Implications of Green Land Cover on Urban Temperature in Malang City, Indonesia

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Abstract*—Development in the Malang City area affects changes in land use patterns, one of which is changes in green land cover. Changes in green land cover will impact temperature changes in the area. Therefore, this study was conducted to determine the implications of green land cover changes in Malang urban areas in 2016-2020. This study uses remote sensing technology from Sentinel 2 satellite imagery and band canals to produce a green land density map (NDVI). Next, identify changes in urban temperature that occur. Based on the sensing results, there has been a significant change in land use patterns in the last five years. In addition, it is also known that changes in green land cover have a significant effect on changes in urban temperature, which impact the occurrence of urban heat islands. Thus, the Malang City government, in carrying out development and planning, the Malang City government must pay attention to and consider these changing conditions to minimize the impact of urban microclimate changes so that the city's sustainability is maintained

Keywords*—Land Use, NDVI, Urban Heat Island, sustainable city

I. INTRODUCTION

The growth and development of a city are closely related to human activities, both in social, economic, and cultural aspects. The physical growth and development can be seen from the increase in population, availability of complete infrastructure and facilities, increase in the number and density of buildings, and the development of the surrounding areas [1]. Currently, 54 percent of the world's population lives in urban areas, of which almost half live in smaller settlements with a population of less than 500,000. Population growth and continued urbanization are expected to add 2.5 billion urban residents by 2050, and 90 percent of this increase is likely to occur in Africa and Asia [2].

Increasing urban development can lead to changes in land use, which will reduce the existence of green open space, which has an essential role as an element of urban micro-temperature regulation. Green open space has changed its function into settlements, business facilities, offices, industries, etc. Thus, areas with natural vegetation will be replaced by areas with surfaces that are difficult to evaporate, such as asphalt and concrete. This condition will trigger the occurrence of surface radiation which causes the surface temperature of the city to be higher than the surrounding environment [3]. On a regional scale, land use and land cover patterns are the strongest drivers of urban temperatures. Changes in land cover and land use can increase temperature and temperature in an urban area [4]. Urbanization replaces vegetated surfaces – which provide shade, evaporative cooling and the functions of rainwater interception, storage and infiltration – with watertight building surfaces [5]. In addition, development in urban areas generally uses water-resistant materials, such as concrete and asphalt. Using concrete and asphalt materials can absorb solar heat radiation during the day and reflect the heat at night [6]. Therefore, in the development of a city, it is necessary to pay attention to changes in the land cover surface and its impact on the environment.

The city of Malang in the last five years has experienced significant changes in the urban microclimate. An increase in surface temperature was recorded in 2013 (25.6 – 26.8 C) and (26.37 – 28,56 C) in 2015 [7]. The pattern of development that does not pay attention to the green land cover factor will cause a continuous increase in temperature. It will have an impact on the emergence of various natural disasters. By looking at the development of land use changes, the vegetation density index or green land cover can also be seen, known as the Normalized Difference Vegetation Index (NDVI). This change can be made by utilizing remote imaging technology. Based on this background, the research questions are 1. What are the patterns of land use and land use changes in Malang City in 2016-2020?. 2. What is the percentage change in the green cover density index in 2016-2020?. 3. What are the implications of green cover changes on urban microclimate changes in Malang City?

II. METHODS

This research was located at Malang City, a second big city in East Java after Surabaya. Malang city is also known as an education city. This condition makes Malang city a complex city with many activities that support educational aspects like boarding houses, apartments, student centers, food courts, cafés, etc. Malang City has an area of 110.06 KM2, divided into five (5) administrative regions, namely Kedungkandang, Sukun, Klojen, Blimbing, and Lowokwaru Districts.

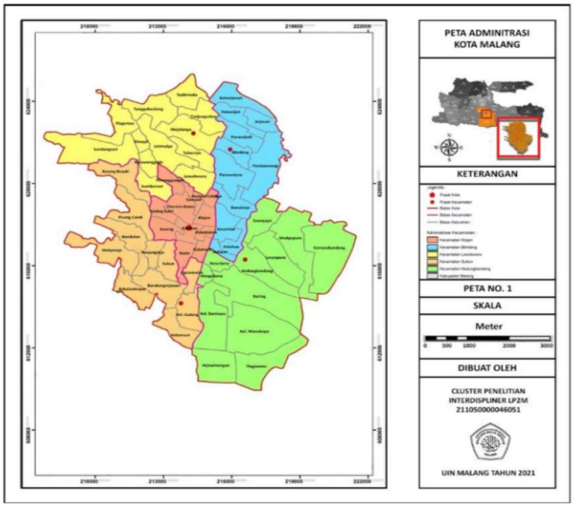

Fig 1. The Map of District in Malang City

The rapid development of Malang City impacts land use patterns and reduces green open space. The Vegetation Index (VI) or vegetation index is needed to find changes in green open space in a city. The often-used index is the Normalized Difference Vegetation Index (NDVI). NDVI produces an image that shows the level of greenery from the existing vegetation in an area. NDVI analysis aims to determine the vegetation density class based on remote sensing image data obtained from satellites, one of which is Sentinel 2. A mathematical combination is needed between the red band and the NIR band (Near-Infrared Radiation) to determine the greenery level from time to time [8]. Here is the formula to determine the NDVI value [9]:

$$NDVI=NIR-REDNIR+RED$$

The NDVI value is negative or close to zero if the surface is water, slightly positive if the surface is natural soil, and very positive if the surface is vegetation [10].

Table 1. NDVI Classification

Klasifikasi NDVI

No.	Kelas	Nilai	Keterangan
1.	Kelas 1	-1 s/d -0.03	Lahan Tidak Bervegetasi
2.	Kelas 2	-0.03 s/d 0.15	Kehijauan Sangat Rendah
3.	Kelas 3	0.15 s/d 0.25	Kehijauan Rendah
4.	Kelas 4	0.25 s/d 0.35	Kehijauan Sedang
5.	Kelas 5	0.35 s/d 1	Kehijauan Tinggi

(sumber: Peraturan Menteri Kehutanan Republik Indonesia, 2010)

After getting an overview of the vegetation index, a comparison is made with the microclimate conditions of the Malang city to produce a correlation of changes.

III. RESULT AND DISCUSSION

A. General Condition of Malang City

Geographically, Malang City is located on the astronomical line 112.06 - 112.07 East Longitude and 7,060 - 8020 South Latitude. The city of Malang has natural potential surrounded by mountains with a reasonably high altitude, reaching 445-526 above sea level. This condition causes Malang City to have a humid tropical climate with an average 18-22 Celsius temperature. Malang City is one of the cities with a reasonably high urban appeal. This is due to the heterogeneity of regional functions such as education, Tourism, service trade, etc. This condition causes the population of Malang City to increase every year and results in a relatively high population density. The population of Malang City until 2020 reaches 84,3810 people, with a rate of 0.66%.

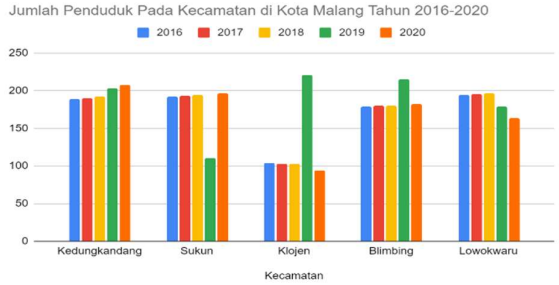

Fig 2. The Total of Malang City Population from 2016-2020

B. Land Use abd Land Use Change

Based on BPS data in 2020, land use in Malang City consists of 3 main functions, namely paddy fields (10.14 ha), non-agricultural land (17.48), and non-agricultural land (82.44 ha). There has been a land use conversion of 47 hectares in the last year. This conversion occurs from a decrease in the area of agricultural land into settlements.

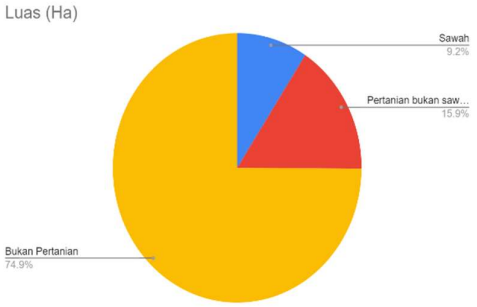

Fig 3.The composition of land in Malang City

From the diagram, it can be seen that non-agricultural land use dominates land use in Malang City. Analysis of land change data during 2016-2020 shows a significant number of changes—the rapid land use changes in Malang City impact land cover patterns. Based on spatial mapping through a hybrid combination of 5 canals, namely canals 2,3,4, 5, and 8 A, it shows the interpretation of the classification of settlements/open land/built-up land, irrigated rice fields, mixed dryland agriculture, and

shrubs/grass. The spatial analysis results show an increase in all classes in the last five years. The following is data on land change in Malang City for 2016-2020.

TABLE 2. MALANG CITY LAND USE IN 2016-2020

Kelas Penggunaan Lahan	Luas (ha)				
	2016	2017	2018	2019	2020
Pemukiman/ Lahan Terbuka/ Lahan Terbangun	5644.4	6233.93	6454.17	7080.56	7309.51
Sawah Irigasi	446.59	350.57	288.4	353.26	449.05
Pertanian Lahan Kering Campuran	4859.73	4342.62	4115.84	3431.18	3009.19
Semak Belukar/ Rerumputan	44.29	67.89	136.6	130.01	227.26

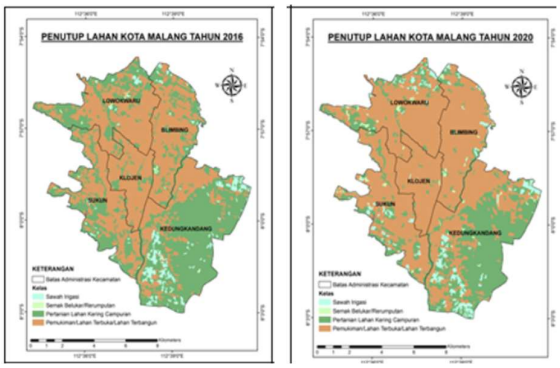

Fig 5. The Map of Land Use at 2016 and 2020 in Malang City

C. *Percentage of Green Land Cover Change (NDVI) in Malang City*

Vegetation density analysis through NDVI illustrates the interpretation of land cover. Interpretation of land cover is carried out temporally to determine the extent of changes that result in changes in the urban microclimate. The NDVI interpretation in Malang City is classified based on non-vegetation, low-vegetation, medium-vegetation, and high-vegetation. This interpretation is illustrated by a lighter green color getting darker. Based on the spatial analysis conducted with the NIR and Red bands, it is known that the most changes in the 2016-2020 period were in the non-vegetation category, which reached 38% changes in 2018 to 2019.

TABLE 3. NDVI CHANGING IN 2016-2020

Klasifikasi	Luas					Prosentase Perubahan			
	2016	2017	2018	2019	2020	2017	2018	2019	2020
Non Vegetasi	67.86	34.44	21.60	37.90	73.35	-49.25	-37.28	75.48	93.51
Sangat Rendah	746.07	724.41	584.20	856.28	1032.05	-2.90	-19.35	46.57	20.53
Rendah	1594.95	1827.02	1791.09	1946.33	1780.97	14.55	-1.97	8.67	-8.50
Sedang	2167.30	2270.63	2481.51	2348.98	2089.65	4.77	9.29	-5.34	-11.04
Tinggi	6410.06	6129.74	6107.84	5796.75	6010.23	-4.37	-0.36	-5.09	3.68

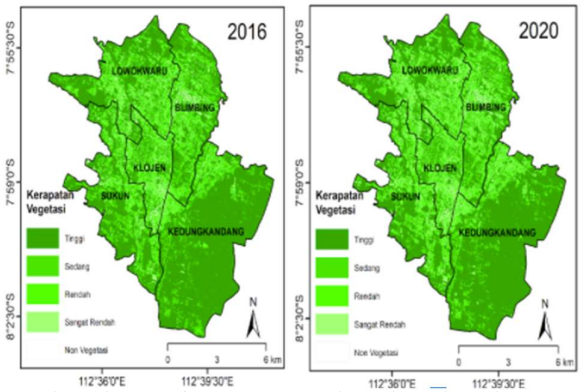

Fig 6. The Map of NDVI at 2016 and 2020 in Malang City

D. *Implications of land use change on Urban temperature*

Dense land use has implications for vegetation density. The denser the land use, the lower the vegetation density. This results in exposure to sunlight to the surface will reflect excess heat and affect changes in urban microclimate. It was identified that changes in ground surface temperature increased by 1.7 degrees Celsius at the highest temperature and 2.5 degrees Celsius at the lowest temperature. And the average temperature increase for five years is 0.5 degrees Celsius. The following table measures the temperature increase in Malang City.

TABLE 4. TABLE OF TEMPERATURE IN 2016 - 2020

Temperature	Year				
	2016	2017	2018	2019	2020
Maximum	35.53	37.11	36.71	36.62	36.12
Mean	32.39	34.35	34.33	34.40	33.53
Minimum	27.48	29.12	29.54	29.28	28.56

Based on the table above, it can be seen that there is a change in temperature in the Malang city area. The maximum temperature increase occurred in 2017, namely: 37.11, while the highest average temperature throughout the year was in 2019. However, in 2020 there was a significant decrease in temperature.

The increase in temperature in the area causes discomfort for humans so that it requires more energy to lower the temperature to reach a comfortable standard [11]. The decrease in temperature, especially in the room, is done by using air conditioning or a fan so that it requires electrical energy as the driving force.

The increase in temperature will also impact the occurrence of urban heat islands in the area. Consequences of urban heat island on human health caused by thermal stress [12]. These health problems include an increased risk of heart disease, lung disease, mental health, anxiety, and other health risks for children and the elderly. [13].

IV. Conclusion

Development in Malang City has an impact on changes in land use patterns. In 2016-2020 there has been a significant change in land use patterns. This can be seen from the increase in the built-up area and the reduction in the green area. Seen from the index value obtained, in 2018-2019, as many as 38% there was a change in the non-green category. Changes in non-green areas cause changes in urban temperature, where the average temperature increases every year (reaching 0.5 C in the last five years). And suppose this temperature increase is not minimized. In that case, it will continue to impact the emergence of urban heat islands, which have a significant risk on the city's sustainability in the future

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