HEALTH ANALYSIS OF SUGARCANE PLANTS USING COMPARISON OF LANDSAT-8 SATELLITE IMAGE TIME SERIES (CASE STUDY: PAKIS DISTRICT, MALANG REGENCY)

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ABSTRACT

Sugarcane is one of the most widely cultivated plant commodities in Indonesia. The need for sugar consumption in Indonesia is very high, in 2021 it required 3.2 million tons of sugar consumption. Sugar productivity is strongly influenced by the physical condition of the sugarcane plant which can be influenced by nature, be it weather, temperature, and humidity and the effect of sugarcane plant care in providing plant nutrition and so on. Therefore, an analysis of the health of sugarcane was carried out using the time series comparison method of Landsat-8 satellite imagery with a case study in Pakis District, Malang Regency. In 2017, Pakis Subdistrict contributed 89,793 tons of sugarcane production from a total of 4,001,879 tons of sugarcane production. The productivity level is the age and health of sugarcane. Based on the results obtained using vegetation indices such as the Normalized Different Vegetation Index and Normalized Different Moisture Index and using the Land Surface Temperature parameter, it can be seen that the highest NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index) values occur in February 2022 and the lowest in August 2021 while the highest soil surface temperature occurred in August 2021 and the lowest in February 2022. The sugarcane plants studied had NDVI values ranging from 0.392 to 0.726 and NDMI values ranging from 0 to 0.4. The index value is included in the category of healthy sugar cane. So, if there is a point area outside this value, then there is unhealthy sugar cane. This value is associated with the Pearson correlation so that NDVI and NDMI are very strongly correlated, while the correlation between LST-NDMI and LST-NDVI has a moderate to very strong correlation. However, these parameters need validation in the field to determine the original conditions and the accuracy of the results obtained.

Keyword: Sugarcane, LST, NDVI, NDMI

Introduction

Sugarcane is one of Indonesia's most widely cultivated plant commodities because the climatic conditions support its growth and development. Sugarcane plants have an essential role in the Indonesian economy. National sugar production in 2021 will reach 2.35 million tons, up 10.3% from 2020 production of 2.13 million tons [1]. The achievement of sugar production still does not meet the 3.2 million tons of consumption sugar needs, so additional production is needed for self-sufficiency of 850 thousand tons of White Crystal Sugar. One of the largest contributors to the production of sugarcane plantations in East Java is Malang Regency. The area used for sugar cane plantations was 44,318 hectares in 2017 [2]. The production level cannot be separated from the age and health of the sugarcane plants. Harvesting sugarcane at the ideal age with its ripening time can increase the soaking of sugarcane [3].

Remote sensing is the science and the art of obtaining information about an object, area, or phenomenon by analyzing data obtained with a tool without direct contact with the object, area, or phenomenon being studied [4]. The utilization of satellites for monitoring plant health and growth conditions can be used as a faster, more accurate, and more precise solution to

obtain direct information with a broader range. The vegetation index is often used in estimating biophysical parameters and modeling plant health conditions.

The determination of these indices is based on two things, namely the high value of the absorption of visible wavelengths of solar radiation by plant pigments and the high value of scattering of infrared and/or Short Wavelength Infrared (SWIR) waves by the leaf mesophyll coating.

This study aims to analyze the health condition of sugar cane using Landsat-8 satellite imagery temporally with vegetation index parameters, such as NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index), as well as the Land Surface Temperature index. NDVI can estimate leaf chlorophyll content, while NDMI can estimate leaf moisture or water content.

Methodology

Data and Research Area

This research was conducted in Pakis District, Malang Regency, East Java. The data used in this study are Landsat-8 Operational Land Imager (OLI) Collection 2 Level-1 satellite images for Band 10 and Collection 2 Level-2 from May 2021 to June 2022. Image selection is based on the plant phase, so it was obtained on 31 May 2021, 19 August 2021, 19 February 2022, 2 May 2022, and 19 June 2022. Landsat 8 satellite imagery is secondary data that can be accessed through the USGS (United States Geological Survey) website, and the shapefile of the RBI map can be accessed through the Ina-Geoportal website owned by the Geospatial Information Agency (BIG).
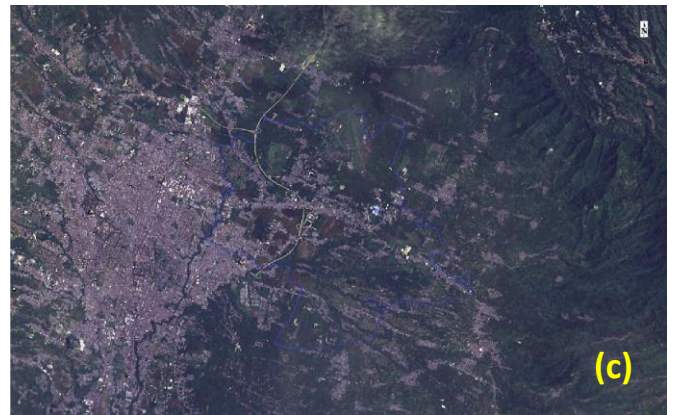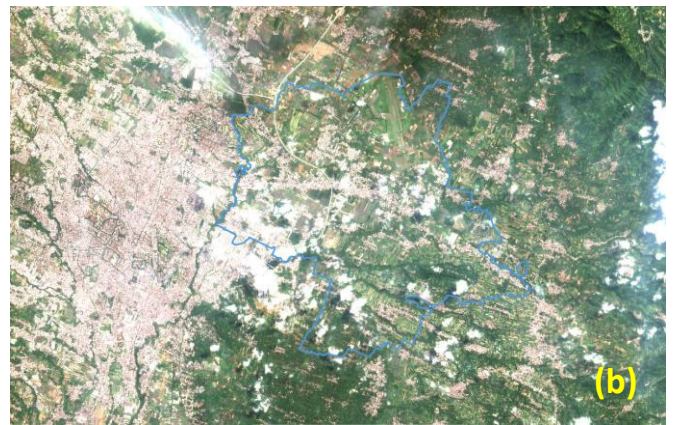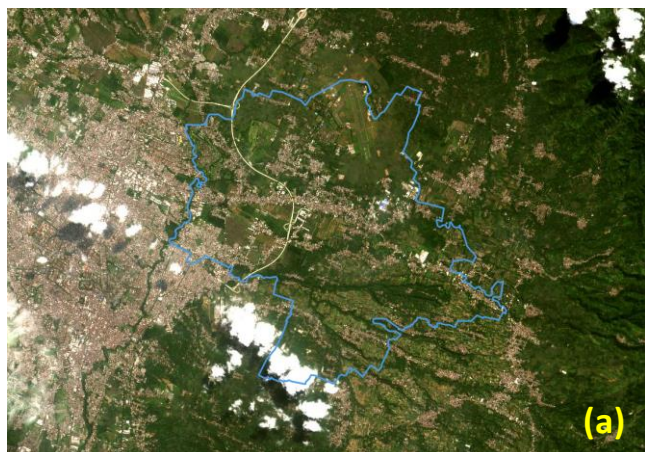

Figure 1. Landsat 8 Natural Color Level 2 Satellite Imagery, Pakis District, Malang Regency in (a) May 2021, (b) August 2021, (c) February 2022, (d) May 2022, and (e) June 2022
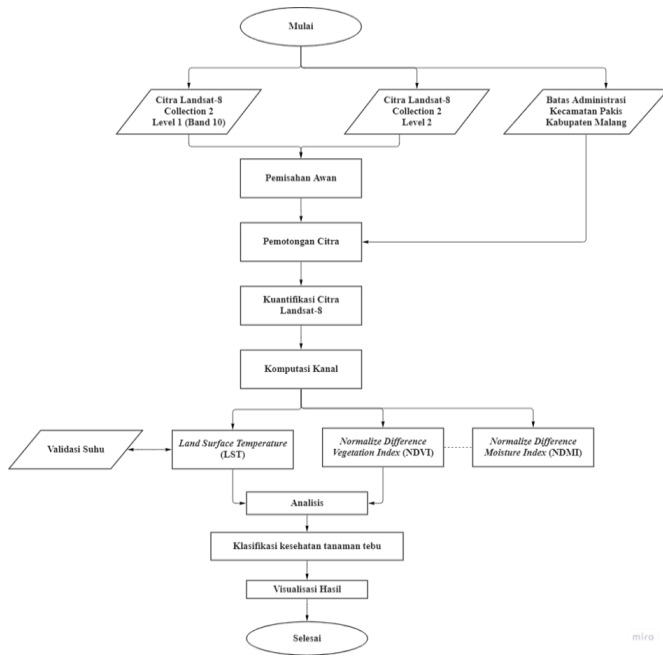
Vegetation Index Processing

Figure. 2 Research Flowchart

NDVI (Normalized Difference Vegetation Index) is a method used to compare the greenness of vegetation from satellite imagery with NIR (Band 5) and Red (Band 4) reflectance. The value range is -1 to 1, with negative values being non-vegetation objects and positive values being vegetation objects [5].

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

NDMI (Normalized Difference Moisture Index) is a method used to detect moisture levels in vegetation using the NIR (Band 5) and SWIR (Band 6) spectral bands. The value range is -1 to 1, with a value of -1 to 0 indicating no vegetation, lack of water, and high-water stress. Meanwhile, values from 0 to +1 indicate plants that are slightly moist to vegetation with sufficient water [6].

$$NDMI = \frac{(NIR - SWIR1)}{(NIR + SWIR1)}$$

Result and Discussion

Result

The author will explain the results after the processing and classification stages in this section. Based on the results obtained below, it can be seen that the sugarcane plants observed in May and August 2021 and February, May, and June 2022 have average plant health that is very good. In August 2021, 21.06 acres came into very poor grade. This condition is because some plots of sugarcane land have experienced a harvest period. Because the sugarcane plant is already in the ripening stage, the chlorophyll in the leaves decreases.

Table 1. Land Area Calculation Based on The NDVI Value for May and August 2021

NDVI		Area (ha)	
Value	Description	May 2021	August 2021
<0.392	Poor	0.81	21.06
0.392 – 0.57	Normal	2.52	47.79
0.571 – 0.726	Good	9.45	57.87
>0.7276	Very Good	181.35	67.32
Total		**194.13**	**194.04**

Table 2. Land Area Calculation Results Based on NDVI Values for February, May and June 2022

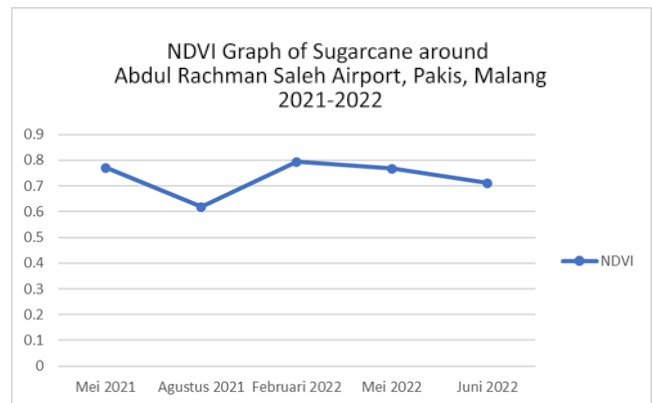| NDVI		Area (ha)		
Value	Description	May 2021	August 2021	June 2022
<0.392	Poor	0	0	6.66
0.392 – 0.57	Normal	0.18	0.18	19.62
0.571 – 0.726	Good	8.73	15.66	28.53
>0.7276	Very Good	185.13	178.2	139.23
Total		**194.04**	**194.04**	**194.04**

Figure 3. NDVI Graph of Sugar Cane Samples Around Abdul Saleh Airport, Pakis District, Malang Regency in 2021-2022

Based on the results obtained below, it can be seen that the sugarcane plants observed in May and August 2021 and February, May, and June 2022 have an average high to very high humidity. As the NDVI results explained above, in August 2021, there were 23.58 hectares included in the very low class. This condition is because the sugarcane plant is already in the ripening stage, so the chlorophyll in the leaves has decreased because leaf water is used to accumulate sucrose in the stems and the growth of stem biomass almost stops completely.

Discussion

The Landsat-8 satellite imagery data is processed to obtain Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), and Normalized Difference Moisture Index (NDMI) values and then

correlated using the Pearson method. The Pearson method is a correlation measure used to measure the strength and direction of a linear relationship between two variables. In this case, Pearson Correlation is used to correlate LST with NDVI, LST with NDMI, and NDVI with NDMI. Table 5 is a correlation table between the three variables.

Table 3. Land Area Calculation Results Based on NDMI Values for May and August 2021

NDMI		Area (ha)	
Value	Description	May 2021	August 2021
<0	Very Low	1.71	23.58
0.01 – 0.2	Low	2.16	57.96
0.21 – 0.3	Normal	7.47	31.86
0.31 – 0.4	High	146.25	72.09
>0.4	Very High	36.54	8.55
Total		**194.13**	**194.04**

Table 4. Land Area Calculation Results Based on NDMI Values for February, May and June 2022

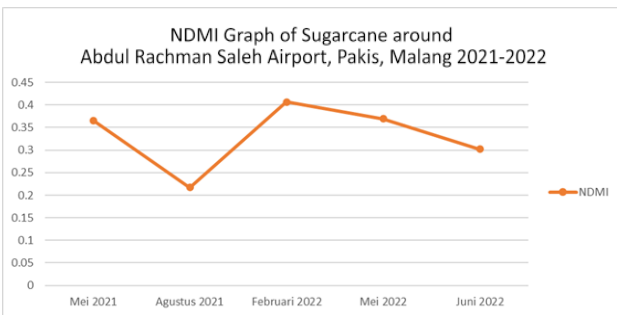| NDMI		Area (ha)		
Value	Description	February 2021	May 2021	June 2022
<0	Very Low	0	0	9.99
0.01 – 0.2	Low	0.27	0.18	20.97
0.21 – 0.3	Normal	4.23	1.35	18.09
0.31 – 0.4	High	69.21	167.58	134.73
>0.4	Very High	120.33	24.93	10.26
Total		**194.04**	**194.04**	**194.04**

Figure 4. NDMI Graph of Sugar Cane Plant Samples Around Abdul Saleh Airport, Pakis District, Malang Regency in 2021-2022

Based on the table 5, it can be seen that data for August 2021 has a very strong correlation with the LST-NDVI, LST-NDMI, and NDVI-NDMI variables. The LST-NDVI and LST-NDMI relationships have an inverse direction denoted by a negative symbol (-), while the NDVI-NDMI relationship has a directly proportional direction. The correlation between LST-NDVI, LST-NDMI, and NDVI with NDMI is visualized in figures below.

Table 5. Pearson correlations of LST-NDVI, LST-NDMI, and NDVI-NDMI

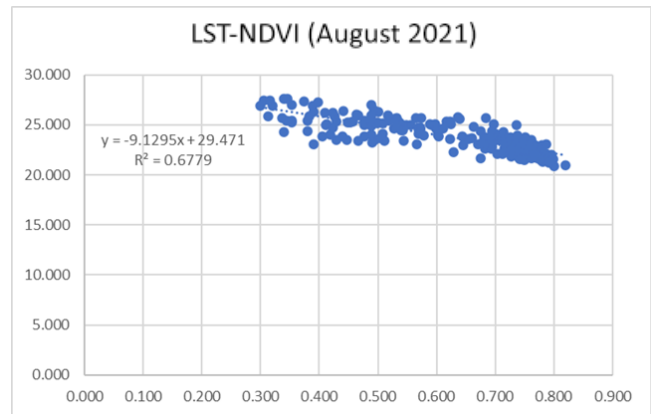| Month	Pearson Corelation		
	LST-NDVI	LST-NDMI	NDVI-NDMI
May 31, 2021	-0.632	-0.624	0.976
August 19, 2021	-0.823	-0.778	0.977
February 19, 2022	-0.378	-0.356	0.964
May 2, 2022	0.145	0.074	0.890
June 19, 2022	-0.438	-0.449	0.975

Figure 5. LST-NDVI Regression Chart (August 2021)
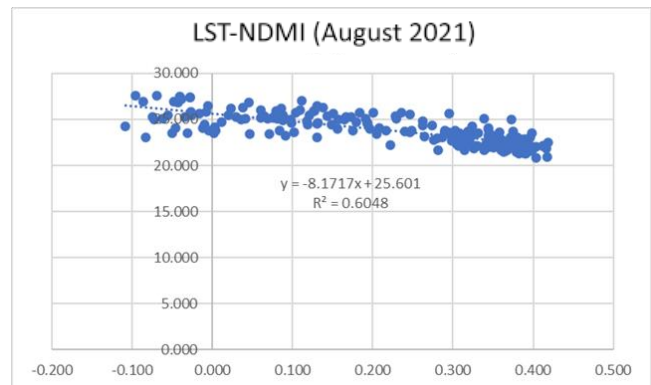

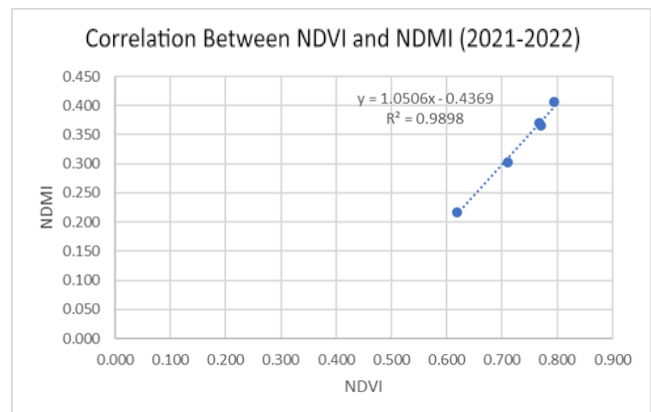**Figure** 6. LST-NDMI Regression Chart (August 2021)

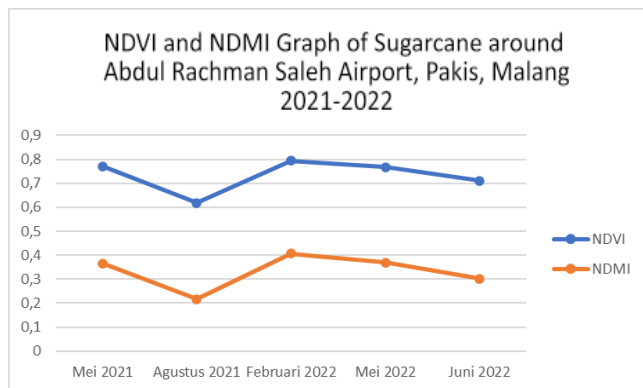**Figure 7.** NDVI-NDMI Regression Chart (August 2021)

Figure 8. NDVI and NDMI Charts of Samples of Sugar Cane Plants Around Abdul Saleh Airport, Pakis District, Malang Regency in 2021-2022

Conclusion

The values for the chlorophyll concentration and leaf moisture represented by the NDVI and NDMI indices have the same pattern, where when the NDVI index value is high, the NDMI index value is also high and vice versa. High NDVI and NDMI index values represent better plant health. The LST value has a pattern inversely proportional to NDVI and NDMI, where the LST will be low if the NDVI and NDMI index values are high and vice versa. The highest NDVI and NDMI occurred in February 2022, reaching 0.852 and 0.496, with a maximum LST value of 21.368°C. Meanwhile, the lowest NDVI and NDMI values occurred in August 2021, with values of 0.300 and -0.109, and the lowest LST values were 20.873°C.

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