Vol. 12(2): 258-278, May 2024

DOI: https://doi.org/10.23960/jsl.v12i2.829

Jurnal Sylva Lestari

P-ISSN: 2339-0913
E-ISSN: 2549-5747

Journal homepage: https://sylvalestari.fp.unila.ac.id

Full Length Research Article

Microclimate Impacts of Land Cover Types in Halu Oleo University Botanical Garden and Its Surroundings

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ARTICLE HISTORY:

Received: 16 October 2023
Peer review completed: 29 January 2024
Received in revised form: 26 February 2024
Accepted: 1 March 2024

KEYWORDS:

Botanical garden
Microclimate
Settlement
Temperature humidity index
Vegetation

ABSTRACT

Halu Oleo University (UHO) Botanical Garden is one of the green open spaces that contribute to maintaining climate stability and environmental comfort in Kendari City, along with the high land use change due to increased population and city progress. The study aimed to determine the effect of land cover types on microclimate in UHO Botanical Garden and its surroundings. The research was conducted from June 2021 to January 2022. The research was conducted on three types of vegetation land cover. The variables measured were microclimate, including light intensity, temperature, relative humidity, and temperature humidity index. Measurements were conducted in the morning, afternoon, and evening. The method used was descriptive quantitative and statistical analysis using the analysis of variance and the least significant difference (LSD) test. The results showed that the microclimatic conditions of UHO Botanical Garden in tree-dominant land cover are more comfortable and significantly different from grass-dominant and settlement-dominant, but they are not significantly different between grass-dominant and settlement-dominant. This fact indicates the importance of the conservation of tree vegetation and the need for supervision so that there is no diversion of functions into settlements to maintain the preservation and sustainability of UHO Botanical Garden as one of the green open spaces that control climate stability and environmental comfort in Kendari City.

1. Introduction

Global warming and climate change are two phenomena of serious concern to all parties, along with the increasing population, land use change, and the greenhouse gas effect (Barati et al. 2023; Manik and Timotiwu 2022). The growing population causes the need for land to increase for settlements and facilities to support economic activities, which directly triggers a decrease in the quantity of vegetation cover and indirectly disrupts ecosystem stability, especially climatic and soil conditions, and environmental comfort (Ata et al. 2021; Herrmann et al. 2020). According to Mortei et al. (2023), converting agricultural land, forests, grasslands, and shrubs is the main land cover change affecting climate. This is relevant to the statement of Masitoh and Rusydi (2020) and Sy and Quesada (2020) that land use and land cover change cause significant impacts on ecosystem change and further change regional climate on a regional and global scale. Likewise, Nirwani et al. (2023) and Sun et al. (2023) believed that any change in land function, no matter how small, can cause changes in microclimate conditions. It is further argued that changes in the microclimate from various places will affect the formation of the climate at large (macro). Besides that, it also impacts the surrounding environment as a determining factor in the life of organisms, mainly vegetation, animals, and humans. Vegetation has an essential role in maintaining the stability of the global ecosystem, and it is closely related to climate and soil conditions and the level of comfort in the ecosystem (Imran et al. 2022; Wahyuni et al. 2020).

Kandari et al. (2019) stated that the naturally designed trilogy relationship between vegetation, climate, and soil can be disrupted due to improper management. It is further argued that climate not only affects plants, but the climate is also affected by the presence of vegetation. Kandari et al. (2020) stated that climatic conditions affect the type and growth of vegetation that grows in a place where the influence of climate is much stronger than that of soil under certain conditions. This opinion aligns with Rodrigues et al. (2018), who explained that the same soil shows a much different vegetation type due to various climatic conditions.

Land use and cover change affect surface temperature (Gogoi et al. 2019). This opinion aligns with Karyati et al. (2020) and Masitoh and Rusydi (2020) that land cover type affects microclimate conditions, namely the climate in a minimal space. Ambarwati et al. (2023) stated that the presence of vegetation has a role as a regulator of microclimate, namely reducing surface temperature, which directly affects the distribution of air temperature. Haesen et al. (2021) stated that microclimate is a climate in the air layer near the earth's surface with a height of ± 2 m, where in this area, the air movement is more minor because the earth's surface is rough and the temperature difference is significant. Mala et al. (2018) stated that the elements affecting a GOS's microclimate are light intensity, crown density, air temperature, relative humidity (RH), and wind speed.

One form of green open space in urban areas is a botanical garden. According to Presidential Regulation Number 83 of 2023, a botanical garden is an ex-situ plant conservation area that has documented plant collections and is organized based on taxonomic classification patterns, bioregions, thematic, or a combination of these patterns for conservation, research, education, tourism, and environmental services. Botanical gardens can also play a role in supporting communities in adapting to global climate change (Horotán et al. 2023; USBG 2023). On the other hand, there is still a lack of awareness regarding the relationship between botanical gardens and climate mitigation (Akinyoyenu et al. 2017; Rahayu and Yusri 2021).

Efforts to mitigate climate change, namely reducing greenhouse gas emissions, can be carried out, among others, by utilizing trees in urban areas, which have an essential role as carbon sinks (Agonafir and Worku 2017; Heriyanto et al. 2023). Abbas et al. (2022) suggested that RH can also educate the general public about the impacts of climate change and how to mitigate and adapt to climate change. Xiao et al. (2018) stated that more research has been conducted on the role of urban green spaces in addressing climate impacts, especially on temperature increase.

UHO Botanical Garden is one of 34 botanical gardens in Indonesia, established through the Decree of the Head of the Indonesian Institute of Sciences (LIPI) Number B-3439/K/KS/IV/2015, covering 22.8 ha consisting of secondary forest of 18 ha, wetlands of 3 ha, and an arboretum of 1 ha. UHO Botanical Garden is one of the green open spaces in Kendari City. Its existence contributes to conservation activities while playing a role in ecological, socio-cultural, scientific, and technological aspects. In addition, it is an essential asset in maintaining climate stability and environmental comfort because it has a variety of tree vegetation within the botanical garden and its surroundings (Kandari et al. 2021; Nurdin 2021). Environmental climate or microclimate factors play a role in the comfort level of an environment (Abraham and Ariffin 2021; Hermawan et al. 2018).

Rania et al. (2023) stated that changes in the physical condition of the environment will impact changes in temperature and thermal comfort of an urban area. According to Noor et al. (2018) and Permatasari et al. (2024), comfort is a term used to express the influence of the physical environment of the atmosphere on humans. Solaimani (2024) stated that the Temperature Humidity Index (THI) method could assess an area's comfort level, especially in tropical regions. According to Nirwani et al. (2023). THI is determined based on the value of air temperature and RH, where the higher the air temperature and the lower the RH, the more uncomfortable the environment. Ornelas et al. (2023) stated that the comfort interval is 21–26°C, where areas with THI values of more than 26°C are considered uncomfortable for the human population.

In general, many have conducted research at UHO Botanical Garden. Still, those that examine land cover associated with microclimate characteristics with in-depth and detailed analysis do not yet exist. This is very important because the UHO Botanical Garden is a buffer for the campus. Generally, the city of Kendari from land use change to increase the comfort of the campus and the city of Kendari, which is getting hotter due to global warming and climate change triggered by the rapid development of the campus and the city of Kendari and an increase in the population of both students and the general public.

Based on this and various descriptions that have been stated, this research is essential to carry out. The research aims to study and determine the influence and differences in microclimate characteristics and environmental comfort categories in three land cover types at UHO Botanical Garden and its surroundings. The expected benefits can be a driver of awareness of the importance of conservation to maintain the existence of vegetation in UHO Botanical Garden.

2. Materials and Methods

2.1. Study Area

The research was conducted at UHO Botanical Garden, Kambu Village, Kambu District, Kendari City, with a geographical position of 04°00'24"-04°00'58" N and 112°31'02"-122°32'21" E and 26 mdpl. UHO Botanical Garden has an area of 22.82 ha covering three parts: secondary forest of 18.37 ha, wetland of 3.43 ha, and arboretum of 1.02 ha. The research site includes 3 (three) types of land cover, namely: (1) tree-dominant vegetation (04°00'57" N; 112°31'24" E), (2) grass-dominant vegetation (04°00'58" N; 122°31'24" E), and (3) settlement-dominant land cover (04° 00'25" N; 122° 31'02" E) (**Fig. 1**). The data collection was conducted in May–August 2021, and the data analysis was conducted in September 2021–January 2022.

2.2. *Materials*

This study was conducted on vegetated land with different cover types as the object of observation of microclimate and environmental comfort data. Materials used included expedition books, tally sheets to record and archive measurement data, including machetes, stakes, ropes used for pioneering and establishing plots and barriers, respectively, and gauge meter to measure the distance between the plots used. The geographical position of the coordinates of the sampling sites

(N, E), m above sea level, was determined using the Global Positioning System (GPS). Measuring climatic element parameters used a solar power meter for sunlight intensity, a thermo hygrometer for air temperature and relative humidity (RH), and a camera for documentation and writing instruments.

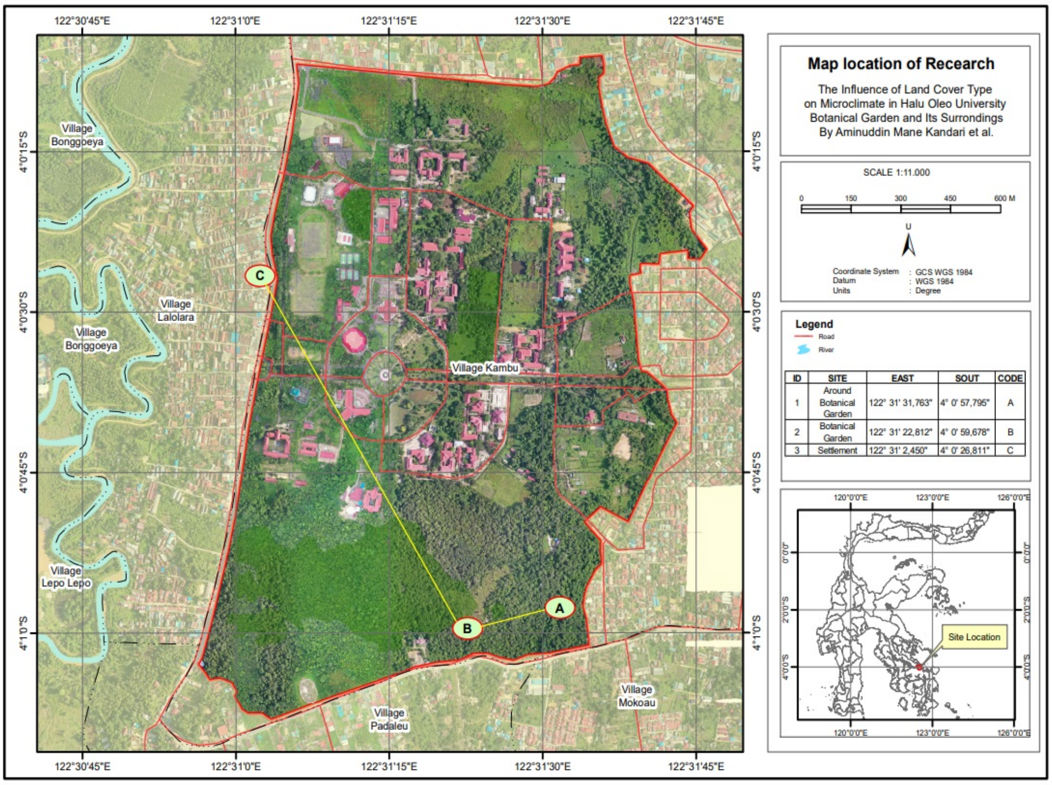

Fig. 1. Research location at UHO Botanical Garden and its surroundings.

2.3. Observation Variables

The observed variables are microclimate and environmental comfort. Microclimate variables consist of light intensity, air temperature, and RH. At the same time, the environmental comfort variables include RH, air temperature, average RH index, and Temperature Humidity Index (THI).

2.4. Data Collection Techniques

2.4.1. Measurement of microclimate variables

The microclimate variables measured consist of light intensity (Wm^{-2}), temperature (°C), and RH (%). Measurements were carried out on three types of land cover in UHO Botanical Garden and its surroundings, determined visually based on the data interpretation results: tree-dominant vegetation, grass-dominant vegetation, and settlement-dominant land cover. Measurements were carried out three times every day: morning (07.00–08.00), afternoon (12.00–13.00), and evening (16.00–17.00).

2.4.2. Calculation of environmental comfort variables

Environmental comfort variables include three parameters: air temperature index and RH index, each calculated based on average air temperature and RH, and comfort index calculated based on the Temperature Humidity Index (THI) formula.

2.5. Data Analysis

Data was analyzed to determine microclimate characteristics and environmental comfort in three land cover types at UHO Botanical Garden and its surroundings. Data was analyzed using quantitative descriptive methods and statistical analysis methods. The quantitative descriptive method is used to describe the value of each parameter in the form of tables, histograms, and graphs of microclimate variables (light intensity, air temperature, and RH) and environmental comfort variables analyzed based on the level of index values presented in **Table 1–3**. Statistical analysis to determine the influence and differences between land cover types on microclimate parameters and environmental comfort.

2.5.1. Parameters of microclimate variables

2.5.1.1. Light intensity

Light intensity data that have been tabulated, presented as a table of observations in the morning, afternoon, and evening, then analyzed to obtain the average daily value using the formula adapted by Koesmaryono and Askari (2023) according to Equation 1.

$$LIa = \frac{(LI\ morning)+(LI\ afternoon)+(LI\ evening)}{3} \quad (1)$$

where *LIa* is the daily average light intensity (Wm^{-2}), and *LI* is the light intensity (Wm^{-2}).

2.5.1.2. Air temperature

Air temperature data have been tabulated, presented as a table of observations in the morning, afternoon, and evening, and then analyzed to obtain the average daily value using Equation 2 by Koesmaryono and Askari (2023).

$$Ta = \frac{(2T\ morning)+(T\ afternoon)+(T\ evening)}{4} \quad (2)$$

where *Ta* is the air temperature daily average (^oC), and *T* is the air temperature (^oC)

2.5.1.3. Relative humidity

Data on RH in the morning, afternoon, and evening were analyzed to obtain the average daily value using Equation 3 by Koesmaryono and Askari (2023).

$$RHa = \frac{(2R\ morning)+(RH\ afternoon)+(RH\ evening)}{4} \quad (3)$$

where *RHa* is the daily average relative humidity (%) and *RH* is the relative humidity (%).

2.5.2. Environmental comfort variables

Environmental comfort was assessed based on three parameters: air temperature index, relative humidity index, and THI comfort level index.

2.5.2.1. Air temperature index

The air temperature index expresses the environment's heat and coldness, grouped into several categories based on the average air temperature (**Table 1**).

Table 1. Environmental comfort categories based on average air temperature (Karyati et al. 2021)

No	Average temperature (°C)	Comfort category
1	≤ 21	Very Cold
2	> 21 – 23	Cold
3	> 23 – 25	Slightly Cold
4	> 25 – 27	Cool
5	> 27 – 29	Slightly Hot
6	> 29 – 31	Hot
7	> 31	Very Hot

2.5.2.2. Relative humidity index

The relative humidity index expresses the environment's dry, humid, and wet conditions based on the calculation of average RH (**Table 2**).

Table 2. Environmental comfort category based on average RH (Karyati et al. 2021)

No	Daily average RH (%)	Comfort category
1	≤ 70	Dry
2	> 70 – 75	Somewhat Dry
3	> 75 – 80	Medium
4	> 80 – 85	Moist
5	> 85	Wet

2.5.2.3. Environmental comfort level index

The level of environmental comfort was analyzed based on microclimate data using the THI formula (Karyati et al. 2021):

$$THI = 0.8T \frac{RH \times T}{500} \quad (4)$$

where THI is the temperature humidity index, T is air temperature (°C), and RH is relative humidity (%). Categories of environmental comfort index values at a location are presented in **Table 3**.

Table 3. Comfort index criteria based on the Temperature Humidity Index (Sapariyanto et al. 2016)

No	Temperature Humidity Index	Comfort category
1	< 19.0	Very Comfortable
2	19.0 - < 23.0	Comfortable
3	23.0 - 27.0	Medium
4	> 27 - 30.5	Uncomfortable
5	> 30.5	Very Uncomfortable

2.5.3. Effect of land cover type

The effect of land cover type on the three parameters of microclimate variables at UHO Botanical Garden and its surroundings was analyzed based on the overall observation data, both measured (microclimate variables) and calculated (environmental comfort variables), using statistical methods, namely the analysis of variance (ANOVA) with 95% confidence level and continued with the least significant difference (LSD) test with 95% confidence level to determine differences between land cover types on the value of microclimate variable parameters, especially parameters that have a significant effect through the SPSS (Statistical Package for the Social Sciences) program.

3. Results and Discussion

3.1. Microclimate in Three Land Cover Types

The results of measurements of microclimate variable parameters (light intensity, air temperature, and RH) on three types of land cover (tree-dominant vegetation, grass-dominant vegetation, and settlement-dominant land cover) from three measurement times (morning, afternoon, and evening) of the day at UHO BC and its surroundings are presented in **Table 4**. **Table 4** shows the parameter values of microclimate variables in three land cover types from three measurement times carried out at UHO Botanical Garden. Its surroundings vary between land cover types at the same measurement time (**Fig. 2**) and at different measurement times (**Fig. 3** and **Fig. 4)**.

Table 4. Microclimate variable parameters in three types of land cover at UHO Botanical Garden and its surroundings

Land cover types	Measurement Times	Light intensity (Wm^{-2})	Air temperature (°C)	RH (%)
Tree-dominant vegetation	Morning	18.4	24.5	92.2
	Afternoon	23.1	29.5	79.0
	Evening	20.0	27.5	84.2
Average		20.5	26.5	86.9
Grass-dominant vegetation	Morning	110.2	30.3	80.8
	Afternoon	165.0	37.3	59.8
	Evening	29.9	29.2	72.5
Average		101.7	31.8	73.5
Settlement-dominant	Morning	38.6	25.3	86.3
	Afternoon	176.9	39.3	56.3
	Evening	57.9	27.9	74.2
Average		91.1	29.5	75.8

Fig. 2 shows that different land cover types provide different values of microclimate variables. The lowest light intensity, air temperature values, and the highest RH were achieved for morning measurements in the tree-dominant vegetation land cover type. In contrast, the grass-dominant vegetation land cover type achieved the highest light intensity and air temperature and the lowest RH. In afternoon measurements, the lowest values of light intensity and air temperature, as well as the highest RH, were found in the tree-dominant vegetation land cover. In contrast, the settlement-dominant land cover type achieved the highest light intensity, air temperature, and lowest RH.

Similarly, in the afternoon measurement, the tree-dominant vegetation land cover type achieved the lowest light intensity and air temperature values and the highest RH. The settlement-dominant land cover achieved the highest light intensity and lowest RH, while the grass-dominant vegetation land cover type achieved the highest air temperature (29.2°C). This fact is relevant to the statement of Ayuni et al. (2023) and De Frenne et al. (2021) that changes in vegetation patterns can alter local meteorological parameters or microclimate characteristics. The high temperature in the settlement-dominant land cover type from the daytime measurement is closely related to the high light intensity coupled with the absorption of light by the reflected residential buildings, thus adding heat energy in the area of the settlement-dominant land cover type. Karyati (2019) also reported that areas with high building density usually produce very high air temperatures because many building elements absorb sunlight directly, while areas that do not have high building density usually produce minimal air temperature because the sunlight reflected on the building elements is very small.

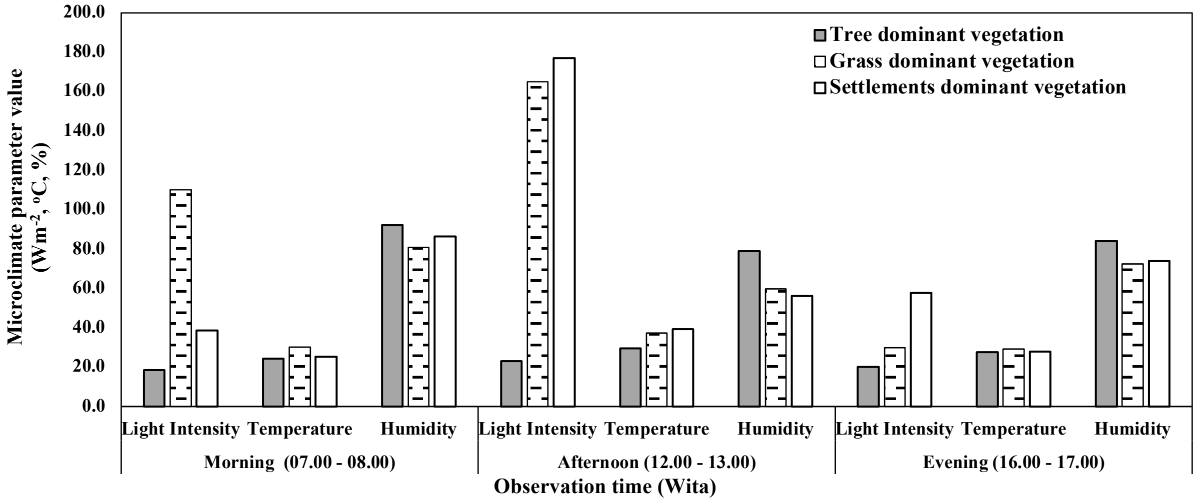

Fig. 2. Histogram of the values of three parameters of microclimate variables in three types of land cover from the same measurement time in UHO Botanical Garden and Its surroundings.

Fig. 3 shows the value of climatic variable parameters in the morning, afternoon, and evening for the same type of land cover in UHO Botanical Garden and its surroundings, where measurements on tree-dominant vegetated land cover appear to be morning measurements giving the lowest light intensity and air temperature values and the highest RH (18.4 Wm^{-2}, 24.5°C, 92.2%), while the highest light intensity and air temperature values with the lowest RH 23.1 Wm^{-2}; 29.5°C; 79.0%) are achieved in afternoon measurements. In the grass-dominant land cover type, the lowest light intensity and air temperature were achieved in the afternoon (29.9 Wm^{-2}; 29.2°C), while the highest RH was achieved from the morning observation (80.8%), while the highest light intensity and air temperature and lowest RH were achieved from the afternoon measurement (165.0 Wm^{-2}; 37.3°C; 59.8%).

On the settlement-dominant cover type, the lowest light intensity and air temperature and the highest RH were achieved from morning measurements (38.6 Wm^{-2}; 25.3°C; 86.3%), while the highest light intensity, air temperature, and RH were achieved in the afternoon measurements. **Fig. 3** shows that measurements in the tree-dominant vegetation land cover appear to be morning measurements, giving the lowest values of light intensity and air temperature and the highest RH (18.4 Wm^{-2}, 24.5°C, 92.2%), while the highest values of light intensity and air temperature with the lowest RH (23.1 Wm^{-2}; 29.5°C; 79.0%) were achieved in the afternoon measurements. In the grass-dominant land cover type, the lowest light intensity and air temperature were achieved in the afternoon (29.9 Wm^{-2}; 29.2°C), while the highest RH was achieved from the morning observation (80.8%), while the highest light intensity and air temperature and lowest RH were achieved from the afternoon measurement (165.0 Wm^{-2}; 37.3°C; 59.8%). In the vegetated land cover type dominated by settlements, the lowest light intensity and air temperature and the highest RH were achieved from morning measurements (38.6 Wm^{-2}; 25.3°C; 86.3%), while the highest light intensity and air temperature and the lowest RH were achieved from afternoon measurements (176.9 Wm^{-2}; 39.3°C; 56.3%). The highest (maximum) air temperature measurements in the three land covers occurred during the daytime due to surface heating by high light intensity. According to Liu et al. (2022) and Koesmaryono and Askari (2023), fluctuations in air temperature (and soil temperature) are closely related to the energy exchange process that takes place in the atmosphere due to sunlight, where the absorption of solar radiation energy will cause the air temperature to increase. It is further explained that the maximum daily air temperature is reached sometime after the maximum light intensity is reached when the light beam falls perpendicularly at midday.

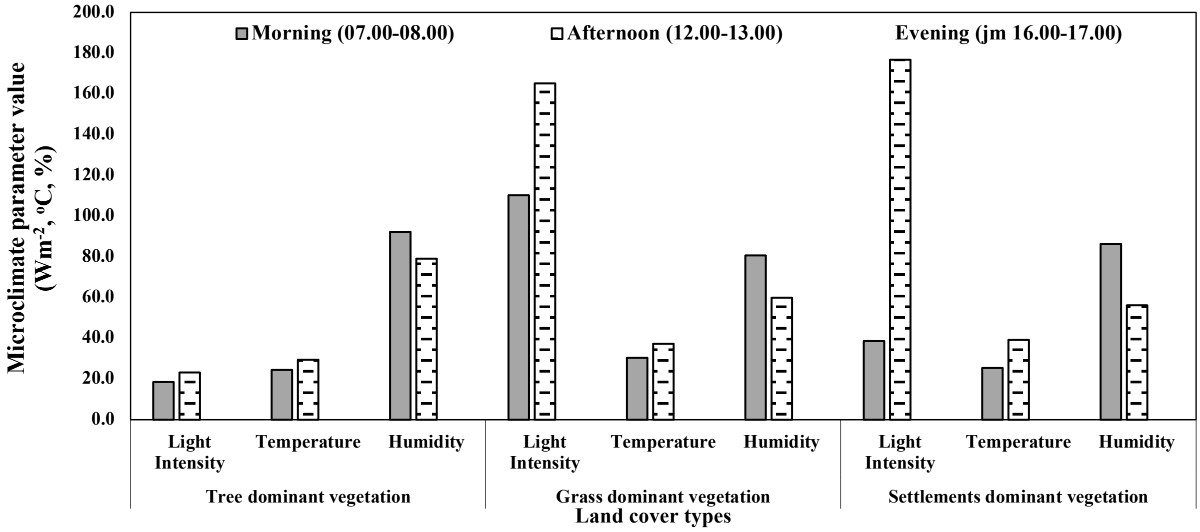

Fig 3. Histogram of the values of three parameters of microclimate variables from three types of land cover at different measurement times at UHO Botanical Garden and Its surroundings.

Figure 4 shows that each land cover type produces different mean values of microclimate variable parameters, where tree-dominant vegetation land cover produces the lowest mean values of light intensity and air temperature (20.5 Wm^{-2}; 26.5°C) and the highest RH (86.9%) compared to other land covers. The grass-dominant land cover achieved the opposite result: the highest mean light intensity and air temperature (101.7 Wm^{-2}; 31.8°C) and the lowest RH (73.5%). This fact is closely related to the characteristics of land cover, where tree-dominant vegetation has a larger crown, resulting in denser land cover so that the intensity of light after arriving at the surface of the crown (intercept radiation) is partially reflected (reflection radiation) and absorbed (absorption radiation) and partially forwarded (transmission radiation) to the ground surface with relatively low light intensity, which has a further effect of low temperature and high RH.

Another case in the grass-dominant vegetation shows the highest light intensity and air temperature, more due to the absence of trees so that the intensity of light that is transmitted (transmission radiation) directly to the ground surface without any obstacles becomes the highest, which in turn has the highest air temperature and lowest RH. This fact aligns with Koesmaryono and Askari (2023) and Teshnehdel et al. (2020) that several characteristics of tree structures can affect microclimate, including crown shape, planting, plant size, and crown density. In the afternoon and evening, the highest RH is in the tree-dominant vegetation land cover type. This type has the most extensive crown, so the radiation transmission is low, lowering the air temperature. The high air temperature and low RH in the grass-dominant vegetation land cover are because the space is open, so the intensity of the incoming light is perfect because nothing is blocking it. This is in accordance with Ariyanto et al. (2021) statement that open land receives higher light intensity, so the air temperature is also high and causes low RH. RH will be lower if the air temperature increases and vice versa; RH is higher if the air temperature is lower (Gunawan et al. 2022; Koesmaryono and Askari 2023).

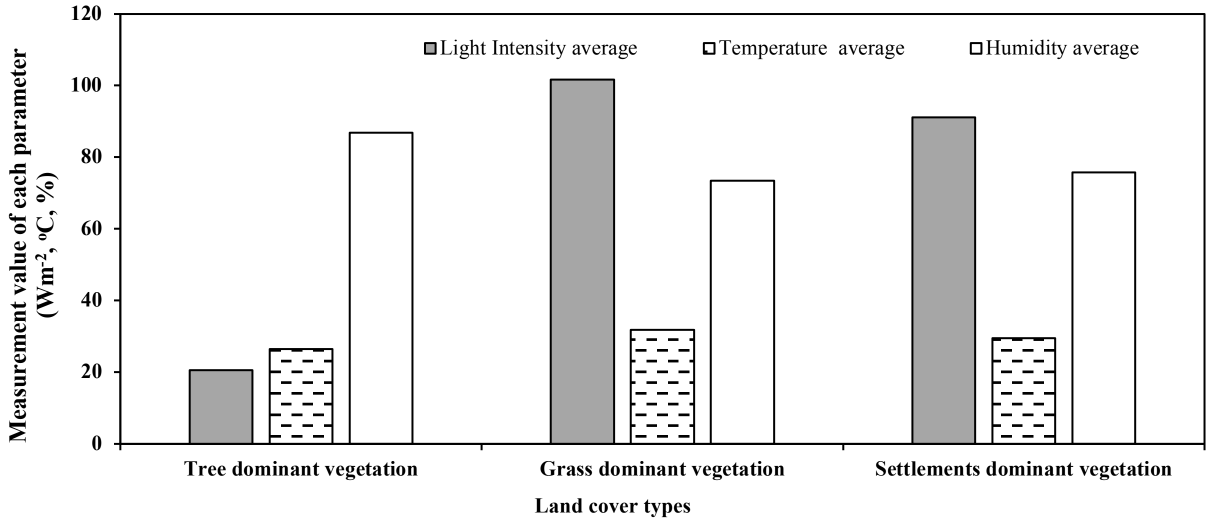

Fig 4. Average of three microclimate parameters from three measurement times at three land cover types in UHO Botanical Garden and its surroundings.

3.2. Environmental Comfort Categories in Three Land Cover Types

3.2.1. Environmental comfort index based on average air temperature

The results of the analysis of the environmental comfort index based on the average air temperature from three measurement times (morning, afternoon, and evening) in three types of land cover (tree-dominant vegetation, grass-dominant vegetation, and settlement dominant vegetation) at UHO Botanical Garden and its surroundings are presented in **Table 5**.

Table 5. The results of the analysis of environmental comfort based on the average air temperature in three land cover types at UHO Botanical Garden and its surroundings

Land cover types	Temperature (ºC)				Environmental comfort index
	Morning	Afternoon	Evening	Average	
Tree dominant vegetation	24.5	29.5	27.5	26.5	Cool
Grass dominant vegetation	30.3	37.3	29.2	31.8	Very Hot
Settlement dominant	25.3	39.3	28.2	29.5	Hot

Table 5 shows that the environmental comfort index based on the average air temperature varies between land cover types, where the tree-dominant vegetation land cover type reaches the lowest average air temperature of 26.5°C with an excellent category, and the highest is achieved in the grass-dominant vegetation land cover type of 31.8°C with a very hot category. This fact is closely related to the characteristics of each land cover type, where the tree-dominant vegetation land cover type has a large and relatively dense canopy so that the intensity of radiation is more retained and reflected so that what is forwarded to the ground surface is relatively low which causes the average temperature to be low and the environment is classified as cool. The opposite is true in the grass-dominant vegetation land cover type, where this type is open without any tree

crowns so that radiation enters. Consequently, the ground surface reaches a high-temperature average with hot environmental conditions. Compared to the settlement-dominant land cover type, the average air temperature is relatively lower than the grass-dominant vegetation land cover type due to the reduction of radiation melted by the presence of little vegetation and dominant settlements. However, there is still room for light intensity to enter, so it is still higher than the tree-dominant vegetation land cover type with relatively dense crowns. This proves that trees with high density have lower temperatures than trees with low density.

Differences in the characteristics of each vegetation type in absorbing or reflecting the solar energy it receives. Vegetation conditions with high tree density and extensive land cover will affect microclimate conditions (Ambarwati et al. 2023; Kandari et al. 2021). According to Wang et al. (2023), the presence of vegetation, through its role as a regulator of microclimate, can reduce surface temperature, which directly affects the distribution of air temperature with increased humidity while at the same time increasing the comfort of people's lives. Therefore, the low air temperature in the morning, afternoon, and evening under the shade of trees in the tree-dominant land cover type, compared to the air temperature in the grass-dominant and settlement-dominant land cover types, is in line with the results of microclimate research (air temperature) in urban parks in Kototabang by Gunawan et al. (2022) which shows that the air temperature under the shade of trees during the day is lower when compared to that on the grass, as well as the results of research by Locke at al. (2024), that the air temperature measured at the grass height of 1.5 m above the concrete surface in the morning humans feel uncomfortable and during the day feeling sick.

3.2.2. Environmental comfort index based on average RH

The results of the analysis of the environmental comfort index based on the average RH from three measurement times (morning, afternoon, and evening) in three types of land cover (tree-dominant vegetation, grass-dominant vegetation, and settlement-dominant land cover) at UHO Botanical Garden and its surroundings are presented in **Table 6**.

Table 6. Results of analysis of environmental comfort index based on average RH at UHO Botanical Garden and its surroundings

Land cover types	RH (%)				Environmental comfort index
	Morning	Afternoon	Evening	Average	
Tree-dominant vegetation	92.2	79	84.2	86.9	Wet
Grass-dominant vegetation	74	59.8	79.3	71.8	Somewhat dry
Settlement-dominant	86.3	56.3	74.2	75.8	Medium

Table 6 shows that the environmental comfort index based on the average RH varies between land cover types, where the tree-dominant vegetation land cover type achieves the highest average RH of 86.9% with a comfort index classified as wet. The lowest average RH in the grass-dominant vegetation land cover type is 71.8%, with a relatively dry category. This fact is the same as the environmental comfort factor due to the air temperature factor, which is closely related to the characteristics of each land cover, where the tree-dominant vegetation land cover has a large and relatively dense crown so that the intensity of radiation is more retained and reflected which the radiation that is forwarded to the ground surface is relatively low which causes the highest average RH and the environment is classified as cool. In addition, tree canopy can spread sunlight

so that the surrounding air temperature can be reduced (Aguiar et al. 2018; Locke et al. 2024). The opposite is true for land cover with grass-dominant vegetation because it is open without any canopy, so the intensity of incoming radiation is relatively high. Consequently, the ground surface reaches a low average RH with a very hot environmental comfort category.

Similarly, the settlemanet-dominant land cover type show a relatively high average RH compared to the grass-dominant vegetation, allegedly due to the reduction of radiation obstructed by the presence of settlements and vegetation in the form of trees. However, the number is small, so there is still room for the incoming light intensity even though it is lower than the grass-dominant vegetation land cover type. According to Abir and Saha (2021) and Meili et al. (2021), increased H_2O and CO_2 absorption in tree-dominant vegetation cover affects the increase in RH. The lowest RH in the afternoon and evening is achieved in the land cover type with grass or settlement vegetation. The low RH in the grass-dominant vegetation land cover type is thought to be caused by the condition of the green space at this location, which is only in the form of grass, where grass is a vegetation structure commonly used as a ground cover which, when compared to other vegetation structures, the benefits of grass as a temperature reducer are included in the smallest category (Du et al. 2021).

3.2.3. Environmental comfort index based on Temperature Humidity Index (THI)

The results of the calculation of environmental comfort based on the Temperature Humidity Index (THI) factor value from three measurement times (morning, afternoon, and evening) at three types of land cover (tree-dominant vegetation, grass-dominant vegetation, and settlement-dominant land cover) at UHO Botanical Garden and its surroundings are presented in **Table 7**, and visually in **Fig. 5**.

Table 7. The environmental comfort index of three types of land cover in UHO Botanical Garden and its surroundings

Land cover types	**Measurement Times**	**THI factor**		**THI value**	**Description**
		Temperature (°C)	**RH (%)**		
Tree-dominant vegetation	Morning	24.5	92.2	24.1	Medium
	Afternoon	29.5	79.0	28.3	Uncomfortable
	Evening	27.5	84.2	26.6	Medium
Average		27.17	85.13	26.3	Medium
Grass-dominant vegetation	Morning	30.3	80.8	28.8	Uncomfortable
	Afternoon	37.3	59.8	34.3	Very uncomfortable
	Evening	29.2	72.5	28.0	Uncomfortable
Average		32.27	71.03	30.4	Uncomfortable
Settlement-dominant	Morning	25.3	86.3	24.6	Medium
	Afternoon	39.3	56.3	35.9	Very Uncomfortable
	Evening	27.9	74.2	26.5	Medium
Average		30.83	72.27	29.0	Uncomfortable

Table 7 shows that the environmental comfort index based on THI values varies between different measurement times in the same land cover type and between the exact measurement times in different land cover types. Generally, there are moderate, uncomfortable, and very uncomfortable environmental comfort categories. In the morning measurement, the grass-dominant vegetation land cover type achieved the highest comfort index (28.8) with an

uncomfortable category. In contrast, the lowest index was achieved by the tree-dominant vegetation land cover type (24.1) with a moderate category. In the afternoon measurement time, the highest environmental comfort index was achieved by the settlement-dominant land cover (35.9) with a very uncomfortable category.

The highest THI values during morning and evening measurements on grass-dominant vegetation land cover are closely related to the absence of trees, so direct radiation to the land surface, high air temperature, and low RH create relatively uncomfortable environmental conditions. The highest THI conditions on settlement-dominant land cover (afternoon) are thought to be due to the lack of tree canopy, as well as reflections from settlements so that the air temperature is relatively high and low RH so that environmental conditions are relatively uncomfortable (Masitoh and Rusydi 2020; Meili et al. 2021).

In contrast, the lowest comfort index was achieved by the tree-dominant vegetation land cover (28.3) with an uncomfortable category. In the afternoon measurement, the highest comfort index value was achieved by the grass-dominant vegetation land cover type (28.0) with the uncomfortable category. In contrast, the lowest comfort index was achieved by the settlement-dominant land cover type (26.5), relatively the same as the tree-dominant vegetation land cover (26.6) with the same category, namely moderate. The condition is visually presented in **Fig. 5.**

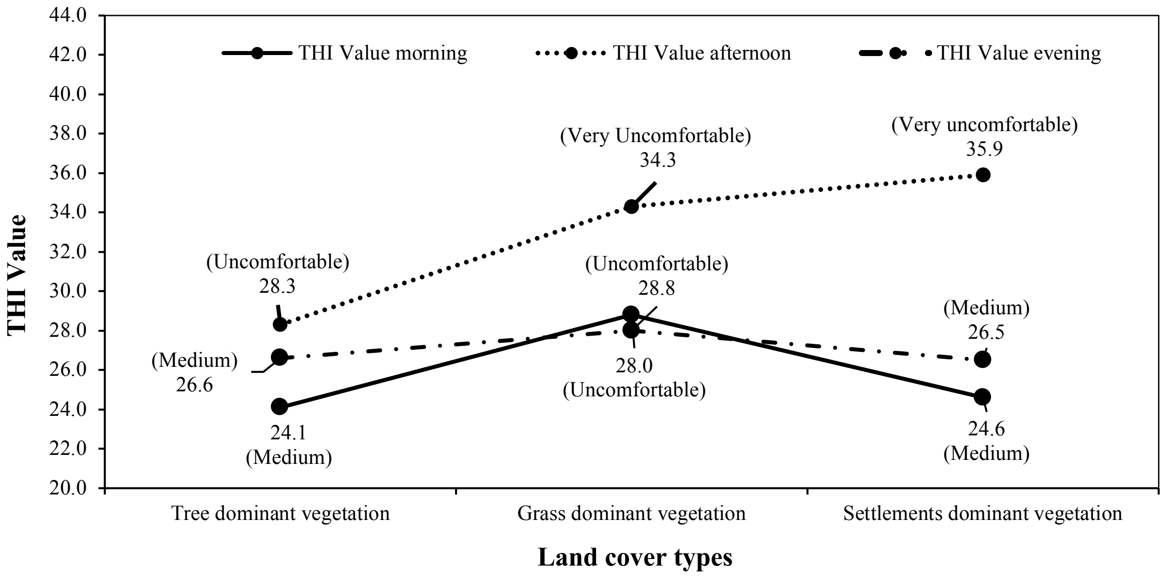

Fig. 5. Description of environmental comfort categories based on the THI value on three land cover types in UHO Botanical Garden and its surroundings.

The fact in **Table 7,** which is visually shown in **Fig. 5**, is closely related to the structure of the vegetation canopy in each type of land cover where tree-dominant vegetation reaches the lowest index value of the three observations with moderate categories (morning and evening), uncomfortable (afternoon), has a large and dense canopy so that the intensity of light entering is relatively minimal, the measured air temperature is also low, and the RH reached is quite maximum so that the environmental conditions created are relatively more comfortable.

3.3. Effect of Land Cover on Microclimate and Environmental Comfort

3.3.1. ANOVA results

The results of ANOVA at the 95% level on the parameter values of microclimate variables and environmental comfort index (THI) from three observation times at three types of land cover in UHO and surrounding areas are presented in **Table 8**.

Table 8. ANOVA results on the parameter values of microclimate variables and environmental comfort at three land cover types in UHO Botanical Garden and its surroundings

Source of variance		Sum of Squares	df	Mean Square	F	Sig.
Light intensity	Between groups	23394.443	2	11697.222	60.584*	.000
	Within groups	2896.122	15	193.075		
	Total	26290.565	17			
Temperature	Between groups	84.714	2	42.357	9.869*	.002
	Within groups	64.377	15	4.292		
	Total	149.091	17			
RH	Between groups	615.074	2	307.537	4.959*	.022
	Within groups	930.330	15	62.022		
	Total	1545.404	17			
THI	Between groups	50.430	2	25.215	9.998*	.002
	Within groups	37.830	15	2.522		
	Total	88.260	17			

Note: *Significantly affected at the 0.05 level.

Table 8 shows a significant influence between land cover types on all parameters of microclimate variables. The land cover factor has a real influence on the value of the three measured microclimate parameters, and the THI is calculated from three measurement times at three types of land cover in UHO Botanical Garden and surrounding areas. This fact is relevant to the statement of Abir and Saha (2021) that variations in land cover also affect the climatic conditions of the land surface.

3.3.2. Further test of Least Significant Difference (LSD)

Based on the ANOVA results on the parameter values of microclimate variables and environmental comfort, there is an indication of a real influence between land cover types. Therefore, it was continued with the LSD test to determine the differences between land cover factors presented in **Table 9. Table 9** shows that each parameter of microclimate variables and environmental comfort reached significantly different values between land cover types in the UHO Botanical Garden and its surroundings. Light intensity and RH achieved in the tree-dominant vegetation land cover type significantly differ from the grass-dominant vegetation land cover type and settlement-dominant land cover. In contrast, the grass-dominant vegetation and settlement-dominant land cover are not significantly different.

Air temperature achieved in the tree-dominant vegetation land cover type was significantly different from grass-dominant vegetation but not significantly different from settlement-dominant area. Similarly, between grass-dominant vegetation and settlement-dominant vegetation, the difference was not significant. While THI, the environmental comfort index, which is achieved in the land cover type of tree-dominant vegetation, is significantly different from the environmental comfort in the land cover type of grass-dominant vegetation and settlement-dominant vegetation, as well as the environmental comfort between the land cover type of grass-dominant and settlement-dominant vegetation is significantly different. This fact is relevant to the opinion of Primack et al. (2021) and Munadi et al. (2023), stating that the presence of tree vegetation in botanical gardens makes the living environment feel more comfortable because, in addition to beautifying the environment, tree vegetation can also modify climate elements, such as light intensity, air temperature, and RH. It is further explained that trees do not change these climatic elements drastically. Still, the small changes caused are very pronounced for humans. This fact is relevant to the opinion of Permatasari et al. (2024) that increasing ambient temperatures due to climate change have significantly impacted human physical and mental health and safety. For example, when the sun shines fully, the air conditions under shady trees cannot penetrate the canopy, so the canopy feels more shady, cool, humid, and comfortable (Sandiah et al. 2022; Wati and Fatkhuroyan 2017). Vegetation in the form of trees functions as climate control for environmental comfort because the tree canopy absorbs heat from the sun's rays so that it lowers air temperature, increases RH, and the overall microclimate is cool (Findlater et al. 2022; Kandari et al. 2021).

Table 9. Results of LSD test on three parameters of microclimate variables and environmental comfort index (THI) on three types of land cover in UHO Botanical Garden and its surroundings

Multiple Comparisons					
Dependent variable	**Land cover Types**	**Land cover types**	**Mean difference (I-J)**	**Std. error**	**Sig.**
Light Intensity	Tree-dominant vegetation	Grass-dominant vegetation	81.2167*	8.0224	.000
		Settlement-dominant	70.6333*	8.0224	.000
	Grass-dominant vegetation	Settlement-dominant	10.5833	8.0224	.207
Temperature	Tree-dominant vegetation	Grass-dominant vegetation	-5.3000*	1.1961	.000
		Settlement-dominant	-2.9833*	1.1961	.025
	Grass-dominant vegetation	Settlement-dominant	2.3167	1.1961	.072
RH	Tree-dominant vegetation	Grass-dominant vegetation	13.3833*	4.5469	.010
		Settlement-dominant	11.1000*	4.5469	.028
	Grass-dominant vegetation	Settlement-dominant	-2.2833	4.5469	.623
THI	Tree-dominant vegetation	Grass-dominant vegetation	-4.1000*	.9169	.000
		Settlement-dominant	-2.0500*	.9169	.041
	Grass-dominant vegetation	Settlement-dominant	2.0500*	.9169	.041

Note: * The mean difference is significant at the LSD. 0.05 level.

Kaplick et al. (2019) stated that the plant canopy system's absorption of solar radiation energy will spur plants to increase their transpiration rate, especially to maintain plant temperature stability. RH depends on several factors, including air temperature, wind movement, quantity and quality of irradiation, vegetation, and water availability (Sapariyanto et al. 2016; Wang et al. 2023). García et al. (2023) stated that differences in the land cover area cause different microclimate characteristics between observed land cover types. This occurs because the extent of land cover will increase the intensity of retained light as a source of energy in physiological processes in the plant body so that vegetation can suppress the increase in air temperature through photosynthesis and transpiration. At the same time, the measurement of microclimate parameters in the grass-dominant vegetation and settlement-dominant land cover types produces characteristics of air temperature classified as hot and RH classified as dry as a result of the absence of trees in the dominant grassland cover type and few trees in the settlement-dominant land cover type (Aguiar et al. 2018).

This fact is closely related to environmental comfort, which can be known based on the THI value of the air temperature and humidity factors (Sapariyanto et al. 2016). THI value describes the level of environmental comfort based on the value of air temperature and RH (Santi et al. 2019; Saroh and Krisdianto 2020). It is further explained that the quality of environmental comfort of botanical gardens is generally related to the number of shady trees, where the greater the number of shady trees in botanical gardens, the better the microclimate conditions and environmental comfort. Spaces covered by tree stands will have relatively high RH. In contrast, open spaces without trees will have dry soil (sand, gravel, and the like) and tend to cause high temperatures and low RH (Devi 2021; Karyati et al. 2021). The grass-dominant vegetation and settlement-dominant land covers have high air temperatures because they directly receive high light intensity, without any shading and the reflection of sunlight from grass and settlement, while trees will influence the creation of a cooling effect by lowering air temperature and increasing RH (Luo et al. 2023; Martinez-Gomez et al. 2021).

4. Conclusions

Based on the research results presented, it can be concluded that the microclimate conditions of UHO Botanical Garden are influenced by the type of land cover where trees are dominant, which is more comfortable and significantly different from grass-dominant and settlement areas. The microclimate characteristics of the tree-dominant vegetation land cover type are more comfortable and significantly different from grass-dominant and settlement-dominant vegetation. Meanwhile, land cover with dominant grass vegetation and settlement is considered uncomfortable. The level of environmental comfort in the tree-dominant vegetation land cover, and the average THI is in the cool category. Meanwhile, the average THI is in the uncomfortable category in the grass-dominant vegetation land cover. This fact shows the importance of vegetation conservation and the need to continue monitoring so that there is no conversion of land into settlement areas or building construction to maintain the preservation and sustainability of UHO Botanical Garden as one of the green open spaces controlling climate stability and environmental comfort in Kendari City.

Acknowledgments

The authors thank the Minister of Education, Culture, Research, and Technology and the Rector of Halu Oleo University for providing grants or assistance to the author to conduct research through the Higher Education Excellence Basic Research Scheme DIPA Fund 2020/2021.

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