Urban Heat Island Analysis of Gresik City East Java

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Abstract. Gresik is a regency in East Java that has the largest industrial area in East Java. With an industrial area of 2326.2 Ha, Gresik Regency is ranked as the first regency with the largest industrial area in East Java. Located on the North Coast of Java, Gresik has great potential for port and trade activities. The north of Gresik borders the Java Sea and the east borders the Madura Strait and Surabaya City. This condition also made the government inaugurate Gresik as the location of the Java Integrated Industrial and Ports Estate (KEK JIIPE) special economic zone. Along with the establishment of KEK JIIPE, there tends to be changes in land cover, from vegetated areas to built-up areas. The development process will affect the land area needed to support daily activities and affect the temperature which triggers the urban heat island phenomenon. This study aims to determine whether the land cover characteristics of Gresik Regency are associated with higher or lower surface temperatures. The urban heat island phenomenon is then analyzed using a remote sensing data approach through several extractions, namely the use of supervised classification, NDVI (Normalized Difference Vegetation Index) and LST (Land Surface Temperature). Data processing was carried out using Landsat 8 oil satellite images in 2023, 2022, 2021 and 2019. The processing results in the form of surface temperature distribution were then correlated with the value of vegetation index and land cover change using a simple regression test. The output and target achievement of this research is the proceedings of the ICSSL FISH international seminar in 2023.

Keywords: Surface Temperature, Land Cover, Urban Heat Island

1 Introduction

Gresik is a regency in East Java that has the largest industrial area in East Java. With an industrial area of 2326.2 Ha, Gresik Regency is ranked as the first district with the largest industrial area in East Java. Located on the North Coast of Java, Gresik has great potential for port and trade activities. The north of Gresik borders the Java Sea and the east borders the Madura Strait and Surabaya City. These conditions made the government formalize Gresik as the location of the Java Integrated Industrial and Ports Estate (KEK JIIPE) special economic zone. This ratification was stipulated through Government Regulation (PP) Number 71 of 2021 dated June 28, 2021 signed by President Joko Widodo. Java Integrated Industrial and Ports Estate (JIIPE) in Gresik, East Java Province, was officially authorized as a Gresik Special Economic Zone (KEK) with the theme of Technology and Manufacturing. KEK Gresik JIIPE is the first

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National Strategic Project (PSN) in Indonesia which combines modern industrial estates, deep sea ports, and international standard independent cities. The existence of JIIPE will more or less affect land cover changes, from vegetated areas to built-up areas. The development process will affect the land area needed to support industrial activities and affect the temperature which triggers the urban heat island phenomenon. This will bring changes in the average air temperature in the city, where the increase in built-up land and the reduction of green open space will trigger a contrast in surface radiance and air temperature in the city when compared to the village. This difference in air temperature between urban and rural areas is called the Urban Heat Island (UHI) effect. The Urban Heat Island phenomenon is influenced by several factors including land use in urban areas, minimal vegetation in urban areas, and surface temperature. [1]. This study aims to determine whether changes in land cover in Gresik Regency are associated with higher or lower surface temperatures. The urban heat island phenomenon was analyzed using a remote sensing data approach through several extractions, namely the use of supervised classification, NDVI (Normalized Difference Vegetation Index) and LST (Land Surface Temperature). Data processing was carried out using Landsat 8 oil satellite images in 2022, 2021 and 2019. The processing results in the form of surface temperature distribution were then correlated with the value of vegetation index and land cover change using a simple regression test.

The increase in human activity and the rapid development of built-up land has led to an increase in micro-temperature in urban areas called Urban Heat Island (hereinafter UHI) or heat island. The phenomenon of the heat island (Iswari) is characterized as an "island" of hot surface air that is concentrated in the city area, especially in the downtown area and will increasingly decrease in temperature in the surrounding area, namely in the suburban area. UHI occurs because there is a dominance of artificial materials that hold heat (heat storage) in the city area. The dominance of these artificial materials causes the trapping of solar radiation so that the surrounding temperature is getting higher. Temperature increases in urban areas are also triggered by anthropogenic heat release from urban activities such as industrial and transportation activities. [2]. Some factors that can trigger the occurrence of UHI in urban areas include the degree of heat of building materials, height and distance between buildings, and the level of air pollution. [3].

Urban Heat Island is formed when part of the vegetation is replaced by asphalt and concrete for roads, buildings and other structures. The replaced land surface absorbs more solar heat and also reflects it more, causing the surface temperature and ambient temperature to rise. The change of vegetation into concrete, asphalt, or open land will cause an increase in diurnal temperature, which in turn will also affect the climatological temperature. [4].

Land is the basic material of an environment related to a number of natural characteristics namely climate, geology, soil, topography, hydrology, and biology. Land use relates to human activities on a piece of land, while land cover is the physical manifestation of objects that cover the land. Land cover classification and land use classification are efforts to group various types of land cover or land use into a

commonality according to a certain system. Land cover classification and land use classification are used as guidelines or references in the remote sensing image interpretation process for the purpose of making land cover maps and land use maps. [5].

Classification is a technique used to remove detailed information from input data to display important patterns or spatial distributions to facilitate interpretation and analysis of imagery so that useful information can be obtained from the image. [6]. For land cover mapping, the results can be obtained from the multispectral classification process of satellite images. Multispectral classification begins with determining the pixel value of each object as a sample and then used as input in the classification process.

Supervised maximum likelihood classification is a classification based on pixel values that have been categorized by objects or made in training samples for each land cover object. Poor selection of training samples can result in less than optimal classification so that the accuracy obtained is low. Thus, statistical analysis or accuracy test of the training sample is needed. Accuracy test or accuracy test of land cover classification results in this study using the confusion matrix method. [7]

Normalized Difference Vegetation Index (NDVI) is a technique developed to identify the greenness of leaves in plants and is most commonly used to find vegetation index values. The vegetation index value is calculated as the ratio between the measured reflectance of the red band (R) and the infra-red band (approximated by the NIR band). The result of the red and infra-red band intersection yields the maximum difference between vegetation and soil. The original values of NDVI always ranged from -1 to +1 [8]. [8]. The calculation of the vegetation index value using the NDVI method can be seen in formula 1.

Land surface temperature (LST) is a state controlled by the energy balance of the surface, atmosphere, thermal properties of the surface, and subsurface media. [9]. The surface temperature of an area can be identified from Landsat satellite images extracted from thermal bands. The method of calculating LST or brightness temperature is done using formula 2.

2 Method

This type of research uses quantitative research. The research location is Gresik Regency, East Java. Determination of the research location was done purposively. Consideration of the selection of this research location is because Gresik Regency has the largest industrial area in East Java. The population and sample in this study were Gresik Regency, East Java Province. The data collection technique is by observation.

The types of data used are primary data and secondary data. Primary data includes the distribution of surface temperature samples in Gresik Regency. Secondary data includes Landsat 8 OLI satellite imagery in 2022-2019, RBI Map of Gresik Regency Scale 1: 25000 and SHP Administrative Boundaries. The tools used for data collection are infrared thermometer and GPS.

The data analysis used used the following steps: Guided classification or known as Supervised Classification is image processing by taking several pixel samples/region of interest to get the pixel characteristics of each object / class which is then grouped based on the characteristics of the pixel value. [10]. The classification stage in this study uses the maximum likelihood method. Accuracy is determined by the quality of sampling and the number of samples. The sample area is made using Region Of Interest (ROI). ROI must first be created before performing this supervised classification process.

NDVI (Normalized Difference Vegetation Index) is an algorithm for estimating vegetation index from satellite images. [11]. NDVI is also used to determine the density of vegetation in a particular area. In Landsat 8 images, NDVI processing uses channel 4 and channel 5. In the process of extracting surface temperature, thermal channels are used in Landsat satellite images. Landsat 8 uses band 10 [12]. Land Surface Temperature processing stages are divided into four stages, namely 1) Conversion of digital numper to radiance 2) Atmospheric correction of image radiance 3) Conversion of atmospheric corrected radiance to brightness temperature 4) Conversion of surface temperature from kelvin to centigrade units. Surface temperature sampling is carried out using an infrared thermometer on each existing land cover. This sampling was adjusted to the recording time of the Landsat image.

3 Result and Discussion

a. NDVI (Normalized Difference Vegetation Index Classification)

Gresik Regency is located between 7˚ -8˚ N and 112˚ - 133˚ E with an area of about 1,193.76 km² consisting of 18 sub-districts namely Tambak, Sangkapura, Ujungpangkah, Panceng, Dukun, Sidayu, Bungah, Manyar, Gresik, Kebomas, Duduk Sampeyan, Balongpanggang, Benjeng, Cerme, Menganti, Kedamean, Driyorejo and Wringinanom. The availability of green open space in Gresik Regency can be known from the results of processing Landsat 8 OLI images through Quantum GIS software by entering formula (2) so as to produce an index value between -1 to 1. The NDVI value of Gresik Regency from 2017 to 2021 is as follows:

Table 1. NDVI Value of Gresik District

Year	NDVI Value	
	Min	***Max***
2019	-0.501128	0.911712
2020	-0.416108	0.897223
2021	-0.314126	0.865811
2022	-0.397219	0.889401

Nilai NDVI Kabupaten Gresik dalam tabel 1 memiliki perbedaan setiap tahunnya. In 2018 the NDVI value obtained has the largest range, namely 1.493738 with a minimum NDVI value of -0.58153 and a maximum of 0.912208. Meanwhile, 2021 has the smallest range of NDVI values, namely 1.179937 with a minimum NDVI value of -0.314126 and a maximum of 0.865811. 2018 is the year with the highest maximum and minimum values compared to other years. The NDVI values of Gresik Regency were then classified into five land cover classifications.

b. Supervised Classification

Classification was conducted through a threshold test to determine the maximum and minimum thresholds for each land cover class. The formula used in the threshold test is formula (3). Nilai yang diperoleh setelah uji threshold dilakukan verifikasi. The verification results are shown in Table 2.

Table 2. Supervised Classification

Classification	**Threshold**	
	Min	***Max***
Water Body	< 0,193728963	0,193728963
Built-up Land	0,193728963	0,349091913
Open Land	0,349091913	0,521356613
Sawah	0,521356613	0,699125012
RTH	0,699125012	>0,699125012

In table 2 above, the lowest NDVI value is owned by the water body land cover type. Water bodies have a maximum limit of 0.193728963. The highest NDVI value is owned by the RTH land cover type. The minimum limit of RTH is 0.699125012. The index values in table 2 are used in processing the NDVI map of Gresik Regency. Data processing is done by reclassifying the table to find out the area of each type of land cover in Gresik Regency in a span of 4 years, namely 2019 to 2022.

Changes in land cover area include water bodies, built-up land, open land, rice fields and green spaces in Gresik Regency from 2019 to 2022. All types of land cover experienced changes in land area in each year. Rice fields are the type of land cover with the largest area in Gresik Regency. Rice fields experience a decrease in land area every year. In 2019, rice fields amounted to 31% of the total area of Gresik Regency. In 2022 the rice field area will be 24% of the total area of Gresik Regency. Open land is the type of land cover that has the largest area after rice fields. The area of open land in 2019 amounted to 251.29 km² or 21% of the total area of Gresik Regency. Open land experienced a drastic decline in 2020 until the area was only 184.76 km². In 2022 open land also experienced a drastic increase to 324.45 km² with a percentage of 27% of the entire Gresik Regency area. This makes open land the largest type of land cover in 2022. Fluctuations experienced by built-up land cover. Fluctuations occurred quite

stable from 2019 to 2022. In 2022 there was a surge in the addition of built-up land area from an area of 163.65 km² in 2022 to 248.2 km² or around 21% of the total area of Gresik Regency. The increase in built-up land area occurred by 7% in that one year.

In research [13] the maximum limit value of water bodies is -0.026684 and the minimum limit value of open space is 0.57391. Differences also exist in the classification of built-up land and open land. Built-up land has a higher NDVI value than the NDVI value of open land. Whereas in this study, open land has a higher NDVI value compared to the NDVI value of built-up land.

Differences in the classification of land cover types were also found in the study of [14]. In its classification, rice field land cover has a higher NDVI value compared to green space land cover. The NDVI value of rice fields obtained was between 0.029-0.550 and RTH between 0.004-0.029. In contrast to the classification in this study, RTH has a higher NDVI value compared to paddy fields. NDVI value of RTH is between 0.6991250120->699125012, while NDVI value of paddy fields is between 0.521356613-0.699125012.

The increase in the area of built-up land is in line with the reduction in the area of green spaces in Gresik Regency. The availability of green spaces in Gresik Regency is only 13% of the total area. [15] in his research said that there is a relationship between the Urban Heat Island (UHI) phenomenon in Makassar City and the area of Green Open Space (RTH). Research results [15] showed a reduction in green space area followed by an increase in surface temperature in Makassar City in 2013 and 2018. The research concluded that every additional 1 km² of green open space can reduce the temperature by 0.0689°C and vice versa.

Research [15] similar to research [16] which states that the surface temperature in Kendari City is strongly influenced by the availability of green space as a surface temperature cooler. Research results [17] also shows that there is a relationship between land cover change and the level of thermal comfort, the increasing area of built-up land and the decreasing area of vegetation land and open land causes the value of comfort level. thermal increases, the increasing value of THI indicates uncomfortable conditions for humans. The importance of the availability of green open space can also be seen from the Gerarkis formula by Wisesa 1988 that the human oxygen demand per day per person is the same at 600 liters / day or 0.864 kg / day. Therefore, Gresik Regency needs to increase the availability of green spaces to reach 30% to meet oxygen needs and keep the ecosystem (hydrology, microclimate, ecology) of the region balanced.

4 Conclusion

The results of the interpretation and analysis of temperature changes and UHI in Gresik Regency from 2019 to 2022 can be concluded that the conditions of temperature change are always changing but only focused in locations that have high mobility and development levels. The difference in surface temperature in Gresik Regency can be a factor in the UHI phenomenon, this can be shown by the results of LST and NDVI processing which are able to produce temperature class data. Meanwhile, the Urban

Heat Island in Gresik Regency spreads around the city center area with a high level of mobility and high development in 2022 almost evenly distributed in the city center administrative area, in contrast to 2019 UHI has decreased even though it has decreased but the UHI area has increased with a decrease in green vegetation areas. And this UHI phenomenon moves towards the south of Gresik. The relationship between vegetation density and the UHI phenomenon in Gresik Regency is inversely proportional, namely if the area of built-up area is getting bigger and vegetation is decreasing, the surface temperature will be higher, and vice versa. This phenomenon shows that with NDVI class density or very high density levels do not have UHI phenomena. while in the NDVI class very low density to moderate greenness has a fairly high UHI.

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