IRSAJ
International Remote Sensing Applied Journal
e_ISSN =2775-3409
p_ISSN =_____-_____
Vol 2 No 1 | June 2021

UTILIZATION OF REMOTE SENSING FOR LAND SURFACE TEMPERATURE (LST) DISTRIBUTION MAPPING IN SOLOK CITY IN 2021

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ABSTRACT: Solok City is one of the cities in West Sumatra which has a fairly rapid population growth, this has led to an increase in development and a decrease in green open land or vegetation land. This affects the ground surface which absorbs and reflects more of the sun's heat. These conditions have an impact on rising surface temperatures. This research was conducted to analyze changes in vegetation land, built-up land and changes in surface temperature in Solok City using Landsat-8 Imagery of Solok City in 2015 and 2021 using the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDVI) algorithm models. (NDBI) and Land Surface Temperature (LST). The results of the study explain that the normalized difference vegetation index (NDVI) in Solok City has decreased, in 2015 the area of vegetation density was 2344 Ha and in 2021 it was reduced to 1888 Ha. This is in line with the increase in building area / Normalized Difference Built-up Index (NDBI) in 2015, namely 1 from 921 Ha to 2295 Ha in 2021. Reduced vegetation area and increased built-up area increased Land Surface Temperature (LST) in the area. research, the temperature in 2015 was around 32.9° C and in 2021 there was an increase in surface temperature to 33.6° C. Pearson product-moment correlation was carried out to see the level of relationship between LST and NDVI and NDBI.

Keywords: Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), Land Surface Temperature (LST)

1. INTRODUCTION

An increase in surface temperature is a phenomenon of rising surface temperature caused by several factors, both directly and indirectly. One of them is due to the rapid increase in urbanization. Indonesia is a country experiencing rising temperatures due to urbanization. Urbanization is a phenomenon of the movement of rural populations to urban areas or urban areas. This will have an impact on increasing the population, and in the future will bring about various changes, such as changes in land use or land cover to become building land that is difficult to evaporate.

The population density in the city can increase due to the increase in population. Population growth can increase the number of residences so there are many changes in land use (Iyengar, 2003). The land originally used for agriculture and animal husbandry can be purchased or converted into non-agricultural or animal husbandry activities such as settlements and industry (Bakker et al., 2015).

Rapid development has led to changes in land cover, where built-up land increasingly dominates and forces natural lands (forests) to change functions. In line with urban development, increasing pressure on land and areas classified as natural carbon stock areas (forests), results in changes in carbon stocks every year (Pribadi et al., 2006). Urbanization or the recent movement of people from villages to cities has been the cause of changes in land use in urban areas. The development of urban areas with population growth like this has resulted in the number of green areas or vegetation decreasing.

with the demand for settlement needs and built-up areas. This situation will affect the redistribution of solar radiation, and trigger the contrast of surface radiation temperature and air between urban and rural areas (Weng, in Nala Hutasoit, 2010).

Solok City is a city that has a fairly rapid population growth, an increasingly dense population growth requires space for residence, especially in urban areas. This causes the development of built-up land. The conversion of land into built-up land that occurs in Solok City can increase the surface temperature in Solok City. The lack of vegetation due to land conversion from vegetation land to built-up land that occurs in Solok City will result in accelerating the increase in surface temperature in Solok City.

Land surface temperature (LST) is one of the important climatic elements in the energy balance so if there is a change in surface temperature, the potential changes other climate elements. The more increasing activity conversion of undeveloped land to built-up land is a result of the rate of urbanization in Solok City. This research is intended to see the distribution of Land Surface Temperature (LST) in Solok City, the results of this study can be used as input for stakeholders in Solok City regional planning in the future.

2. THE METHOD

2.1 Types of research

Quantitative approach method with Classification of Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI) and Land Surface Temperature (LST).

2.2 Time & Location of Research

The research was conducted from September 2021 to April 2022 with the study area being Solok City, West Sumatra Province.

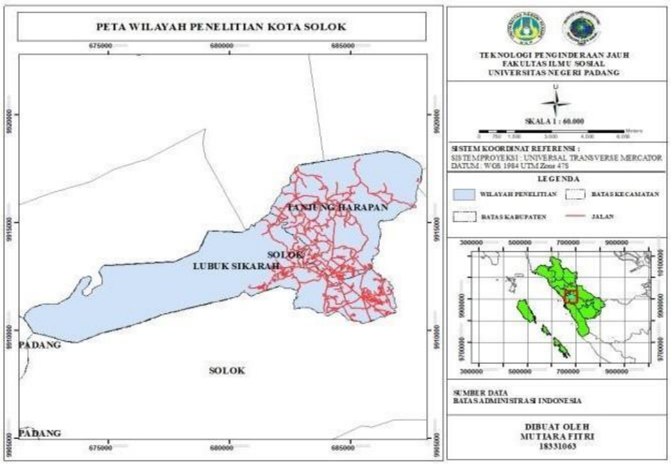

Fig. 1 study area being Solok City, West Sumatra Province.

2.3 Tools and Materials

The tools and materials used to support the research are as follows:

Table 3. Tools used in research

equipment	Utility
Laptop	Data analysis
Software ENVI	Land Surface Temperatur
Software ArcGis	Map Layout
stationery	writing

e_ISSN =2775-3409
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Table 4. Materials used in the study

equipment	Utility
Landsat 8 Image 2021	USgs EarthExplorer
Landsat 8 Image 2015	USgs EarthExplorer
Map Administration	Bappeda

2.4 Data Analysis Stage

1. Identification of Vegetation Density (NDVI)

The density of vegetation on Landsat imagery can be identified from the Normalized Difference Vegetation Index (NDVI). NDVI is calculated on a per-pixel basis from the normalization difference between the red and near-infrared bands of the image. The formula for NDVI is:

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

Information : NIR = band near-infrared, RED = band red

2. Identification of Normalized Difference Built-up Index (NDBI)

NDBI (Normalized Difference Built-up Index) or built-up land index is an algorithm to show the density of built-up land/bare soil. NDBI makes use of the near-infrared and mid-infrared bands.The NDBI formula is as follows:

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}$$

Information : SWIR = Shorewave Infrared, NIR= Near Infrared

3. Identification of Land Surface Temperature (LST)

Data on satellite imagery when it is just downloaded is still in the form of a digital number, so it must go through several conversion stages first to get the actual surface temperature value. What needs to be done is

Changing the Digital Number (DN) value to TOA radiance (radiance value) using the band math tool uses the following equation:

Information :

L□ = TOA radiance (radiance value) ML = Band-specific multiplicative rescaling factor (found in metadata)
AL = Band-specific additive rescaling factor (in metadata)
Qcal = DN at each pixel in the Landsat image band

Change the radiance value to brightness temperature using the math band tools according to the equation:

$$T = K2 / \{a \log(k1 / L\lambda + 1)\}$$

IRSAJ
International Remote Sensing Applied Journal
e_ISSN =2775-3409
p_ISSN =______-_____
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Information :
T = Brightness temperature L□ □ TOA radians
K1 = thermal constant band 10 or 11 (found in metadata)
K 2 = band 10 or 11 thermal constant (found in metadata)

Bands or channels in the image that can be used for extraction of LST values are bands that have Thermal channels. In Landsat 8 imagery, there are only 2 bands that have Thermal channels, namely Band 10 and Band 11.

The following is the algorithm for Band 10, then the radiance value will change to the brightness temperature in degrees kelvin (K):

$$1321.08/ \text{alog} (774.89 / b1+1)$$

Next convert temperature brightness in degrees Celsius (C)

$$C = K - 273 = b1-273$$

4. Accuracy Test

Conduct field validation to see the correctness of the calculation results of the 2015 and 2020 LST estimates. This activity is needed to find out how much difference or similarity is obtained from the processed image results with field events. Checking the temperature in the field using a tool infrared thermometers and digital thermometers. To find out the relationship between LST temperature processing results and temperature from field validation, you can use the Confusion Matrix accuracy test.

The accuracy or thoroughness test is an attempt to determine the level of truth of interpretation and mapping results, this is done to find out the amount of trust given to remote sensing interpretation data or mapping, this is done to find out the amount of trust given to remote sensing interpretation data (Sutanto, 1994: 116-118).

The method used to test the accuracy of the mapping is the confusion matrix table, which is a table created to link the results of classification or mapping with the results of the data obtained for accuracy tests from the field. The accuracy test of the classification results is needed as a scientific justification regarding the appropriateness of the approach or method used and to recommend how much the level of truth of the interpretation results is. The accuracy test used in this study is the accuracy test of interpretation results based on the method performed using the Short method (confusion matrix) (1982).

3. RESULTS AND DISCUSSION

3.1 Vegetation Density / NDVI Year 2015 and 2021

The density of vegetation on Landsat imagery can be identified from the Normalized Difference Vegetation Index (NDVI). The NDVI algorithm is obtained from the ratio between the red band and the near-infrared band from remote sensing imagery, so the "green" index of vegetation can be determined. Normalized Difference Vegetation Index (NDVI) is the most commonly used ratio index for vegetation. NDVI is calculated on a per-pixel basis from the normalization difference between the red and near-infrared bands of the image.
NDVI identification can be done in ArcGIS by using the raster calculator tool by entering the values for the near-infrared band (Near Infrared) and the red band (Red). Then the raster results from these calculations are cut according to the research area, namely the City of Solok. Then adjust the symbology and map layout to make it look more attractive. The following is a map of the vegetation density of Solok City in 2015 and 2021.

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International Remote Sensing Applied Journal
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p_ISSN =______-_____
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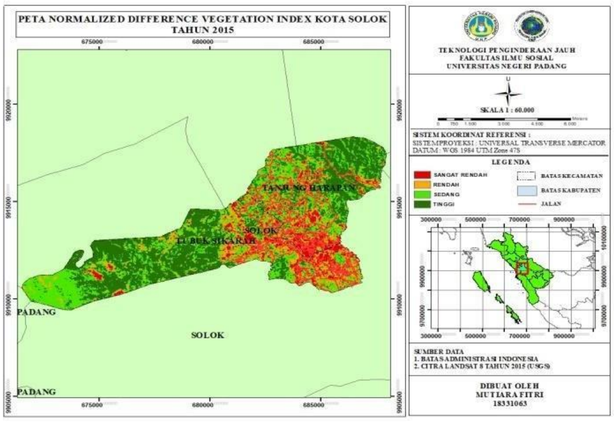

Fig 3.Solok City NDVI 2015

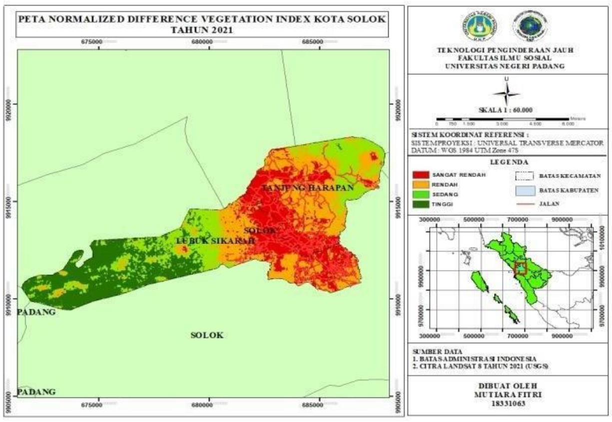

Fig 4. NDVI Solok City in 2021

The overall area of the class in the NDVI classification can be seen in the following table. Table of the area of vegetation density/NDVI classification classes in 2015 and 2021 in Solok City.

Table 3. class in the NDVI classification

density class	Wide 2015	Wide 2021
tall	2344	1889
currently	1967	1519
low	1003	1358
very low	770	1319

Based on the results of NDVI processing in Solok City in 2015, a minimum value of -0.10 was obtained and a maximum value of 0.63. In 2021 a minimum value of 0.04 and a maximum value of 0.47 are obtained. Classification is carried out as the NDVI classification, which consists of 4 classes, namely high which is shown in dark green, medium is shown in light green, low is shown in yellow and very low is shown in red.

From the identification carried out in 2015, it was found that the class was very low in the Pasar Pandan Air Mati area, Aro IV Koorong, Koto Panjang, Sinapa Piliang. The medium low-density class is dominated by the VI Tribe area, Kampai Tabu Karambia, and Simpang Rumbio. Medium-density classes are found in areas IX Korong, Kampung Jawa, Nan Balimo, and Tanjung Paku and high-density classes are dominated by Laing and Tanah Garam areas.

In the identification carried out in 2021, the high-density class was found in the Tanah Garam area, the medium-density class was found in the Laing area, the low-density class was found in the VI Suku, IX Korong, Nan Balimo and Tanjung Paku areas, then the very low-density class was dominated by the area of Kampai Tabu

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Kerambil, Simpang Rumbio, Pasar Pandan Air Mati, Aro VI Korong, Koto Panjang, Sinapa Piliang, Kampung Jawa.

3.2 Building Density / NDBI in 2015 and 2021

NDBI which is also known as the Normalized Difference Built-up Index and UI (Urban Index) is an index that is very sensitive to built-up land or open land developed to highlight the appearance of built-up land compared to other objects. The NDBI index will focus on highlighting urban or built-up areas where there is usually a higher reflectance in the Shortwave Infrared (SWIR) area, when compared to the Near-Infrared (NIR) area. NDBI identification can be done by entering the band value
Shortwave Infrared and Near Infrared bands. Then the raster results from these calculations are cut according to the study area. Then adjust the symbology and map layout to make it look more attractive.
NDBI Map of Solok City in 2015 and 2021.

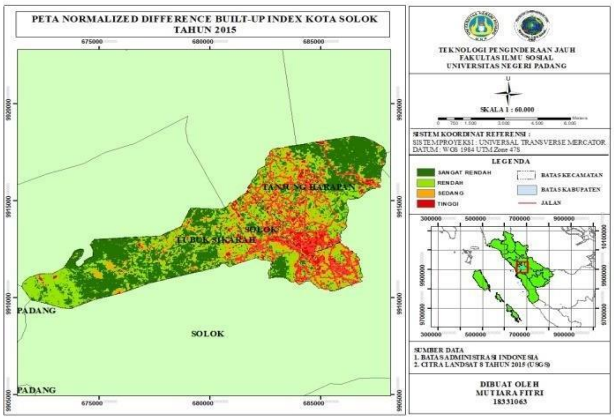

Fig. 5.NDBI Solok City 2015

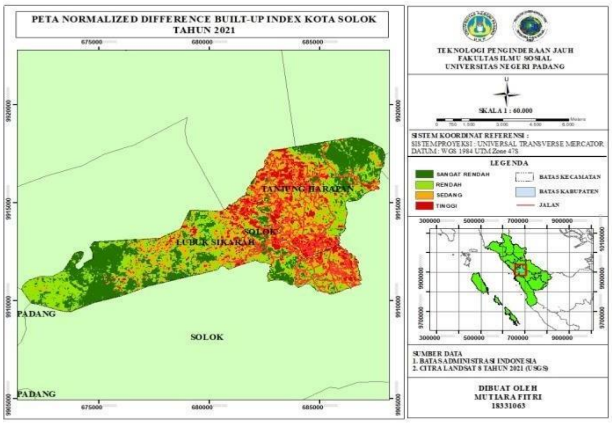

Fig 6.NDBI Solok City in 2021

The total area of classes in the NDBI classification can be seen in the following table. Table of the area of the NDBI classification class in 2015 and 2021 in Solok City.

Table 4. classification class in 2015 and 2021 in Solok City

density class	Wide 2015	Wide 2021
tall	1921	2295
currently	1652	2050
low	1556	1080
very low	953	659

The high-density class in 2015 was 1,921 ha, the medium class was 1,652 ha, the low class was 1,556 ha and the very low class was 953 ha. Whereas in 2021 the high-density class will increase so that the area will be 2,295 ha, the medium class will be 2,050 ha, the low class will be 1,080 ha and the very low class of 659 ha.

From the identification carried out in 2015, it was found that the class was very low in the Tanah Garam area, Lubuk Sikarah, Laing. The medium-density class is dominated by areas VI Suku and Tanjung Paku. The medium-density class is found in areas IX Korong, Kampung Jawa, Nan Balimo, and Tanjung Paku and high-density class is dominated by areas Aro IV Korong, Pasar Pandan Air Mati, Simpang Rumbio , Kampai Tabu Karambia and Sinapa Piliang

In the identification carried out in 2021, a high-density class was obtained in the Pasar Pandan Air Mati Aro IV Korong area, Kampung Jawa, Nan Balimo. The medium density class is found in the Sinapa Piliang, VI Suku, Tanjung Paku, Simpang Rumbio, and Sinapa Piliang areas. The low-density class is dominated by the IX Korong, Kampai Tabu Karambia, and Lubuk Sikarah areas and the very low-densityclass is dominated by the Tanah Garam and Laing areas.

3.3 Distribution of Land Surface Temperature (LST) in 2015 and 2021

To obtain a Land Surface Temperature (LST) map for Solok City, several steps need to be taken, namely changing the digital number value of the Landsat image to a TOA radiance or radian value. After the digital number value is converted to a radian spectral value, then the radian spectral value is converted to a temperature value resulting from the satellite imagery recording. The temperature recorded by Landsat imagery is the temperature in degrees Kelvin. So to convert it into degrees Celsius, use the formula K–273 to convert units of degrees Kelvin to degrees Celsius (273°K is equivalent to 0°C). The result of this conversion is the final result for the value of the surface temperature distribution.

The following is a map of the surface temperature distribution of Solok City in 2015 and 2021.

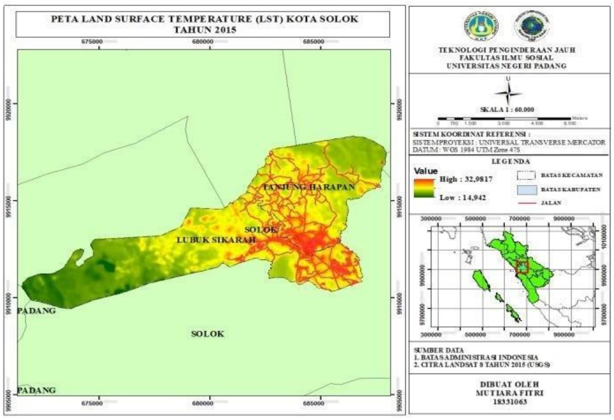

Fig 7.LST Solok City 2015

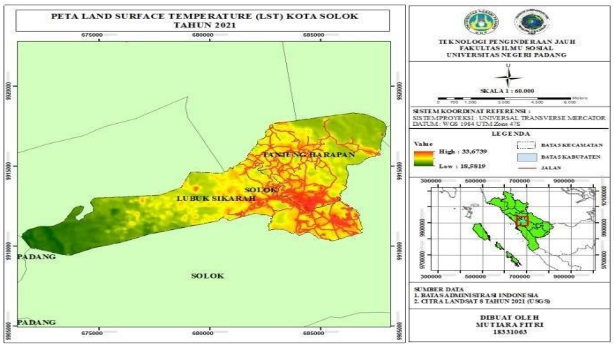

Fig 8.Solok City LST in 2021

Table 5. Solok City Surface Temperature

Land Surface	2015 (celcius)	2021(celcius)
Maximum Temp	32.9	33.6
average temperature	24.6	25.1
Minimum Temp.	14.9	18.5

Based on Landsat image data processing in 2015 and 2021, the minimum and maximum temperature values are obtained in Solok City. It can be seen on the surface temperature map that the green color of the map identifies low temperatures in that area and the red color shows high-temperature values in that area.

In 2015, the minimum temperature value was 14.9˚C and the maximum temperature was 32.9˚C with an average temperature of 24.6˚C. In 2021 a minimum temperature value of 18.5˚C and a maximum temperature are obtained of 33.6˚C with an average temperature of 25.1˚C. The minimum temperature value is located in the western part of Solok City (Lubuk Sikarah District) with high vegetation density, and the maximum temperature is dominated in the eastern part of Solok City (Tanjung Harapan District) with low vegetation density. The increase intemperature in the eastern part of Solok City is caused by an increase in built-up land which causes the area to absorb solar heat more quickly.

4. Accuracy Test

Landsat imagery spatial data classification results 8 OLI is validated using a contingency matrix or what is commonly called an error matrix (confusion matrix). This is done to see the accuracy of the accuracy/accuracy test, namely by comparing the results of the classification of satellite imagery data to the class of land cover/land use at the actual location. The method used in the accuracy test phase is the equalized random sample method. The distribution of random points will be automatically distributed by Argis software with a total of 23 points that have real data references. The real data reference from 23 random sample points is based on observations from Google Earth imagery.

Based on random sample observations made from 23 points distributed in the classification, some points are the same as the results of real observations using Google Earth and some points are different from the results of the observations. This error occurs because the type of land use is classified as color and hue which is similar to the other classes. True and false from the random sample distribution are then entered into the error matrix table which is useful for facilitating the process of calculating the accuracy value of a classification process.

4.1 NDVI Density Accuracy Test

Tabel 7. NDVI Density Accuracy Test

Classification	High	Medium	Low	Very low	Total (user)
Tall	7	0	0	0	7
Currently	2	4	0	0	6
Low	0	1	4	0	5
Very low	0	0	0	5	5
Total (producer)	9	5	4	5	23

Classification errors that occur in the classification results occur because the class has a color and hue that is almost the same as the color and hue of other classes. Based on Table 7 it can be seen that the high-density class contains 9 sample points which are classified correctly. In the medium-density class, 5 sample points are classified correctly and 2 points are classified into the high-density class. In the low-density class, 3 sample points are classified correctly and 1 sample point is classified in the medium-density class. In the very low-density class, 3 sample points are classified correctly. The overall accuracy of the classification results of the Normalized Difference Vegetation Index (NDVI) method is 86.9%.

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4.2 NDBI Density Accuracy Test

Tabel 8. NDBI Density Accuracy Test

Classification	High	Medium	Low	Very low	Total (user)
Tall	7	0	2	0	9
Currently	0	7	0	1	8
Low	0	0	4	0	4
Very low	0	0	0	2	2
Total (producer)	7	7	6	3	23

Classification errors that occur in the classification results occur because the class has a color and hue that is almost the same as the color and hue of other classes. Based on Table 9 it can be seen that the high-density class has 7 sample points classified correctly and 2 sample points are classified in the low-density class. In the medium-density class, 7 sample points are classified correctly and 1 point is classified as a very low-density class. In the low-density class, 4 sample points are classified correctly. In the very low-density class, 2 sample points are classified correctly. The overall accuracy of the classification results of the Normalized Difference Built-up Index (NDBI) method is 86.9%. Where the value is more than the minimum limit that has been set as a requirement for accuracy.

To find out the relationship between vegetation density (NDVI) and built-up land (NDBI) on the distribution of surface temperature in Solok City, the Pearson correlation test was carried out. Pearson correlation is used to determine whether or not there is a relationship between two variables, namely the independent variable and the dependent variable on an interval or ratio (parametric) scale. Assumptions in Pearson correlation, data must be normally distributed. Correlation can produce positive (+) and negative (-) numbers. If the correlation number is positive, it means the relationship is unidirectional. Unidirectional means that if the independent variable is large, the dependent variable is getting bigger. If it produces a negative number it means the relationship is not unidirectional. Not unidirectional means that if the value of the independent variable is large, the dependent variable is getting smaller, or vice versa.

a. NDVI correlation and surface temperature in 2021

It is known that the value of the Pearson correlation coefficient for surface temperature and vegetation in Solok City in 2021 is -0.844, which means that surface temperature with vegetation has a very strong correlation because it is in the range of 0.75 – 0.99 and surface temperature with vegetation has a significant relationship because it has a big value. of 0.001 (smaller than 0.05)

b. NDBI correlation and surface temperature in 2021

Correlations

		Lst	ndbi
Lst	Pearson Correlation	1	.676**
	Sig. (2-tailed)		<.001
	N	23	23
Ndvi	Pearson Correlation	.676**	1
	Sig. (2-tailed)	<.001	
	N	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

It is known that the value of the Pearson correlation coefficient for surface temperature and built-up land in Solok City in 2021 is 0.676, which means that surface temperature with vegetation is strongly correlated because it is in the range of 0.50 – 0.75 and surface temperature with vegetation has a significant relationship because it has a sig value. of 0.001 (smaller than 0.05)

5. CONCLUSION

Based on the results of a study regarding the mapping of the distribution of Land Surface Temperature in Solok City, several things can be concluded, including the following:

1. The results of this study have taken information that the Normalized Difference Vegetation Index (NDVI) / vegetation density has changed in the last 6 years, namely in 2015 - 2021. The NDVI speed changed from 0.63 to 0.47. Reduced density of vegetation occurs around urban centers.Built-up area / Normalized Difference Built-up Index (NDBI) in Solok City has increased over the past 6 years, namely in 2015 – 2021, the building density area has increased from 1921 ha to 2295 ha, so it can affect temperature changes in the Solok City area.

2. The distribution of Land Surface Temperature (LST) in Solok City has increased by 0.7°C. In the period of 2015 it had the lowest temperature value of 13.3˚C and the highest temperature of 30.6˚C until 2021 with the lowest temperature of 14.4˚C and the highest temperature value of 31.6˚C. The highest temperatures are around areas with dense buildings and low vegetation, while the lowest temperatures are around hills and forests with dense vegetation.

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