Spatial Analysis of Universitas Indonesia (UI) Urban Forest Microclimate and Its Biodiversity

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Abstract. Universitas Indonesia (UI) Urban Forest is located in the middle of an urban area. Vegetation analysis is one way to define the vegetation health to reach the urban forest sustainability. On the other hand, the vegetation analysis in UI Urban Forest was done thirteen years ago and needed to be updated. Moreover, there has not been vegetation analysis yet of UI Urban Forest using remote sensing combining the microclimate also biodiversity. This research method combines remote sensing and primary data collection. It classify the Landsat 8 (OLI) to the NDVI as the unit analysis (low, medium, high). Primary data collection started by random stratified sampling with a sampling intensity of 0.77% (18 plots), where in each plot, the temperature-humidity was measured, and the vegetation and bird were identified. As a result, the map of temperature and humidity was produced, and it correlates to the vegetation cover where the vegetation is high, the temperature is low, and the humidity is high. On the other hand, the vegetation structure and composition were analyzed. In conclusion, there is a significant difference between the NDVI vegetation class to the UI Urban Forest microclimate and its biodiversity (vegetations and birds).

1. Introduction

The balance of nature and ecosystems in tropical natural forests and urban areas is different. The credit happens because urban areas tend to be more varied than tropical natural forests, such as vehicle pollution, which requires urban green open spaces as a counterweight [1]. Depok City is one of the buffer cities for the Special Capital Region (DKI) of Jakarta, which has proliferated, and one of the reasons is the University of Indonesia (UI) transfer to Depok City in 1987 [2]. The population of Depok City, which has increased by 1 million people for 20 years (the population) is 1.1 million in 2000 and 2.1 million in 2020), is one indicator that the epicenter of community activity formed in Depok City so that urban green areas are essential to maintain the balance of urban ecosystems [3]. The urban forest is one of the urban green areas that play an essential role. Its legal basis is stated in the government regulations (Peraturan Pemerintah) No. 63 the year 2002 for a minimum area of 0.25 hectare with 10% coverage from its urban area [4]. Besides, the urban forest consists of a minimum of fifteen vegetation
types from various strata such as seedlings, stakes, poles, and trees, forming the smallest ecological unit [5].

The urban forest provides convenience for its surroundings, including the ecosystem balance through its bio-ecological function. Moreover, the vegetation cover of 11% and 33% reduces the carbon emissions up to 3.8% and 3.9% because it can absorb the gas particulate through its leaf [6], [7]. However, those functions will work optimally depends on the environment, weather, vegetation type, and health. One indicator of vegetation health can be described based on the urban forest vegetation analysis that is regularly updated [8]. Therefore, the vegetation analysis can reveal urban forest sustainability both internally and externally. The urban forest ecosystem reveals the relationship between vegetation, microbiota, bird, water systems, and the microclimate. Besides, the external relationship shows the connection between urban forest and the community from its surroundings. On the other hand, the urban forest creates social interaction between-community from various backgrounds resulting from community attachment [9].

University of Indonesia (UI) Urban Forest is defined by The Rector Decree No. 088/SK/R/UI/1985. The Decree was implemented by The Decree No. 084/SK/R/UI/1988, mentioning the function of UI Urban Forest as The Green Crown/Mahkota Hijau balancing the Jakarta urban areas in its north side and the Puncak recreational areas in its south side [10]. Several previous researches conducted in the UI Urban Forest area were about the benefit and cost of forest zonation, tree risk identification assessment, also vegetation community structure [11], [12]. The previous research conducted in 2008 focused on the vegetation community structure based on the three zones (East Wallace, West Wallace, and Natural Vegetation) with 42 plots [13]. The results identified the species number of trees, pole, stake, and seedling were 33, 29, 43, and 66 species. Besides, the analysis used in the previous research was the vertical stratification A (>30m), B (20-30m), C (4-20m), D (1-4m), and E (0-1m). Therefore, this research is expected to be able to analyze UI Urban Forest using remote sensing based on the NDVI classification. Moreover, the function of UI Urban Forest will be optimal if the development uses an ecological approach that concerns the urban forest functions bio-ecologically. However, the research that observed UI Urban Forest using remote sensing has not been conducted yet. Consequently, this research observes UI Urban Forest's microclimate and biodiversity (vegetation and bird) spatial analysis based on the Normalized Difference Vegetation Index (NDVI).

2. Method

The research area is UI Urban Forest, with the total area of 938,586.58 m². This research used remote sensing as the early screening step. This research used NDVI to analyze the Landsat 8 OLI with Path 122 Row 64 date May 11-May 18, 2021. NDVI of UI Urban Forest is defined into six classes (open space, built-up area, shrubland, low, middle, and high vegetation cover). However, the unit analysis used in this research only three from six classes is the vegetation cover (low, medium, and high). Primary data collection is the method used for this research starting from 21-29 August 2021. Temperature and humidity are the indicators for microclimate. The data collection included measuring the temperature and humidity as well as identifying vegetation and bird in each plot as many as 18 plots with a sampling intensity of 0.77%. UI Urban Forest has three areas divided based on the vegetation type from across Indonesia called West Wallace (Wales Barat), East Wallace (Wales Timur), and Native Vegetation (Vegetasi Asli). This research used the random stratified sampling method per NDVI class and the UI Urban Forest sections as the unit analysis.

The temperature and humidity were measured in each plot using the Kestrel 5000 Environmental Meter four times in the four corners of the plot. As a result, the average of those four will be the main data input. The vegetation identification was conducted by the size of a 20x20m plot. The seedling was identified in 2x2m, stake 5x5m, pole 10x10m, and tree 20x20m [14]. The identification started by writing down the species name (both local and scientific) on each vegetation level (seedling, stake, pole, and tree). Then, calculating the frequency of each species also measured the vegetation circumferences (converted to the diameter). The line transects method for bird counting is used in this research rather than the point count method because it has the advantage of counting more birds, less time for
identification, and is excellent for mobilization [15]. The tools used for bird identification are Laser Rangefinder, Binocular Vortex Diamondback, and Nikon Coolpix B700 Camera. This method was used in the research because remote sensing helps to see the updated actual UI Urban Forest. Thus, the measurement of temperature and humidity helps to validate the theory. On the other hand, vegetation and bird identification help to analyze the UI Urban Forest's biodiversity.

3. Results and discussion

NDVI analysis uses the 3 classifications, low vegetation cover (0.23 – 0.3), medium vegetation cover (0.31 – 0.37), and high vegetation cover (0.38 – 0.45). UI Urban Forest's total area is 938,586.58 m². Based on the NDVI vegetation classification, the 18 plots (20x20m) were sampled with as many as 0.77% sampling intensity from West Wallace, East Wallace, and Native Vegetation as in Figure 1.

![Figure 1. The map of NDVI results and microclimate-vegetation-bird identification.](image)

NDVI used the Landsat 8 OLI Band Analysis (NDVI = NIR-Red/NIR+Red). Band 5 for the Near-Infrared/NIR with the wavelength of 0.85 - 0.88µm and Band 4 for the Red (0.64 - 0.67µm). United States Geological Survey (USGS) mentioned that Band 5 was useful for emphasizing biomass content and shoreline also Band 4 functions on discriminates vegetation slopes [16]. Therefore, NDVI was a sensitive indicator of canopy structure. The spectral band from Landsat detects the green biomass, green leaf area index. Thus, it provides the relationships between canopy and climate factors which NDVI classification was the unit analysis for microclimate, vegetation, and bird identification [17] [18] [19]. Around sixty-five percent of UI Urban Forest area was the medium vegetation cover. High and low vegetation covers were 19.36% and 11.96%. Although those percentages were a rough result from the remote sensing method, most UI Urban Forest vegetation cover a medium vegetation density. Consequently, as part of the research, the vegetation identification in the field will validate this early primary screening.

Analyzing the spatial pattern of UI Urban Forest microclimate, the temperature and humidity were measured and recorded as the primary data. The plot sample for temperature and humidity was the same as the vegetation and bird identification which were 18 plots (from inside UI Urban Forest) and 24 plots additional from UI Urban Forest’s surroundings. This additional plot measurement aims to map out the temperature Figure 2 and humidity Figure 3 using the Kriging interpolation method.
Theoretically, the temperature and humidity are inversely proportional, which while the temperature is low, the humidity is high. This research shows that the low vegetation cover has the highest temperature and the lowest humidity. It also connects the previous theory that less vegetation cover may lead to rising temperatures.

Table 1. The vegetation structure and composition each vegetation cover (low, medium, and high).

|                                | Low vegetation cover | Medium vegetation cover | High vegetation cover | Total |
|--------------------------------|----------------------|-------------------------|-----------------------|-------|
| **Total number of individuals**|                      |                         |                       |       |
| Number of individual - seedling| 1295                 | 489                     | 851                   | 2635  |
| Number of individual - stake   | 10                   | 23                      | 24                    |       |
| Number of individual - pole    | 25                   | 24                      | 19                    |       |
| Number of individual - tree    | 48                   | 61                      | 65                    |       |
| **Total number of species**    |                      |                         |                       |       |
| Number of types - seedling     | 18                   | 20                      | 14                    |       |
| Number of types - stake        | 8                    | 8                       | 9                     |       |
| Number of types - pole         | 11                   | 8                       | 7                     |       |
| Number of types - tree         | 14                   | 13                      | 16                    |       |
| **Important Value Index (IVI)**|                      |                         |                       |       |
| IVI - seedling                 | Cyperus rotundus (50.89) | Centotheca lappacea L (80.34) | Brachiaria mutica (31.48) |       |
| IVI - stake                    | Swietenia mahagoni (42.22) | Syzygium polycephalum (55.43) | Hevea brasiliensis (57.5) |       |

Figure 2. The temperature map of UI Urban Forest.

Figure 3. The humidity map of UI Urban Forest.
Table 1. explains the vegetation structure and composition of each vegetation cover class. The low vegetation cover has the highest individual number rather than the medium and high vegetation cover. In addition, the low vegetation cover has more seedlings (1212 individuals) than the medium and high vegetation cover (381 and 743 individuals). The highest number happens because the tree tends to sprawl at low vegetation cover, so the canopy cover detected by the Landsat was low. On the other hand, the trees in the high vegetation cover are mature with a broad canopy so that the reflection to the Landsat 8 sensor is high green biomass. Thus, the trend between the three-vegetation cover classification is individuals’ number on low vegetation cover dominated by the seedling and pole level rather than the stake and tree level. On the contrary, the individuals’ number on medium and high vegetation is dominated by the stake and tree vegetation level. The highest species number on low and medium vegetation cover is in the seedling level (18 and 20 species). On the other hand, the highest species number on high vegetation cover is in the tree level (16 species). Important Value Index (IVI) is a method to measure the species dominancy in a forest area.

In this research, the highest IVI in seedling level was *Centhotheca lappacea* (80.34) located in medium vegetation cover, followed by *Cyperus rotundus* (50.89) in low vegetation cover also *Brachiaria mutica* (31.48) in high vegetation cover. The highest IVI in stake level was *Hevea brasiliensis* (57.5) in high vegetation cover, *Syzygium polycaphalum* (55.43) in medium vegetation cover, and *Swietenia mahagoni* (42.22) in low vegetation cover. The highest IVI in pole level was *Syzygium polycaphalum* (123.1) in medium vegetation cover, *Shorea leprosula Mig.* (68.84) in high vegetation cover, and *Swietenia mahagoni* (68.47) in low vegetation cover.

The highest IVI on tree-level was *Paraserianthes falcataria* (78.4) located in medium vegetation cover. On the other hand, *Acacia mangium* (71.94 and 56.34) were also the highest IVI on tree-level located in low and high vegetation cover. This result is more likely the same as the previous research did thirteen years ago. Then, the highest IVI on tree-level was *Acacia mangium* (180.04 and 139.56), located in Native Vegetation and West Wallace, followed by *Albizia falcataria* (99.23) in East Wallace. *Acacia mangium* adapts easily to the environment with the speed of growth in a short time. In addition, it has a wide canopy, so that it is able to lower the temperature by 4.76%. However, it postpones the other vegetation to grow into a tree [13].

Besides the vegetation analysis, the bird was also identified per NDVI classes. High vegetation cover has the maximum average number of bird individuals (18 individuals/plot). Besides, low and medium vegetation covers are 16.67 and 13.33 individuals/plot. Therefore, it indicates that the higher vegetation cover is, the more bird individuals are to be. However, it was not applied to low and medium where the low vegetation cover has more bird individuals than medium. the total species identified in all vegetation classes were 22 species, with the average number of species each low, medium, and high vegetation cover were 2.5, 2.3, and 2.8 species/plot. The top five species were *Pycnonotus goaiaver* (Merbah Cerukcuk), *Collocalia linchi* (Walet Linchi), *Dicaeum trochileum* (Burung Cabai Jawa), *Pycnonotus aurigaster* (Cucak Kutilang), and *Psilopogon haemacephalus* (Takur Ungkut-Ungkut).
4. Conclusions
In conclusion, there is a significant difference between the NDVI vegetation class to the UI Urban Forest microclimate (temperature and humidity). Besides, it also had a difference with the number of individuals and species on its biodiversity (vegetation and bird). However, different details between the level analysis of the vegetation (seedling, stake, pole, and tree) have occurred. The temperature and humidity will more vary and explains the temporal analysis if measured per hour in each plot. Unfortunately, this research has limitations on human resources and tools. Consequently, the recommendations for the following research are to measure the temperature and humidity per hour and calculate the canopy index for additional vegetation information. To maintain UI Urban Forest's sustainability, the prescreening health could use these research results, including the map as the beginning, so that the UI Urban Forest's manager could see this as part of the program consideration either planting program or maintain the existing.

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