SPATIAL DISTRIBUTION OF GREEN OPEN SPACES AND RELATION TO LAND SURFACE TEMPERATURE IN BANDAR LAMPUNG CITY

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Abstract. Bandar Lampung City, the capital city of Lampung Province in Indonesia, became the number three city on the island of Sumatra, with enormous population growth from 2000 to 2015. Population growth resulted in increasing built-up land affecting several aspects, one of which was the increase in surface temperature in urban areas. This study aims to determine changes in green open space, land surface temperature (LST), and the spatial pattern of changes in Bandar Lampung City. Data processing uses Landsat 8 imagery for green space and Google Earth Engine for LST. The results of this study indicate that the distribution of changes in green open space the east to west experienced a change in green open space to non-green open space which resulted in an increase in temperature in the east, southeast, and west, from 25-30oC the temperature increased to >30oC. The change in green open space in the west and some areas found that a change from non-RTH to a public or private green open space resulted in a decrease in temperature starting from 25-30oC decreased to 20-25oC. The spatial pattern of changes in green open space in Bandar Lampung City has a clustered pattern in the west and east of the area following the topography (100-500 masl). At the same time, the land surface temperature pattern (LST) in Bandar Lampung City has a clustered pattern at temperatures <20oC, 20-25oC (found at an altitude of 100-500 masl), and >30oC (following an altitude of 25-100 masl) while for temperatures 25-30oC has a scattered pattern (following an altitude of 25-100 masl) in Bandar Lampung City.

Keywords: *Land Cover, Landsat, Land surface temperature*

1 INTRODUCTION

The growth of urban areas cannot be separated from the process of urban development and expansion accompanied by an increase in population. The uncontrolled population mobility has resulted in a higher need for residential land and human activities in urban areas. This urban area impacts the conversion of vegetation land and green open space (RTH) into built-up land. Physically, the development of urban areas can be seen from the increasingly dense buildings and the expansion. Bandar Lampung City, the capital city of Lampung Province, became the number three city on Sumatra Island, with enormous population growth from 2000 to 2015. According to data from the Central Statistics Agency for Lampung Province (2021), the population of Bandar Lampung City has increased by 75% over the last decade. It is the most densely populated city in Lampung Province. As a result of the increase in the area of built-up land, infrastructure development causes changes in vegetated areas to decrease. As a result, the existing green open space (vegetation cover) decreases. The area of green open space in a city related to regional spatial planning must meet a minimum of 30% of the city area, with 20% being public (government) and 10% private (private/individual). In addition, it can also affect the state of surface temperature on the earth's surface, which is determined by several factors, such as land cover or land use. High surface temperatures tend to be found in areas of built-up land and more human activities. Conversely, low surface temperatures tend to be in vegetated land or Green Open Spaces (RTH).

2 MATERIALS AND METHODOLOGY

2.1 Location and Data

Lampung City is located at 5°20' to 5°30' S and 105°28' to 105°37' E. Bandar

Lampung is one of the cities in the province of Lampung and is located in Indonesia. Natar (North), Kaca District, Katibung District (South), Tanjung Bintang District (East) and Tataan District, Kaca District (West). The city of Bandar Lampung has a crucial geographical location on the island of Sumatra, located at the top of the island of Sumatra so that it becomes a connecting area between the islands of Java and Sumatra, primarily through the port. The development city is marked by the development of industrial and residential areas on the city's outskirts and infrastructure development such as the Trans Sumatra Toll Road construction. (Figure 2-1).

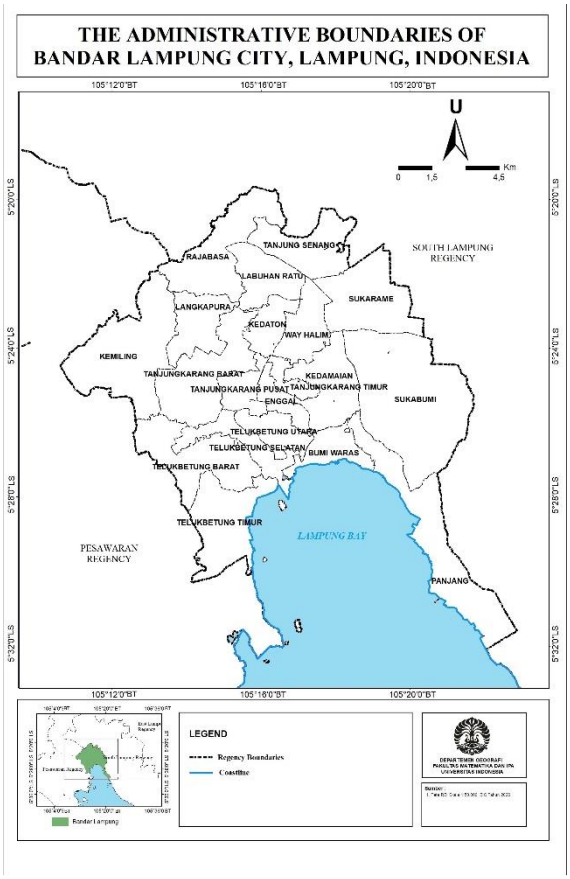


Figure 2-1: Bandar Lampung City Administration Map

This research used two types of data, namely primary and secondary data. Primary data is obtained from the results of a field survey, namely the validation of the surface temperature from a predetermined sample point. At the same time, secondary data is obtained from the results of data acquisition and processing through reliable sources such as administrative boundaries, land cover and others. The research used Landsat 8 OLI/TIRS (secondary data) imagery obtained in 2013, 2017, and 2021 for vegetation index and land surface temperature with cloud content of <10%. LST calculation uses Google Earth Engine. Before processing with vegetation and LST index equation, the first imagery must-corrected from cloud values and geometric correction. It can be the imagery of data corrected from distortion.

2.2 Methods

The NDVI vegetation index (Normalized Difference Vegetation Index) uses image data for 2013, 2017 and 2021 using the algorithm:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Where:
NIR = Reflectance value in the near-infrared band (band 5)
= Reflectance value in the red band (band 4)

Meanwhile, LST data is obtained from calculations using the Google Earth Engine, and processing takes 12 months from the research years 2013, 2017 and 2021. After that, it is classified according to research needs. The primary data in this study were AST values obtained from field surveys in the study area. The Linear Regression Model can answer the spatial relationship between the dependent and independent variables. The dependent is Green Open Space, and the independent is LST. The Data will be analysed using qualitative and quantitative methods. Qualitative analysis was carried out with a spatial approach. The spatial approach is used to analyse the spatial changes pattern of Green Open Space and Land Surface Temperature and the Relationship between Green Open Spaces, LST and AST.

The method used to classify land cover is employing Supervised Classification (Maximum Likelihood) and classification based on the Vegetation Index/NDVI with five types of classification, namely built-up land, water bodies, vacant land, agricultural land and hills with vegetation.

Table 2-1. Type and Source of Data

Data	Data Type	Data Source
The boundary of Region Administration	Secondary	RBI Map Bandar Lampung City, 1: 50.000, Geospatial Information Agency (BIG).
Normalised Difference Vegetation Index (NDVI)	Primary	Landsat 8 OLI/TIRS imagery 1: 50.000, USGS.
Land Cover (LC)		
Land Surface Temperature (LST)		
Air Surface Temperature (AST)	Primary	Field Survey.

Table 2-2. Land Cover Classification

Land Cover Classification	Description
Water Boundaries	*Permanent open waters, lakes, ponds*
Built-up Area	*Residential, commercial and services*
Fallow Land	*Hills, Hilly forests, yard vegetation*
Agricultural Land	*Barren land, open space*
Hill with Vegetation	*Land used for agriculture, rice fields*

The NDVI Processing method used ArcMap 10.8 software with band math tools. The results of NDVI image cuts or extracts with masks according to the administrative boundaries of Bandar Lampung City. Then the NDVI data is then classified using the Reclassify tool with classification according to "vegetation density" data in ArcMap 10.8 software.

Table 2-3. NDVI Classification

Score	NDVI Classification
< 0	*No vegetation*
0-0,2	*Very Sparse vegetation*
0,2-0,4	*Sparse vegetation*
0,4-0,6	*Medium dense vegetation*
> 0,6	*High dense Vegetation*

The method used to obtain the Ground Cover Temperature (LST) value is processing using the Google Earth Engine. This method is carried out to obtain representative temperature values because if data processing only uses one image in a particular month, it has the potential not to be representative of the temperature in that month. Then the ESG data processing from Google Earth Engine is carried out using 12 months of data.

Table 2-4. LST Classification

Score	LST Classification
< 20^{o}C	*Very low*
20^{o}C-25^{o}C	*Low*
25^{o}C-30^{o}C	*Moderate*
>30 ^{o}C	*High*

The AST data processing is statistical processing, which is a simple linear regression test to validate and determine its relationship with LST. Before performing a linear regression test on LST and AST variables, it is necessary to test the classical assumptions first.

This research was conducted using a spatial, temporal, descriptive, and statistical analysis approach. In this study, green open space (RTH) is the dependent variable, and the ground cover temperature (LST) is the independent variable.

3 RESULTS AND DISCUSSION

3.1 LAND COVER, GREEN OPEN SPACE (GOS) AND LST ANALYSIS

The result between 2013 to 2021, land cover in Bandar Lampung City Indonesian, we can see that there is an expansion in the built-up land. This was also followed by a decrease and change in the dynamics of cover in the form of agricultural land and hills with vegetation. (Figure 3-1).

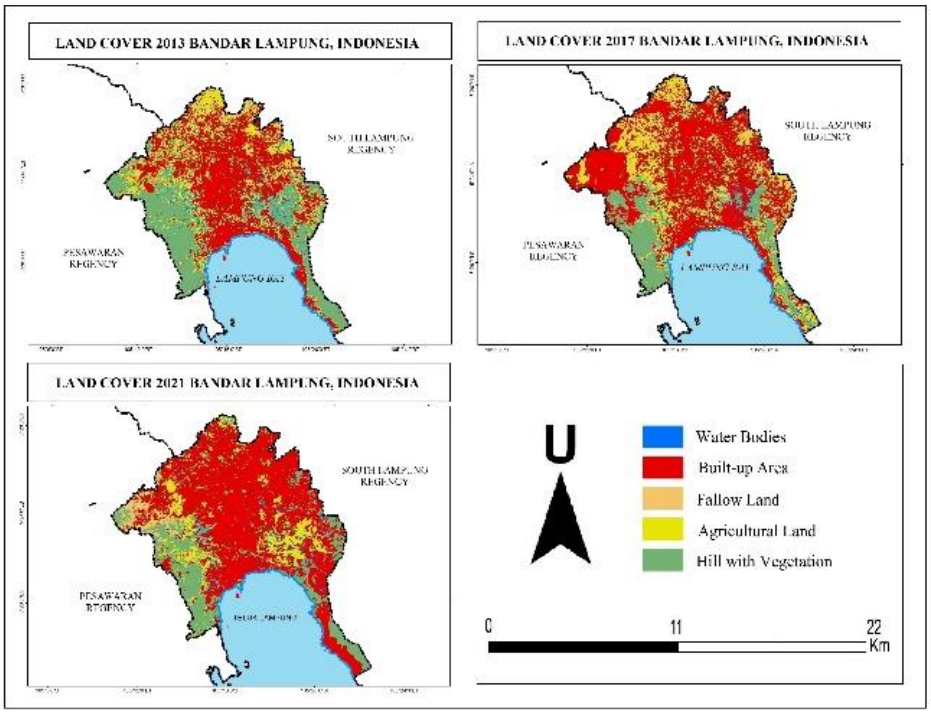


Figure 3-1: Bandar Lampung City Land Cover Distribution Map 2013,2017,2021

Table 3-1. Land Cover Density Area of Bandar Lampung City

Land Cover	2013		2017		2021	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Water Bodies	456,4	2,6	360,1	2,0	386,7	2,2
Fallow Land	401,7	2,3	410,6	2,3	642,4	3,6
Built-up Area	8.269,3	46,4	9.756,8	54,8	10.683,4	60,0
Agricultural Land	4.182,9	23,5	4.344,6	24,4	2.220,13	12,5
Hill with Vegetation	4.509,9	25,3	2.947,5	16,5	3.887,1	21,8

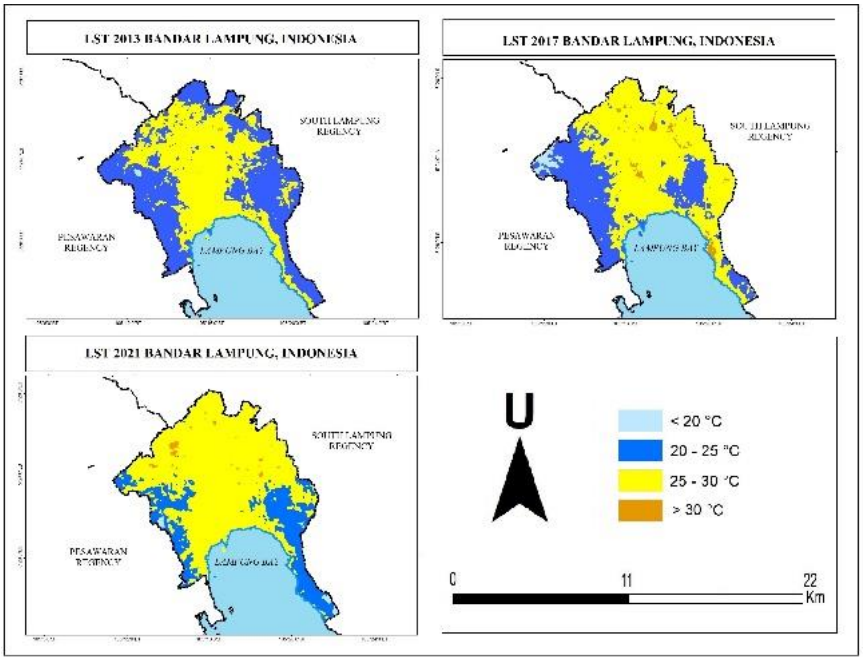


Figure 3-2: Bandar Lampung City LST Distribution Map 2013,2017,2021

Table 3-1 explains that in 2013 the city of Bandar Lampung had a land cover of 8,269.3 ha in the form of built-up area, furthermore, built-up area in 2017 and 2021, the land cover for built-up area increased to 9,756.8 ha (2017) and 10,683.4 (2021). On the other hand, the total area of vegetation (agricultural land and hills with vegetation) in 2013 had 8,692.8 Ha (the widest). Then the vegetation decreased in 2017 become 7,292.1 Ha, and in 2021, with an area of 6,107.2 Ha.

Based on Figure 3-2 explained that in 2013 LST was dominated by temperatures of 20-25 ^{o}C in the east and west, then temperatures of 25-30 ^{o}C tended to be in the central and southern parts of Bandar Lampung City, while in 2017, areas with temperatures of 20 -25 ^{o}C have increased in the east to a temperature of 25-30 ^{o}C. The temperature has expanded towards the west-northwest and east of Bandar Lampung City. In 2021, the temperature in Bandar Lampung City will be dominated by temperatures of 25-30 ^{o}C which continue to expand, and temperatures of 20-25 ^{o}C, which continue to increase. During the last 10 years, LST in Bandar Lampung City has experienced expansion.

From table 3-2, the distribution of LST in Bandar Lampung City is strengthened by processing. In 2013 there were 48.6% or an area of 8,652 Ha from Bandar Lampung City, which had an LST of 25-30^{o}C. Then in 2017, LST 20-25 ^{o}C expanded to an area of 11,271.3 Ha or 63.3% and continued to increase until 2020. In 2020, LST 25-30 ^{o}C expanded again to 73.6% of the total city area in Bandar Lampung, Lampung, Indonesia.

Based on Figure 3-3, it can be seen that between 2013, 2017 and 2021, green open space decreased in the area each year. Changes in public green open space experienced a broad change from the initial public green open space in the west to be reduced in 2021. Meanwhile, private green open spaces also experienced a decrease in area, initially clustered into scattered throughout the city of Bandar Lampung, Indonesia.

From table 3-3, green open space in 2013 is the highest category of private green open space and public green open space compared to 2017 and 2021. The percentage of green open space was 48.8% of the total area of Bandar Lampung in 2013, consisting of private green open space and public green open space. Meanwhile, in 2017, the area of private green open space and public green open space decreased to 40.9% of the total area of Bandar Lampung City. Based on 2021 data, private green open space and public green open space have decreased, reaching 33.4% of the total area of Bandar Lampung City. Thus, 2021 has the lowest green open space area category with 5,943.7 Ha and the largest non-RTH area with 11,875.9 Ha compared to 2013 and 2017.

Table 3-2. LST Area of Bandar Lampung City

Land Surface Temperature	2013		2017		2021	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
<20 ^{o}C	57,05	0,3	217,30	1,2	144,36	0,8
20 – 25 ^{o}C	9.099,43	51,1	6.184,19	34,7	4.298,01	24,1
25 – 30 ^{o}C	8.652,00	48,6	11.271,30	63,3	13.122,15	73,6
> 30 ^{o}C	10,50	0,1	146,20	0,8	254,92	1,4

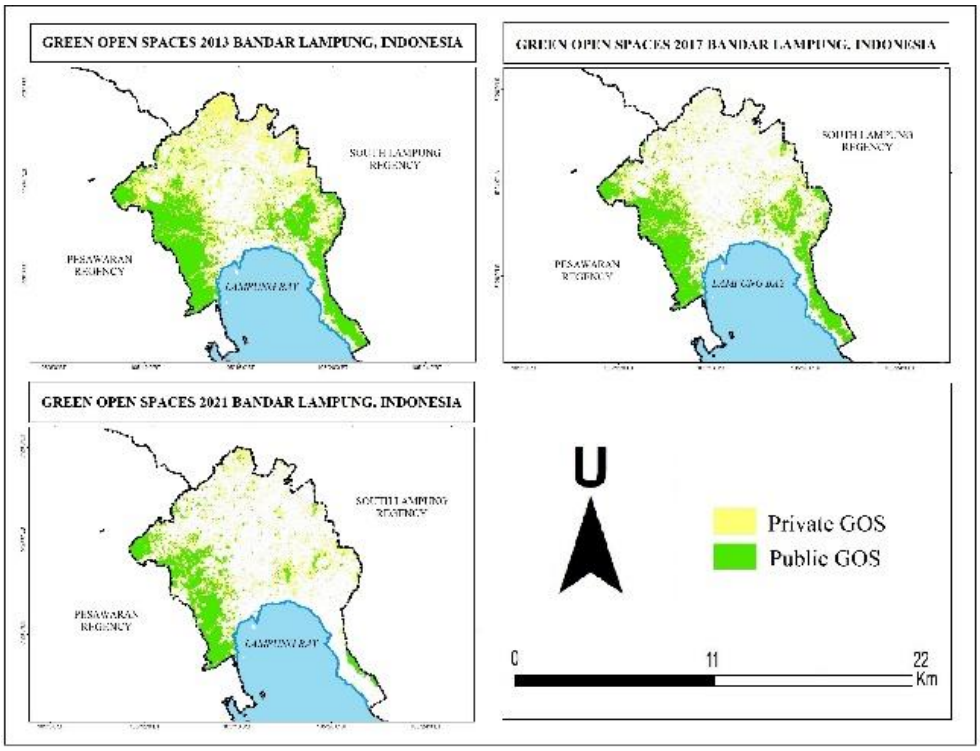


Figure 3-3: Bandar Lampung City Green Open Space Distribution Map 2013,2017,2021

Table 3-3. LST Area of Bandar Lampung City

Year	2013	2017	
	Non-Green Open Space	Private Green Open Space	Public Green Open Space
2013	9.126,9	4.182,91	4.509,87
Total	9.126,9	8.692,8	
Percentage (%)	**44,3 %**	**48,8 %**	
2017	10.525,9	3.173,04	4.120,7
Total	10.525,9	7.293,7	
Percentage (%)	**59,1 %**	**40,9 %**	
2021	11.875,9	2.306,18	3.637,6
Total	11.875,9	5.943,7	
Percentage (%)	**66,6 %**	**33,4 %**	

3.2. GREEN OPEN SPACE AND LST CHANGE MAP

Based on Figures 3-4, there will be changes in the area's dynamics and cover changes in 2013-2021. Changes in green open space refer to five (5) categories, including changes from non-green open space to private green open space and public green open space represented by green gradations. A yellow-orange color gradation represents changes from Private Green Areas to Non-Green Areas and Public Green Areas, and the change from Public Green Areas to Non-Green Areas is represented by red.

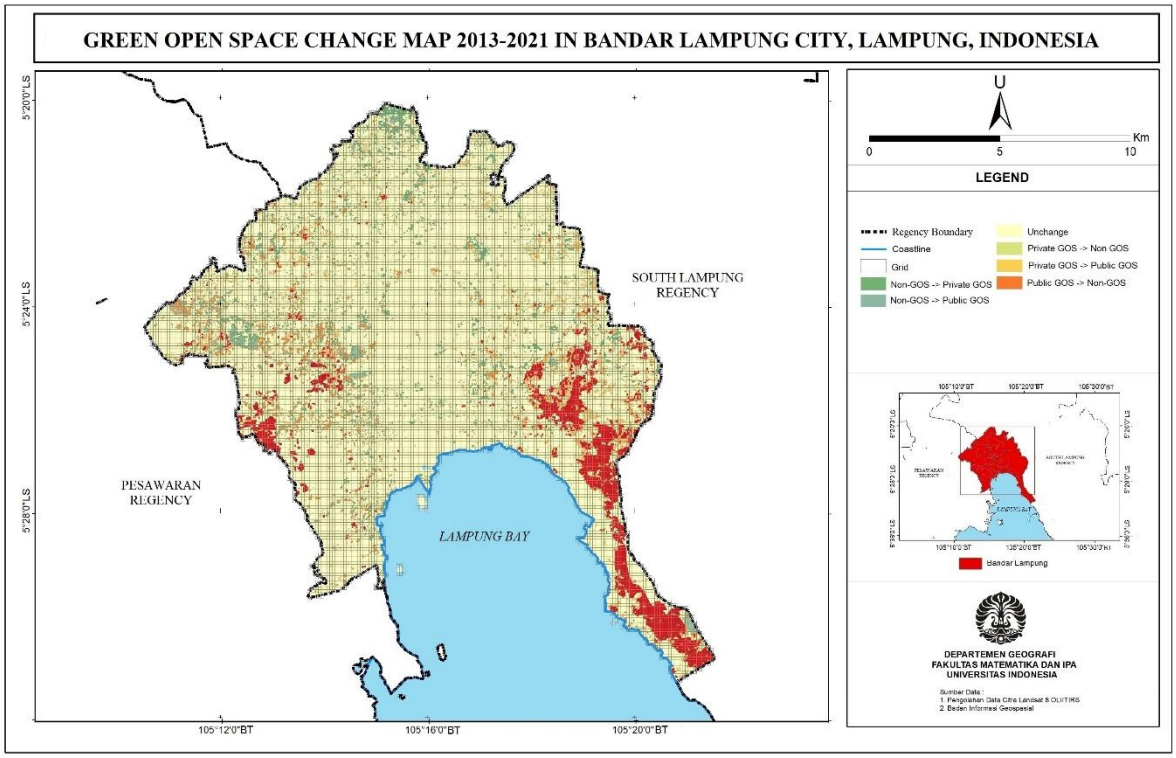
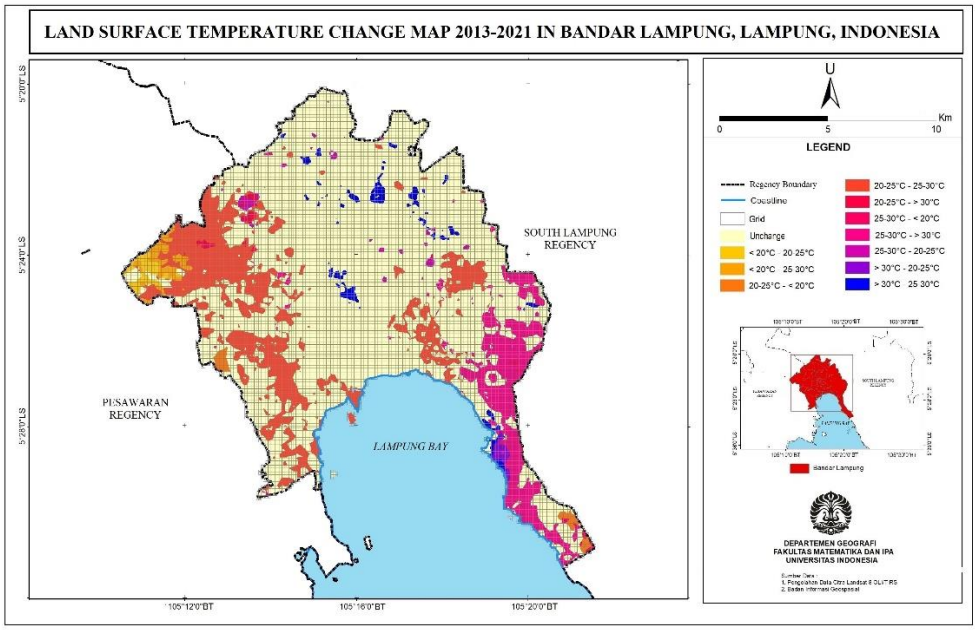


Figure 3-4: Bandar Lampung City Green Open Space Change Distribution Map 2013,2017,2021.

From Table 3-4, In 2013-2021, there will be changes in the dynamics of the area as well as changes in cover. Changes in the areas of each green open space in 2013-2021 that occurred were 7,627.98 ha. The enormous change in area in 2013-2021 occurred in changes to non-green open space covering an area of 6,032.56 Ha. Based on Figures 3-5, there are changes in the dynamics of the area as well as changes in cover in 2013-2021. Changes in ESG values refer to ten (10) categories of changes, including changes that occur, including changes from LST values <20 ^{o}C to LST values >30 ^{o}C. For LST values <20 ^{o}C are represented by orange gradations, 20-25 ^{o}C are represented by red gradations, and LST values 25-30 ^{o}C are represented by purple gradations and LST values >30 ^{o}C are represented by purple-blue gradations.

Table 3-4. Green Open Space Changes Density Area 2013-2021

Green Open Space (GOS) Change	**2013-2021**	
	Area (Ha)	**Total**
Private GOS → Non GOS	4.695,68	6.032,56 Ha
Public GOS → Non GOS	1.336,88	
Non GOS → Private GOS	879,6	879,6 Ha
Non GOS → Public GOS	183,28	715,82 Ha
Private GOS → Publc GOS	532,54	
Total	**7.627,98 Ha**	



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From Table 3-5, In 2013-2021, there will be changes in the dynamics of the area as well as changes in cover. Changes in the area of each green open space in 2013-2021 that occurred were 7,627.98 ha.
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The enormous change in areas in 2013-2021 occurred in changes to Non green open space covering an area of 6,032.56 Ha

Table 3-5. Land Surface Temperature Changes Density Area 2013-2021

Land Surface Temperature (LST) Change	**2013-2021**
	Area (Ha)
20-25°C - < 20°C	460,82
25-30°C - < 20°C	
< 20°C - 20-25°C	1.084,77
> 30°C - 20-25°C	
< 20°C - 25-30°C	7.153,62
20-25°C - 25-30°C	
> 30°C - 25-30°C	
20-25°C - > 30°C	1.885,53
25-30°C - > 30°C	
Total	**10.584,74 Ha**

3.3 RELATIONSHIP OF GREEN OPEN SPACE, LST CHANGE MAP AND AST

From Table 3-6, The change in green open space in 2013-2021 caused a change in temperature in 2013-2021 in the city of Bandar Lampung. The changes that occur cause the temperature to increase and decrease with temperatures ranging from 25-30 ^{o}C, which means that the temperature in Bandar Lampung City is still classified as a temperature that can still be maintained below <30^{o}C. The distribution of private green open space and non-green open space is dominated by a temperature of 25-30 ^{o}C and public green open space with a temperature of < 20 ^{o}C and 20-25 ^{o}C.

Table 3-6. Relationship Green Open Space and LST Change Map in 2013-2021

Coordinate		Time	Grid	LST Change (2013-2021)	Green Open Space Change (2013-2021)
X	Y				
-5.3477	105.253	09.12 PM	O86-G89	25,5 → 30,5 ^{o}C (increase)	 Vegetation → Non-Vegetation
-5.429	105.325	11.34 PM	DA166	24,7 ^{o}C→30,4 ^{o}C (increase)	 Vegetation → Non-Vegetation
-5.411	105.217	09.37 PM	CG46	31,5 ^{o}C→28,9 ^{o}C (fall)	 Non-Vegetation → Vegetation

The spatial pattern of green open space and height changes is carried out in Bandar Lampung. The spatial pattern of changes in green open space in Bandar Lampung City tends to be in the east and west in Bandar Lampung City. This green area happens because there is a relationship between altitude and changes in green open space in Bandar Lampung City. The results of the changes in green open space in Bandar Lampung In Figures 3-6, it can be seen that the results of the "multinomial logistic City have a clustered pattern located in the west and east of the area in Bandar Lampung City. Analysis of green open space with height in Bandar Lampung City found that the green open space located in the east and west is similar to height (100-500 masl). Moreover, it is an urban forest that has been determined based on the "Decree of the Mayor of Bandar Lampung No. 413/04/HK/2010".

regression" relationship between RTH and LST. The results regression

relationship of the two variables was 0.734 in 2013, which strongly correlated with the overall percentage of 94.0%. The regression relationship of the two variables was 0.672 in 2017, which had a moderate relationship with an overall percentage of 92.0%. Moreover, the regression relationship between both variables is 0.502 in 2021, which has a moderate relationship with an overall percentage of 83.0%.

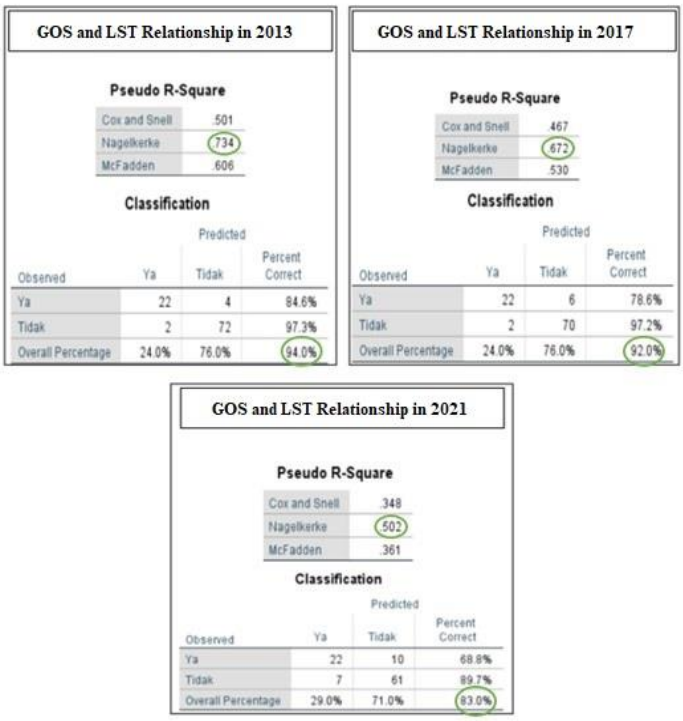
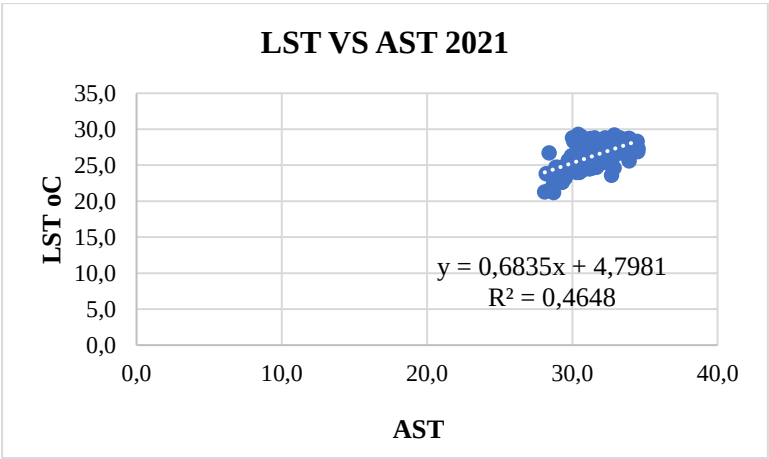


Figure 3-6: Relationship between Green Open Space and LST in 2013,2017, and 2021.

In graphs 3-1, it can be seen that LST and AST, the average air temperature in Bandar Lampung City, experienced a positive trend with the equation y = 0.6835x + 4.7981, indicating that there was an increase in air surface temperature of 0.6 oC/day. The graph above also has a coefficient of determination R2 = 0.4648, which means that the independent variable AST can explain the variance of the dependent variable. The LST variable is 46.4%. The value of the independent variable NDVI also has a correlation of R = 0.604 which means it has a positive correlation, where the more significant the LST value, the higher the AST value with a strong relationship. Therefore, the link between LST and AST in 2021 is strongly related.



Graph 3-1: Relationship LST vs AST in 2013,2017 and 2021.

4 CONCLUSIONS

The conclusion of this research are:

1. The distribution of green open space changes from east to west experienced a change in green open space to non-green open space, which increased from the temperature increase in the east, southeast, and west in Bandar Lampung City, which was initially at 25-30 ^{o}C and increased to > 30 ^{o}C. Meanwhile, the change in green open space occurred in the west, and some areas caused a change in non-green open space, becoming public or private green open spaces. Both resulted in a decrease in temperature in Bandar Lampung City, which was initially temperature 25-30 ^{o}C decreased to 20-25 ^{o}C.
2. The spatial pattern changes of green open space in Bandar Lampung City with the clustered pattern laid on the west and east of the region. The open space in the east and west follows the topographical height (100-500 masl) and is an urban forest determined based on the Mayor's Decree. Bandar Lampung". The pattern of ground cover temperature (LST) in Bandar Lampung City has a clustered pattern at temperatures <20 ^{o}C, 20-25 ^{o}C (found at an altitude of 100-500 masl) and >30 ^{o}C (following an altitude of 25-100 masl) while for a temperature of 25-30 ^{o}C has a scattered pattern (following an altitude of 25-100 masl) in Bandar Lampung City.

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REFERENCES

A, L, Suti., I, P, Ash Shidiq., Rokhmatulloh., A, Wibowo. (2021). Vegetation index-based biomass model and Land Surface Temperature (LST) from urban green spaces in Bandung City derived from multispectral imageries. *IOP Conference Series: Earth and Environmental Science.* 747.

Astuti, Sola Tri., & Fitria N. (2021). Identifikasi Local Climate Zone Sebagai Upaya Mitigasi Urban Heat Island di Kota Semarang. Geomedia, 19(1): 54-65.

A., & Irfan A. R. (2022). The Use of Local Climate Zones in The Urban Environment: A Systematic Review of Data Sources, Methods, And Themes. Urban Climate, 42: 1-17.

Badan Pusat Statistik Provinsi Lampung. (2021). Provinsi Lampung Dalam Angka Tahun 2021. Bandar Lampung: BPS Lampung.

Bannari, A, Morin, D., Bonn, F., Huete A. R. (1995). A Review of Vegetation Indices. *Remote Sensing Reviews*, 13(1-2): 95-120.

B.C. Bilgili & E. Gokyer. (2012). Urban Green Space System Planning Landscape Planning. Dr. Murat Ozyanaz (ed), inTech, ISBN: 978-953-51-4054-8, pp. 107-122-2012

Becker, F., Li Z. (1990). Toward of Local Split Window Method Over Land Surface. International Journal of Remote Sensing, 11(3): 369-393.

Derajat, R.M., Sopariah, Y., Aprilianti, S., Candra T.A., Aria, Rahmawan, T.H., Ridwana, R., & Sugandi, Dede. (2020). Klasifikasi Tutupan Lahan Menggunakan Citra Landsat 8 *Operational Land Imager (OLI)* di Kecamatan Pengandaran. *Jurnal Samudra Geografi:* Universitas Pendidikan Indonesia, Vol. 3(1): 1-10.

Dinas Pekerjaan Umum dan Perumahan Rakyat Kota Bandar Lampung. (2012). *Profil Kota Bandar Lampung*. Bandar Lampung: Dinas PUPR.

Effendi, R., Salsabila, H., Malik, A. (2018). Pemahaman Tentang Lingkungan Berkelanjutan. *MODUL:* 18 (2).

Faturahim, Nur, I.A., & Astrolabe, Sian, P.F.V. (2021). Sebaran Land Surface Temperature dan Indeks Vegetasi di Wilayah Kota Semarang Pada Bulan Oktober 2019. *Buletin Poltanesa*: Vol. 22(1): 45-52.

Hilmi Rachmadian R., Fikriyah Asyarifah R., Dhenti S., & Khairuna T. (2020). Analisis Distribusi Keruangan Kegiatan Ekonomi dengan Metode Tetangga Terdekat/*Nearest Neighbour*

Analysis (NNA), Gravitasi, dan Titik Henti/*Breaking Point* Pada Perusahaan Lapis Tugu Malang. *Jurnal Geografi: Universitas Negeri Malang,* Malang.

H. Rika., & D. Soni. (2018). Analisis Kerapatan Vegetasi Berbasiskan Data Citra Satelit Landsat Menggunakan Teknik NDVI di Kota Bandung Tahun 1990 dan 2017. *Seminar Nasional Itenas*. Bandung: D-33-D39.

Indonesia. Undang-Undang Nomor 26 Tahun 2007 tentang Penataan Ruang Pasal 5 ayat (1), Pasal 20, Pasal 25A, dan Pasal 33 ayat (3): Undang-Undang Dasar Negara Republik Indonesia Tahun 1945.

Jaya INS. 2010. Analisis Citra Digital: Perspektif Penginderaan Jauh untuk Pengelolaan Sumberdaya Alam. Bogor (ID): Institut Pertanian Bogor.

Kayet, N. Khanindra P., Abhisek C., & Satiprasad S. (2016). Spatial Impact of Land Use/Land Cover Change on Surface Temperature Distribution in Saranda Forest, Jharkhand. Modeling Earth Systems and Environment, 2(127): 1-10.

Kusuma, W.I., Kuffer.M., & Sutriadi, R. (2015). Analysis of Urban Surface Temperature for Green Spaces Planning in Bandung City, Indonesia. *Thesis Faculty of Geo-Information Science and Earth Observation of the University of Twente.*

Mardiansjah, F. H., & Paramita R. (2019). Urbanisasi dan Pertumbuhan Kota-Kota di Indonesia: Suatu Perbandingan Antar-Antar Kawasan Makro Indonesia. Jurnal Pengembangan Kota, 7(1): 91-110.

Meng, X., Jie C., Shaohua Z., Sihan L. & Yunjun Y. (2019). Estimating Land Surface Temperature from Landsat Data using The NOAA JPSS Enterprise Algorithm. *Remote Sensing*, 11(115): 1-18.

Pratiwi, K. (2019). Pengaruh Perubahan Tutupan Lahan Terhadap Suhu Permukaan (*Land Surfae Temperature*) Kota Semarang. *Skripsi* FMIPA UI.

Pradhesta, Y. F. Nurjani, E. & Arijuddin, B. I. (2012). Local Climate Zone Classification for Climate-based Urban Planning Using Landsat 8 Imagery (A case study in Yogyakarta Urban Area). IOP Conf. Ser: Earth Environ. Sci. 303.

Robiul, Husain, M., Paul, Alak. (2016). Spatio-Temporal Analysis of Land Use and Land Cover Changes in Chittagong City Corporation, Bangladesh. *International Journal of Advancement in Remote Sensing, GIS and Geography:* IJARSGG: Vol. 4(2): 56-72.

Stewart, I. D., & Oke T. R. (2012). Local Climate Zones for Urban Temperature Studies. Bull Am Meteorol Soc, 93(12): 1879-1900.

Wass H. J. D., & Nababan, B. (2010). Pemeteaan dan Analisis Index Vegetasi Mangrove di Pulau Saparua Maluku Tengah. E-Jurnal Ilmu dan Teknologi Kelautan Tropis, 2(1): 50-58.

Wibowo, A., Mohd, Yusoff, M., Tengku, Hamzah, A. A. binti., & I, P, Ashshidiq. (2020). Urban Heat Hazard Threat on University Campus (the University of Indonesia and the University of Malaya). *International Journal of GEOMATE,* 19:141-148.

Wibowo, A., Yusoff, M.M., & Shalleh, K. O. (2020). Monitoring Urban Heat Signature and Profiles of Localised Urban Environment in The University of Malaya. IOP Conference Series: Earth and Environmental Science, 481(1): 1-6.

Zhang, X. X., Wu. P. F., & Chen. B. (2010). Relationship Between Vegetation Greenness and Urban Heat Island Effect in Beijing City of China. Procedia Environmental Sciences, 2: 1438-1450.