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Correlation Analysis of Normalized Different Vegetation Index and Land Surface Temperature using Landsat 8 Image based on Cloud Computing

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Abstract

The rapid development of technology has a positive impact on several parties, such as the assessment of vegetation density index and land surface temperature. This study aims to determine changes in vegetation density and surface temperature in 2019 and 2023 and their correlation with the Wonosobo District study area. The methods used in this research are Normalized Difference Vegetation Index and Land Surface Temperature by utilizing Landsat 8 Level 2 Tier 2 image data processed through Google Earth Engine and ArcMap 10.8. This research resulted in changes in the highest vegetation index value in the range of 0.74 - 0.92, while the lowest index value is in the value range between 0.03 - 0.36 which indicates that the area is non / rarely vegetated. In the vulnerable years 2019 to 2023, the vegetation density experienced changes in the form of the highest reduction in vegetation land of 108.009108 hectares. Field accuracy testing resulted in 10 spots with a fairly high level of accuracy. The results of observations of land surface temperature on the map show that there is a significant change in temperature in the central to western parts of Wonosobo District. There is a negative correlation between Normalized Difference Vegetation Index and Land Surface Temperature.

Introduction Section

Utilizing technological developments in monitoring vegetation density and surface temperature can be done easily through remote sensing. Digital image processing and analysis models broadly include radiometric and geometric correction, visualization, sharpening and filtering, multispectral classification, special transformation, hyperspectral analysis, radar and lidar image analysis, and integration with geographic information systems [1]. Remote sensing of vegetation is mainly done by obtaining electromagnetic wave reflectance information from the canopy using passive sensors [2]. The application of new technologies such as satellite data for forest cover inventory and monitoring is more than 25 years old [3]. Remote sensing is very useful in reducing terrestrial survey activities when inventorying and monitoring natural resources and the environment [4]. This quote means that the use of remote sensing in monitoring vegetation density has advantages in time and cost efficiency.

Vegetation is the interaction of a group of various plant species that occupy the same area. Vegetation plays an important role for the earth, vegetation also has a correlation to climatic, hydrological and biochemical conditions. Vegetation plays an important role in climate, hydrological and biochemical cycles [5]. With the photosynthesis activity carried out by plants, it provides benefits to the surrounding environment, such as carbon reduction [6]. In addition, there is also an expression that reads, Mapping the density of woody vegetation cover on a large scale is needed in applications such as estimating terrestrial carbon stocks [7]. In the scientific field, the vegetation index can be calculated with several existing algorithms. The vegetation index itself is said to be a simple, effective and empirical measure of surface vegetation conditions [8]. Based on the above quote, it can be concluded that the vegetation index is a measure of the condition of a vegetation. Rapid urbanization has led to the reduction of green spaces in urban areas [9]. Determination of vegetation density is done with the vegetation index approach. The vegetation index (VI) obtained from satellite data is the main source of information for operational monitoring of long-term global vegetation dynamics associated with climate change [10]. The Normalized Difference Vegetation Index (NDVI) is commonly used to assess and monitor ecological variables such as vegetation cover, aboveground biomass and Leaf Area Index. Vegetation that is actively photosynthesizing will absorb most of the red waves of sunlight and reflect higher near infrared waves [11]. In general, NDVI values close to one indicate a high proportion of vegetation cover. Conversely, NDVI values closer to zero tend to indicate the presence of built-up land, grass and bare soil [12].

Unplanned urbanization and urban sprawl will have a direct impact on the land use and land cover in the region [13]. Unplanned and unmanaged urbanization activities generally have negative impacts in the form of loss of green spaces, loss of water bodies and environmental degradation [14]. Urban areas have density conditions that tend to be denser than non-urban areas, the density causes narrowing of land and indirectly has made an increase in surface temperature due to land changes. Changes in land use/cover include loss of agricultural land, loss of forest land, increase in barren land, increase in impervious surface due to built-up land, and others [13]. Land surface temperature plays an important role in identifying the impact of land changes in an area. LST is a key parameter for estimating the surface energy budget in assessing land cover change and other Earth's surface characteristics [15]. Estimation of land surface temperature (LST) is an indication of changes in surface emissivity due to anthropogenic activities [16]. LST has a relationship to the soil surface, canopy and vegetation body [16]. One of the factors that influence temperature increase is building density [12] According to [17]. LST does not always increase over time along with the expansion of built-up areas and the increase in human population. For this reason, it is necessary to conduct research that determines whether there is a positive or negative correlation between NDVI and LST in the study area.

This research begins with a literature study, which aims to obtain material related to research on vegetation density, land surface temperature and its correlation in the study area. The materials collected came from national journals and international journals to support the research to be carried out. This research also uses a survey as a test of the accuracy of the research data. This research refers to the relationship between the NDVI and LST conducted in the Wonosobo District area, Wonosobo Regency. As the center of Wonosobo Regency, the complex problems in this area have a high density compared to other sub-districts and will continue to grow over time. In this condition, the research examines vegetation conditions and surface temperature conditions from 2019 - 2023 and the relationship between these two aspects. NDVI and LST detection can be extracted from Landsat 8 image data. NDVI is analyzed using reflectance from the Red and NIR bands of the Landsat 8 image, while land surface temperature is analyzed based on radiation values in the thermal band [18]. This research aims to analyze the condition of vegetation density and surface temperature in Wonosobo District and determine the correlation between NDVI and LST. This research is expected to be useful information for various parties.

Map making is done on the basis that it is important to do in managing natural resources, this statement refers to a quote that states that Classifying and mapping vegetation is an important technical task in managing natural resources because vegetation provides a base for all living things and plays an important role in influencing global climate change, such as affecting terrestrial [19]. Thus vegetation mapping can be said to have a role in providing information in environmental understanding. Vegetation mapping also provides valuable information for understanding the natural and built environment through quantifying vegetation cover from local to global scales at a specific point in time or over a continuous period of time [20]. The following is a flowchart of the research conducted.

Method

Location and time of research

Geographically, Wonosobo Regency is located between 7˚ 11' and 7˚ 36' South latitude, 109˚ 43' and 110˚ 04' East longitude. Wonosobo Sub-district has an area of 32.38 km2 and consists of 7 villages and 13 sub-districts, namely Tawangsari, Wonolelo, Jogoyitnan, Jaraksari, Mlipak, Sambek, West Wonosobo, East Wonosobo, Kramatan, Pancurwening, Bumireso, Rojoimo, Pagerkukuh, Kejiwan, Kalianget Jlamprang, Wonosari, Bumerto, Sariyoso and Tlogojati. Wonosobo Sub-district is the capital of Wonosobo Regency itself, this area can be said to be the center of government as well as the center of the economy, this is supported by Wonosobo Sub-district which is the most developed area compared to other sub-districts when viewed in terms of development and infrastructure. Research in this area was conducted on November 4, 2023.

Data used

This research utilizes Landsat 8 Level 2, Collection 2, Tier 2 image data and shapefiles of Wonosobo District administrative boundaries. The use of Landsat 8 imagery is because this image can record areas on the earth's surface with a wider / larger coverage, has good spatial, temporal and radiometric resolution, on every topography on the earth's surface [21]. Meanwhile, the shapefile data for the administrative boundaries of Wonosobo Subdistrict which comes from the 2021 Indonesian Earth Map.

Research tools

There are three software in supporting the research to be carried out. the first software is Google Earth Engine as data collection and processing, then there is ArcMap 10.8 which is useful for making maps and the last is Microsoft Excel which is used for quantitative data processing.

Data processing and analysis

Preprocessing of Landsat data and extraction of spectral indices. Information on vegetation density data, land area, and conditions in the field can be detected from remote sensing techniques [22]. By utilizing Landsat 8 imagery, vegetation density information can be known by using the NDVI method and formula.

$$\mathbf{NDVI}\,\frac{(\mathbf{Nir}-\mathbf{red})}{(\mathbf{Nir}+\mathbf{Red})} \tag{1}$$

The explanation of the formula is that NIR is band 5, while Red is band 4 in the Landsat 8 image. NDVI values range between -1.0 and +1.0, but are usually positive for soil and vegetation [23]. Image interpretation was conducted using the Google Earth Engine and utilized Landsat 8 image data using the NDVI method. This processing is carried out by several processes described as follows (a) importing Landsat 8 Level 2 Tier 2 images with the search menu on the google earth engine, (b) exporting the Wonosobo District administration as a boundary, (c) determining the date, month and year of the beginning and end using a script (d) compositing the image (e) entering the NDVI formula.

Interpretation of Landsat 8 imagery by LST method. Land surface temperature was conducted using the Google Earth Engine web cloud, utilizing Landsat 8 imagery. LST is the temperature measured at the earth's surface or "ground" in a broad sense [24]. Measurements are made by utilizing the *Thermal Infrared Sensor (TIRS*) sensor which is emitted to the ground surface. The calculation of LST is done using the following formula:

$$(TB / (1 + (\lambda * (TB / 1.438)) * \log(em))) - 273.15 \tag{2}$$

Where,

λ = Length of emitted radiation

TB = Thermal Band

Em = Emissivity

Correlation test. The correlation test was conducted using ArcMap 10.8 software by creating a fishnet on the ArcToolbox menu, then extracting values from NDVI and LST into the fishnet points. The extracted values were then adjusted by removing undefined values such as -9999. The extracted values are then entered into *Microsoft Excel* to create correlation graphs and calculate how much correlation between LST and NDVI.

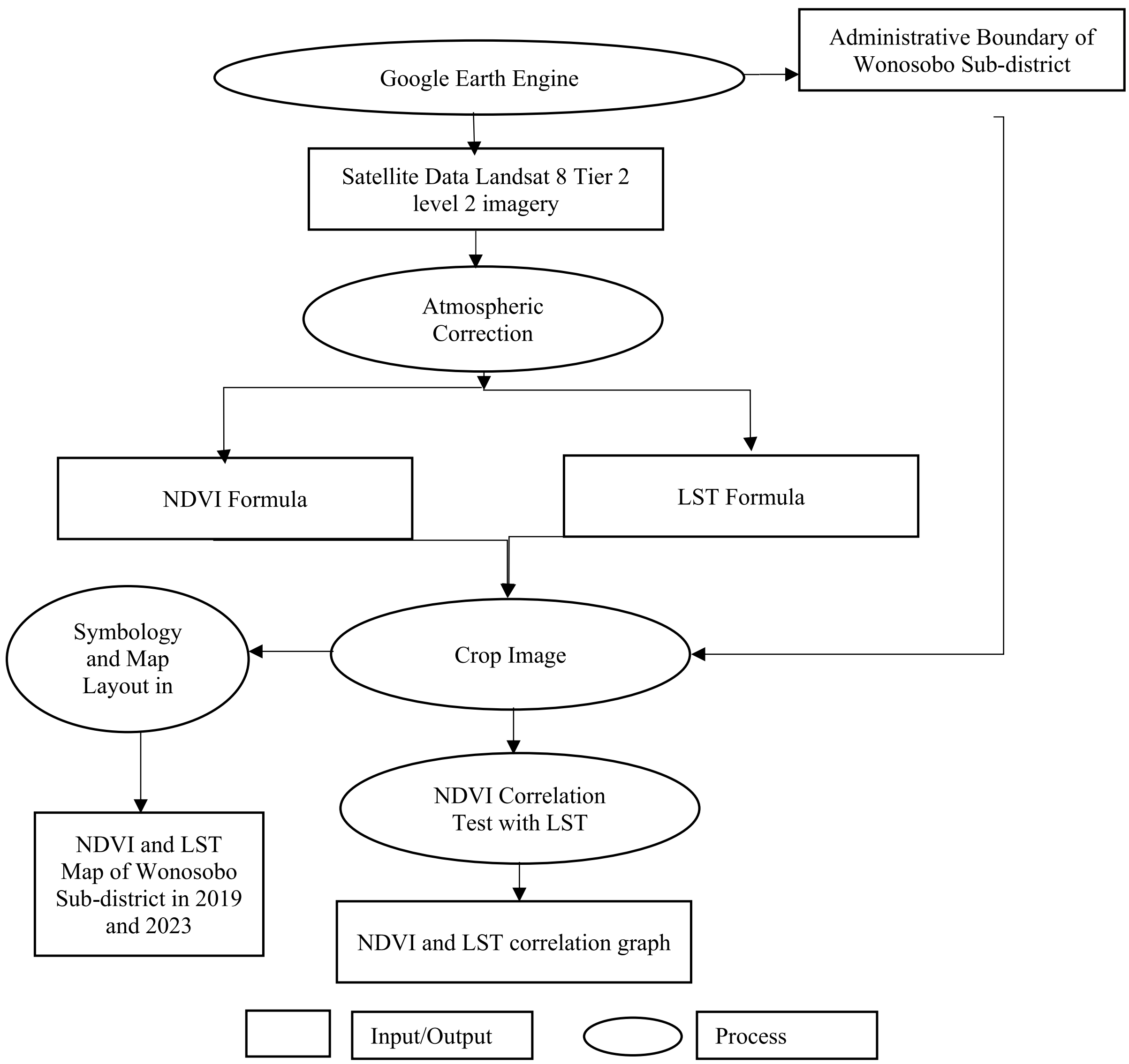

Figure 1. Flow Chart

In figure one, explains the flow of the research conducted. The research begins with data donwloading then processing through Google Earth Engine until it ends up being a map of vegetation density and land surface temperature.

Results and Discussion

NDVI Wonosobo Sub-district

Determination of vegetation density information with NDVI was obtained using Google Earth Engine computing as initial data, which was then refined using ArcGIS software. The following is the condition of vegetation density using the NDVI method in Wonosobo Sub-district in 2019 and 2023. . Vegetation information can be extracted using spectral signatures, which are graphical representations that show the relationship between wavelength and reflectance values in different spectra [25]. The condition of vegetation density in Wonosobo Sub-district using the NDVI method in 2019 and 2023 is classified into four classes, with a description of the first class, namely non/low vegetation, the second class of low vegetation, the third class of medium vegetation and the fourth class of high vegetation. The vegetation class categories are visualized in dark red, orange, light green and dark green, as shown in the NDVI 2019 map and NDVI 2023 map. NDVI will produce a range of values between ÿ1 to +1, which illustrates that the closer to +1 the denser the vegetation density is [26]

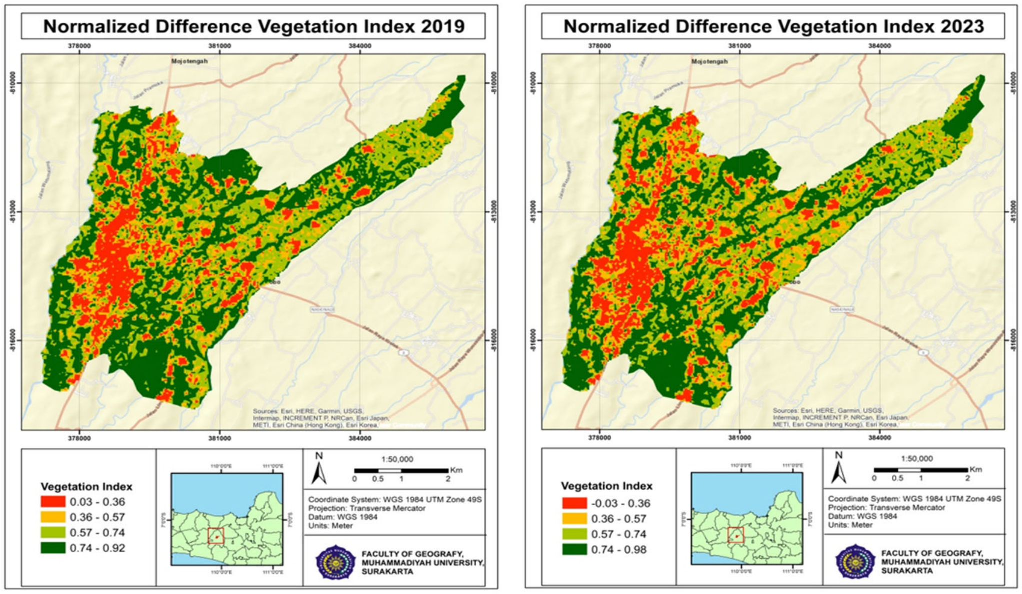

Figure 2. NDVI map 2019 and 2023

In figure 2, the condition of vegetation density in Wonosobo Sub-district in 2019 is still quite evenly distributed, dominated by the very dense category marked with dark green color on the map. It is found that the highest vegetation index value is in the range of 0.74 - 0.92, while the lowest index value is in the value range between 0.03 - 0.36 which indicates that the area is non-vegetated. The vegetation area when viewed on the map is in the periphery of Wonosobo Sub-district [27]. The density of vegetation in Wonosobo Sub-district in 2023 experienced a slight change at several points. The results of map observations found that many changes in vegetation density occurred in the very dense class to medium to sparse or non-vegetation classes, which were marked by changes in dark green color to yellow or red. This indicates that there is a land use change carried out by the surrounding community in the period from 2019 to 2023.

The data shows that all classes of vegetation density experienced changes in both the reduction and addition of areas. Based on the data in the table, it is known that significant changes occurred in the very dense class which reduced to 108.009108 hectares, the reduction of this land was the biggest change compared to other changes, this is an indication that the area has a change in the function of vegetation land into built-up land. Similar conditions also occurred in the tight class which experienced a land reduction of 15.342058 hectares, the reduction was the lowest change, but if done continuously it will have a negative impact on the surrounding environment.

The field test was conducted on November 10, 2023 in Wonosobo District. From the results of the field test, it is known that the 10 spots have similarities with the appearance in the image of the NDVI interpretation results in 2023. This shows that the level of accuracy in vegetation density with the field is quite good. In the field accuracy test, 1 area was found to be a building, 4 areas with low density, 3 areas with medium density and 2 areas with high density. Vegetation density analysis in this study has benefits for the Wonosobo District area, in general this analysis is useful in monitoring the condition of vegetation in Wonosoobo District, besides that this research is expected to contribute as a provider of information for policy makers in Siantan District such as the direction of sustainable regional development. Sustainable development is expected to improve economic conditions and the welfare of the surrounding community. Vegetation density analysis can provide benefits in environmental management and sustainable development in the city Vegetation density can be said to be closely related to the environmental conditions in an area such as the problems and processes of air filtration, water runoff, soil pollution, carbon emissions, and livability are directly related to the density and abundance of urban green spaces [25].

Land Surface Temperature Wonosobo Sub-district

Wonosobo Sub-district is the center of the economy and government in Wonosobo Regency. It makes the Wonosobo Sub-district area dense, this condition affects the high and low surface temperature in an area. For this reason, the identification of LST changes over a certain period of time is one of the most important environmental parameters in the research domain [16]. The LST classification is divided into four categories marked with green, yellow, orange and red colors. The following are the surface temperature conditions in Wonosobo Sub-district in 2019 and 2023.

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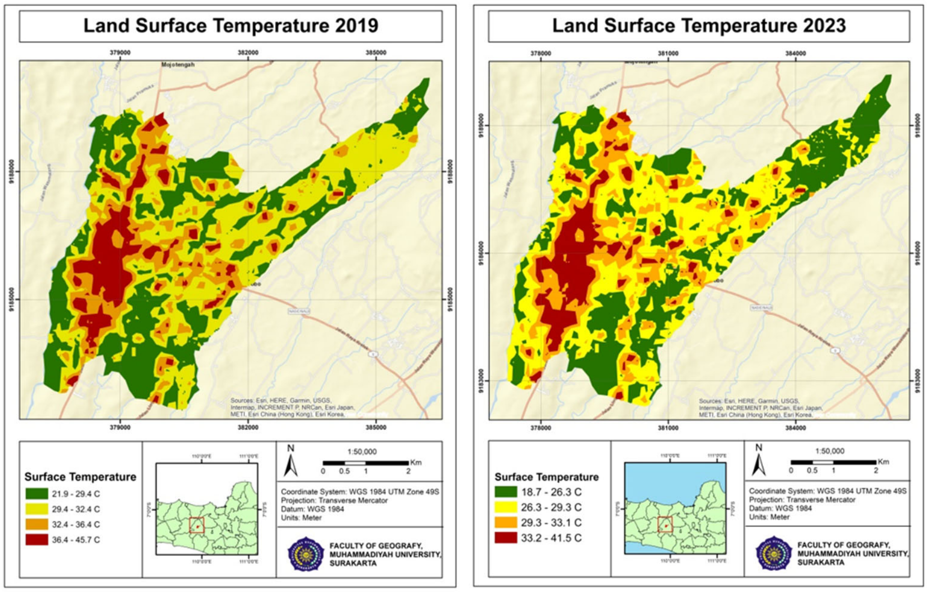

Figure 3. LST Map of Wonosobo Sub-district in 2019 and 2023

In figure 3, the land surface temperature in 2019 tends to be higher with a minimum temperature of 21.9 C and a minimum temperature reaching 45.7 C. while in 2023 the land surface temperature has decreased with a minimum temperature of 18.7 C and a maximum temperature of 41.5 C. The results of observations on the map that there is a significant temperature change in the central to western part of Wonosobo District, the change is in the form of an increase in surface temperature class from green to yellow. This change is an indication that there are changes in land cover that tend to be drier such as buildings or dry land. Whereas in the northeast area of Wonosobo Subdistrict, changes tend to be more for the better for the environment, where changes from the yellow color category class to the green color category indicate a decrease in temperature in the area. This decrease cannot be separated from changes in land cover that was originally covered by dry surfaces to moist vegetation. Factors affecting temperature change are relatively dry surface land cover, such as dry soil and cement, where the surface has relatively high thermal conductivity properties that cause higher temperature radiation while land covered by vegetation tends to have a low temperature [28]. The areas that have high temperatures are in Kalianget, Sambek, Jaraksari, West Wonosobo and East Wonosobo villages, the area can be said to be the city of Wonosobo itself so that a lot of land cover in the form of buildings is quite dense which causes the ground surface temperature to be high.

Based on the table, Wonosobo sub-district in 2019 mostly has a surface temperature of 29.4 - 32.4 C with an area of 1141.53502 hectares. Whereas in 2023 the surface temperature of the Wonosobo area mostly has a lower temperature than in 2019, namely 26.3 - 29.3 C with an area of 1097.222267 hectares [29]. The high and low surface temperature in Wonosobo Sub-district is generally influenced by the condition of land cover in the area.

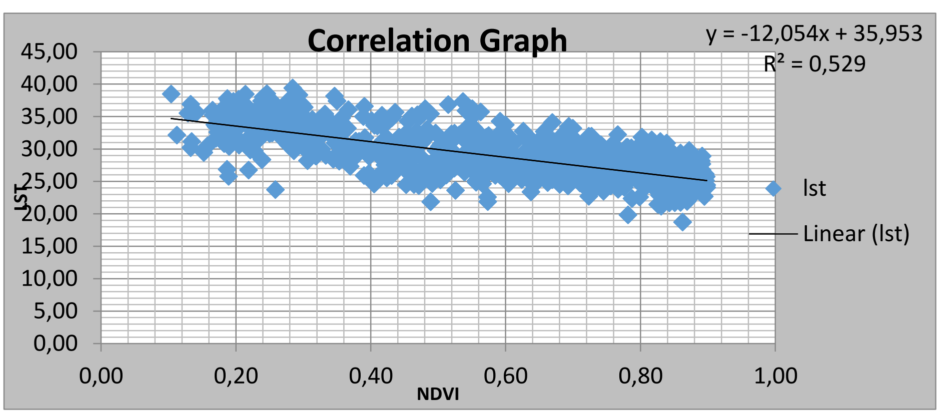

Figure 4. NDVI and LST Correlation Chart

In figure 4, the correlation test results found that the higher the LST value, the lower the NDVI value and vice versa, indicating that there is a negative correlation between NDVI and LST. From the R-square calculation, it is found that this correlation has a value of 0.529. This result is similar to previous studies conducted by several researchers such as [18][30][24].

Conclusions

This study uses NDVI and LST methods with Landsat OLI/TIRS image data in analyzing vegetation density and surface temperature in 2019 and 2023. The results showed that the highest vegetation index value is in the range of 0.74 - 0.92, while the lowest index value is in the value range between 0.03 - 0.36, indicating that the area is non/low vegetation. In the vulnerable years 2019 to 2023, the vegetation density experienced changes in the form of a decrease in the highest vegetation land of 108.009108 hectares, thus indicating that there was a land conversion carried out by the community in Wonosobo District. The accuracy test results found that there were 10 spots with fairly high accuracy. The results of observations of land surface temperature on the map show that there is a significant change in temperature in the central to western parts of Wonosobo Subdistrict, the change is in the form of an increase in surface temperature class from green to yellow. . While in the northeast area of Wonosobo Subdistrict, the changes tend to be better for the environment, where the change from the yellow color category class to the green color category indicates that there is a decrease in temperature in the area. The correlation test conducted resulted in a negative correlation between NDVI and LST.

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