Thermal Comfort Level

The thermal comfort level reflects the heat effects of the interaction between temperature and humidity. This research calculated the THI comfort index using each block's average temperature and humidity data. The results indicated that the Bunder GFP area experienced thermal comfort levels ranging from comfortable to uncomfortable (see Table 4). In the morning, the THI fell within the comfortable range, with an index of 26.1-26.6. However, during the day, it rose to an uncomfortable level, reaching 29.8-31.0, while offering partial comfort in the afternoon with an index of 27.4-28.5. Temperature (T) and relative humidity (RH) are key factors influencing thermal comfort in an area (Nieuwolt 1975). In the morning, the average daily air temperature and humidity in the Bunder GFP area were 27.3°C and 81.4%, respectively. These values increased to 33.2°C and 59.2% RH during the day, then dropped to 29.8°C and 68.3% RH in the afternoon. An increase of 5°C, notably exceeding 31°C, resulted in discomfort, categorizing the microclimate as very hot during the day (Fitriani et al., 2016).

Table 4 presents the THI values for all blocks within the Bunder GFP area, indicating a partially comfortable range, with averages ranging from 27.8 to 28.6. This data reveals that while some areas of Bunder GFP experienced uncomfortable thermal conditions, others maintained a more comfortable environment. Fluctuating air temperatures throughout the region largely determine the variation in thermal comfort. For human comfort in low-latitude areas, optimal temperatures are between 24-28°C with relative humidity levels of 40-60% (Sulistyana et al. 2017). The forest structure, characterized by woody vegetation, was inadequate in regulating the microclimate to sustain these comfortable conditions. The area predominantly comprises diverse tree species, with Cajuput (*Melaleuca leucadendron* L.) being the most prevalent. The narrow leaves and short crowns of cajuput (*Melaleuca leucadendron* L.) trees aid in solar radiation absorption, slightly reducing air temperatures. However, with an open canopy and moderate vegetation density (vegetation index of

Table 4. Temperature Humidity Index (THI) in the Bunder Grand Forest Park

Block	Time	THI factors		THI	Criteria*
		T (°C)	RH (%)		
Utilization	Morning	27,5	82,5	26,6	Comfortable
	Afternoon	33,4	58,4	30,6	Uncomfortable
	Evening	30,0	67,5	28,1	Partially comfortable
	Average	**29,6**	**72,9**	**28,4**	**Partially comfortable**
Protection	Morning	27,5	80,5	26,4	Comfortable
	Afternoon	33,0	59,9	30,4	Uncomfortable
	Evening	29,4	69,0	27,6	Partially comfortable
	Average	**29,4**	**72,5**	**28,1**	**Partially comfortable**
Collection	Morning	27,1	82,9	26,1	Comfortable
	Afternoon	34,0	62,8	29,8	Uncomfortable
	Evening	29,1	70,8	27,4	Partially comfortable
	Average	**29,1**	**74,8**	**27,8**	**Partially comfortable**
Traditional	Morning	27,3	79,4	26,2	Comfortable
	Afternoon	34,0	55,7	31,0	Uncomfortable
	Evening	30,6	65,8	28,5	Partially comfortable
	Average	**29,4**	**70,1**	**28,6**	**Partially comfortable**

Description: *) = Nieuwolt, 1975; Wati and Nasution 2018; Isnoor et al. 2021.

0.32-0.42), the cajuput (*Melaleuca leucadendron* L.) stands fail to provide adequate shade to mitigate sunlight exposure, consequently contributing to elevated air temperatures. This insufficient shading has led to a partially uncomfortable thermal environment, with temperatures of 29°C and THI values between 27 and 29.

Flora and Fauna

The cajuput (*Melaleuca leucadendron* L.) species is the dominant land cover in the Bunder GFP area. Notable dominance at the tree level was recorded in plots 11, 15, 21, and 24, while the sapling level prevailed in plots 19, 22, and 23 (Balai Tahura 2021). As a member of the Myrtaceae family, cajuput (*Melaleuca leucadendron* L.) is an aromatic plant that yields oil with potential medicinal applications. Among the 32 active compounds identified in the leaves, seven primary components include cineole (26.28%), α-terpineol (9.77%), caryophyllene (3.38%), andelemol (3.14%), α-caryophyllene (2.76%), Ledol (2.27%) andα-pinene (1.23%), (Joen 2020). Being an evergreen species, cajuput (*Melaleuca leucadendron* L.) emits aromatic phytoncides that promote healing within forest environments. Phytoncides are natural compounds released by plants to defend against bacteria, insects, and fungi, acting as natural deterrents. These substances facilitate plant communication and influence their interactions with humans (Li 2018). According to the 2021 Flora Inventory Data from Balai Bunder GFP, 118 plant species were identified, with cajuput (*Melaleuca leucadendron* L.) dominating each block. Table 5 presents a selection of plants observed across 15 sampling points. Additionally, field observations revealed various fauna, including jungle fowl (*Gallus gallus*), leaf snakes (*Ahaetulla prasina*), monitor lizards (*Varanus sp*.), and numerous birds such as gemak (*Turnix suscitator)*, turtle doves (*Streptopelia chinensis*), cekakak (*Halcyon cyanoventris*), and srigunting (*Dicrucus leucogastra)*. Bunder GFP exhibits significant wildlife diversity, with approximately 46 animal species documented in the area, encompassing 37 bird species and nine reptiles, mammals, and butterflies (Balai Tahura 2021).

Natural and Artificial Objects

Interpretation objects were crucial in ensuring visitors received adequate information to engage in safe and effective activities. Their presence enhanced the overall experience and mitigated the impact on natural resources. In the healing forest, these interpretation objects served as a bridge between humans and nature, encompassing natural elements (flora and fauna) and artificial components. This research identified various interpretation objects, including natural features from forest ecosystems such as rivers, karst rocks, landscapes, and artificial structures (see Figures 10-15). The rivers identified include the Oyo River, which runs alongside plots 23,

Table 5. Plants identified in the research area

No.	Local name	Scientific name	No.	Local name	Scientific name
1	Acacia	*Acacia auriculiformis*	20	Lo	*Ficus glomerata* Roxb
2	Awar-awar	*Ficus septica/Ficus religiusa*	21	Mahogany	*Swietenia mahagoni*
3	Bintaro	*Cerbera manghas*	22	Mahogany	*Swietenia mahagoni*
4	Bulu	*Ficus elasticus*	23	Mangium	*Acacia mangium*
5	Catechu	*Acacia decurrens*	24	Munggur	*Samanea saman*
6	Sandalwood	*Santalum album*	25	Nyamplung	*Calophyllum inophyllum*
7	Ebony	*Diospyros celebica*	26	Podocarpus	*Podocarpus imbricatus*
8	Ficus	*Ficus sp.*	27	Pulai	*Alstonia scholaris*
9	Flamboyan	*Delonix regia*	28	Pulai legaran	*Alstonia spectabilis R.Br*
10	Gamal	*Glirisidae sp*	29	Randu alas	*Bombax ceiba L*
11	Gayam	*Inocarpus fagifer*	30	Rempeni	*Ardisia elliptica*
12	Ilat-ilatan	*Ficus callosa*	31	Sawo beludru	*Chrysophyllum caimito*
13	Jabon	*Anthocephalus cadamba*	32	Sawo kecik	*Manilkara kauki*
14	Guava	*Eugenia aduea*	33	Secang	*Caesalpinia sappan*
15	Dersono Guava	*Syzygium malaccense*	34	Sonokeling	*Dalbergia pinnata*
16	Jati	*Tectona grandis*	35	Suren	*Toona sureni*
17	Johar	*Cassia siamea*	36	Tanjung	*Mimusops elengi*
18	Kayuputih	*Melaleuca Leucadendron L.*	37	Walikukun	*Schoutenia ovata* Korth
19	Kemiri	*Aleuritus moluccana*	38	Waru	*Hibiscus tiliaceus*

Source: Field data, 2023

(a) (b)

Figure 10. The natural object of the Oyo River in the protection block of plot 23 (**a**) and the utilization block of plot 15 (**b**)

(a) (b)

Figure 11. The Ancient Mountains landscape as seen from the protection block of plot 21

(a) (b) (c)

Figure 12. The appearance of the natural object Watu Payung in the protection block of plot 11 (**a**), Watu Sipat in the protection block of plot 22 (**b**), and Natural Rock in the collection block of plot 19 (**c**)

(a) (b) (c)

Figure 13. The natural object of the tributary (Watu Sipat) in the protection block of plot 22 (**a**); seasonal river flow in the protection block of plot 23 (**b**) and utilization block of plot 19 (**c**)

(a) (b)

Figure 14. The facilities and infrastructures in the form of a work hut and toilet in the utilization block of plot 15 (**a**) and a monitoring gazebo in the protection block of plot 21 (**b**)

(a) (b)

Figure 15. The camping ground (**a**) and outbound area (**b**) in protection block 19

19, and 15, and tributaries found on plot 22 and seasonal river flows on plots 19 and 23. The karst rocks featured the Watu Payung karst in Plot 11, the floor karst rocks in Plots 19 and 21, and Watu Sipat in Plot 22. The landscape elements comprise the hilly terrain in plots 11, 20, and 21, the ancient mountain landscape visible in the northern part of plot 21, and the Oyo River, as seen in plot 15. The artificial structures include a camping ground, an outbound area, a gazebo, a work hut, and the Sendang Mole Cajuput oil factory.

Conclusion

In conclusion, the Bunder GFP area generally satisfies the biophysical criteria for a healing forest environment conducive to health maintenance. It features characteristics such as flat to gentle slopes, moderate vegetation density, temperatures ranging from 24.1 to 31.2 ºC, relative humidity between 65.1 and 93.3%, noise levels of 48.9 to 51.7 dB, wind speeds of 0 to 0.2 m/s, and ion content varying from 18,917 to 41,683 ions/cm³ made the area as partially comfortable, with visitors experiencing optimal comfort in the morning hours. The utilization block could serve as a location focused on health maintenance or a preservative healing forest by considering the suitability of its biophysical potential. To enhance the thermal comfort and uniqueness of the Bunder GFP area, the manager should consider enriching the vegetation, selecting natural interpretation objects, and modifying existing infrastructure. The distinct biophysical characteristics of this healing forest environment can effectively stimulate the senses of touch, smell, sight, and hearing. Natural features such as the waters from the Oyo River, karst rocks, mixed forest vegetation, and aromatic cajuput (*Melaleuca leucadendron* L.) plants can evoke these sensory responses. This research also recommends further investigation into how the environmental characteristics of healing forests impact the health responses of Bunder GFP visitors through various therapeutic activities. Developing the healing forest will require a well-considered site plan to align with the area's management objectives.

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