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Investigating the Correlation between Rice Production and RGB Vegetation Index from Drone Imagery and NIR-Based Index from Sentinel Images

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ABSTRACT

Rice is one of staple foods in majority of countries, including Indonesia. Increasing rice demand is correleted to rapid population growth. Estimating of rice production is important in order to determine food availability in an area. Utilization of modern remote sensing technologies such as drone imagery and sentinel imagery are can be used widely for predicting rice production. The purpose of this research is to investigate the relationship between RGB vegetation index of drone imagery and NIR-based index of sentinel imagery with rice production in estimating the level of rice production. In this study a regression analysis between vegetation index values obtained from drone imagery and sentinel-2 imagery and rice paddy production was used to estimate rice paddy production. Five vegetation indices were observed, i.e. TGI, VARI, ExG, RGBVI, and GLI. The research results showed three levels of relationship, namely strong, medium and very strong correlations. TGI vegetation index showed a moderate level of relationship, whereas strong level of relationships was found in VARI, ExG, RGBVI and GLI vegetation indices. Estimation of rice production can be predicted with the NDRE vegetation index which has the highest determinant value, which is 84.06%. Validation of the NDRE vegetation index shows a result of 55.97%, where more data is under estimate which means the estimation results are smaller than the results determined in the field.

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1.INTRODUCTION

Rice is one of the basic needs for people who live in Asia, particularly in Indonesia. Therefore the demand of rice increasing day by day due to rapid population growth. Estimating of rice production is important in order to determine of food availability in an area. Information of rice projection is necessary and can be use as a based data for importing, exporting and storing grain.

Knowledge about rice production in a region is very crucial for the central government to support national food security. Utilization of modern remote sensing technologies such as drone imagery and sentinel imagery are used widely as an alternative for predicting rice production, besides using conventional methods. Sentinel-2 imagery is one of popular satellite images for land monitoring. The satellite has 13 bands with a resolution of 10 m (four bands), 20 m (six bands), and 60 m (three bands) and a swath area of 290 km. Sentinel-2 imagery has a multispectral instrument, one of which is near infrared (NIR). Drone imagery is also one of popular remote sensing technology to retrieve high spatial resolution data

Vegetation index data can be used to identify the condition of vegetated land in a large area. Vegetation index is a value of vegetation greenness obtained from the brightness value of several channels of remote sensing data. The Red Green Blue (RGB) vegetation index can be calculated based on the reflectance of red (RR), green (RG) and blue (RB) bands.

Taking a note on the importance of projection of rice productivity and the possibility of the use of remote sensing technologies in the projection, it is necessary to conduct a study in this issue. This study aimed to investigate the relationship between RGB vegetation index of drone images and NIR-based vegetation index of Sentinel imagery with rice production in estimating the level of rice production.

2.METHOD

2.1. Study area

This research was carried out in October 2021 in Alatengae Village, Bantimurung District, Maros Regency, South Sulawesi. Nine plots of rice field were utilized in this study, namely plot 78, 128, 129, 132, 150, 151, 153, 277, and 282.

2.2. Tools and materials

Tools used in this study were the DJI Phantom 2+ drone and a laptop containing QGIS software. Material used were a basic map of paddy fields and Sentinel-2 imagery of Maros Regency on 21 October 2021 which downloaded at https://earthexplorer.usgs.gov/.

2.3. Field data collection

a. Drone Imagery Data

Data capture was carried out on October 23, 2021 (55 Day After Planting (DAP)) by using the DJI Phantom 2+ model drone with a height of approximately 50 meters.

b. Rice production data

Collection of rice production data was carried out at harvest time by recording the production results from each rice field plot.

Table 1. Field measurement production results.

Plot	Field measurement			Production	
	Area (m^2)	bag	Kg	kg/m^3	tons/ha
78	2315.58	25	1375	0.59381	5.93805
128	1602.24	14.5	797.5	0.49774	4.97742
129	1385.97	14	770	0.55557	5.55567
132	907.74	9.5	522.5	0.57561	5.75608
150	518.92	8	440	0.84791	8.47915
151	362.58	4	220	0.60676	6.06761
153	451.66	5.5	302.5	0.66975	6.69753
277	327.09	3	165	0.55044	5.50440
282	313.68	3.5	192.5	0.61369	6.13693

2.4. Pre-data processing

1. Sentinel Image Data

Before calculating NIR index value, an atmospheric correction was carried out on the Sentinel-2 image. This process has a function to improve the accuracy of the vegetation index model. This correction was carried out using Quantum GIS software by utilizing the Semi-Automatic Classification Plugin tool. After that, cropping of the image data was carried out in the Quantum GIS application.

2. Drone Image Data

Video Data from drone was processed into images by using image composite editor application. After that, the images were cropped into study areas.

2.5. Data processing

1. Calculating RGB vegetation index value of drone images, consisting of *Visible Atmospheric Resistant Index* (VARI), *Triangular Greennes Index* (TGI), *Green Leaf Index* (GLI), *Red Green Blue Vegetation Index* (RGBVI), *Normalized Green Red Difference Index* (NGRDI) and *Excess Green* (ExG).
2. Calculating NIR-based index values from sentinel images, using the NDVI and NDRE formulas.

2.6. Data analysis

a. Regression and Correlation Analysis

Regression analysis and correlation between vegetation index and rice production were carried out to estimate the amount of rice production based on the vegetation index value of imagery data. Correlation analysis was carried out to investigate the level of relationship between the two variables.

b. Rice Production (Yield) Estimations

Rice production estimations were carried out by generating equations based on the relationship between Vegetation Index used in this study with the production of rice plants from the test plots in the field. The highest determinat value (R^2) indicated the best vegetation index in determining rice corp production.

c. Data validation

Data validation was used to examine the accuracy level of Sentinel-2 imagery in classifying rice crop production according to production data in the field. Validation was carried out by comparing the suitability of the image-identified rice field plots with the level of production in the field.

3.RESULTS AND DISCUSSION

3.1. Correlation between VARI Vegetation Index and Rice Production

Visible Atmospheric Resistant Index (VARI) is an index that can be calculated from the reflectance of Red, Green and Blue (RGB). The relationship between the VARI index and rice production can be seen in Figure 1.

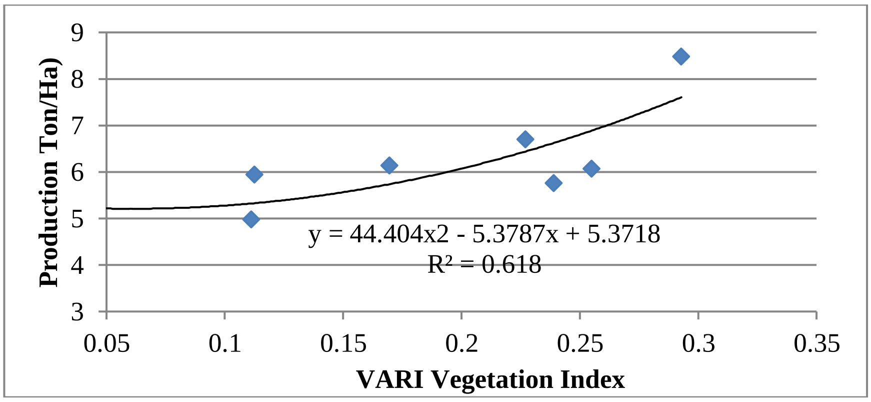

Figure 1. Correlation between the VARI Vegetation Index and Rice Production.

Based on the calculation of the research results between VAR and rice production in the field, the production value equation was 44.404(VARI)^2 - 5.3787(VARI) + 5.3718 with a coefficient of determination (R^2) equals 0.618. This means that 61.8% of VARI contributes to rice production. Thus, it can be seen that the correlation value (r) from the results of the relationship between the VARI vegetation index and rice production was 0.786, and can be categorized as strong. This is in accordance with the Jumaigra interval table (2019), for correlation interval values (r) with intervals above 0.60 to 0.799 is identified as a strong relationship between the two variables. In this linear regression there was one outlier data in plot 277, thus the data was not included in the graph. This was based on Dewi et. al. (2016) which stated that outlier data is observational data that is far from other observations. Where this data will interfere with the process of data analysis.

3.2. Correlation between TGI Vegetation Index and Rice Production

The relationship between the *Triangular Greennes Index* (TGI) vegetation index and rice production can be seen in Figure 2.

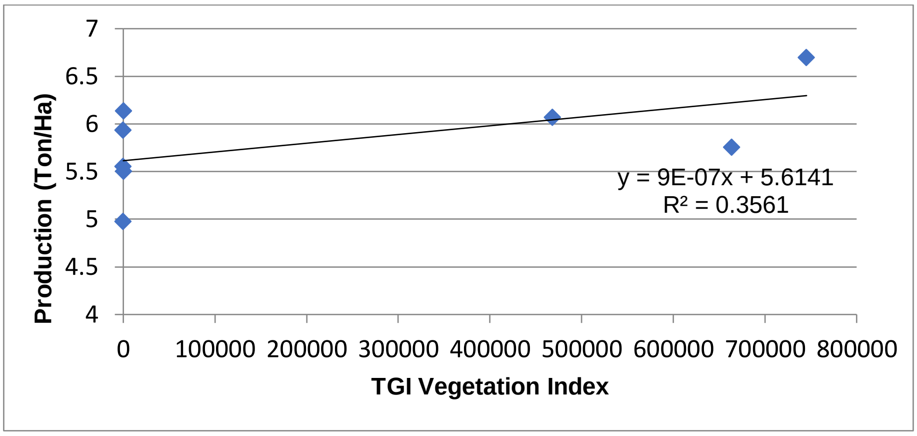

Figure 2. Correlation between the TGI Vegetation Index and Rice Production.

Based on the correlation between the TGI value and rice production in the field, the production value equation was 9E-07(TGI) + 5.6141 with a coefficient of determination (R^2) of 0.3561 which means that 35.61% of TGI contributed to rice production. Thus, the relationship between the TGI vegetation index and rice production was 0.59674, and can be categorized as moderate. Jumaigra (2019) said that for the value of correlation interval (r) with an interval of 0.40 to 0.599 means a moderate relationship between the two variables. In this linear regression there was one outlier data in plot 150, thus, it was not included in the graph.

3.3. Correlation Between GLI Vegetation Index with Rice Production

The relationship between the *Green Leaf Index* (GLI) vegetation index and rice production can be seen in Figure 3.

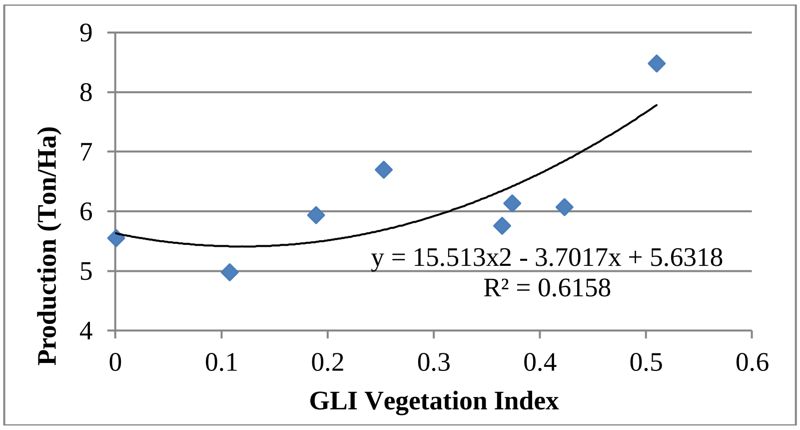

Figure 3. Correlation between GLI Vegetation Index and Rice Production.

The production value equation between the RGB value (GLI) and rice production in the field was 15.513 $(GLI)^2$ – 3.7017(GLI) + 5.3297 with a coefficient of determination (R^2) 0.6158. This means that 61.58% of GLI contributed to rice production. The relationship between GLI vegetation index and rice production was 0.7847, and categorized as a strong relationship. This is based on Jumaigra (2019) interval table which stated that correlation interval values (r) above 0.60 to 0.799 identified as a strong relationship between the two variables. In this linear regression there was one outlier data in plot 277, thus it was not included in the graph

3.4. Correlation between RGBVI Vegetation Index and Rice Production

The relationship between the *Red Green Blue Vegetation Index* (RGBVI) vegetation index and rice production can be seen in Figure 4.

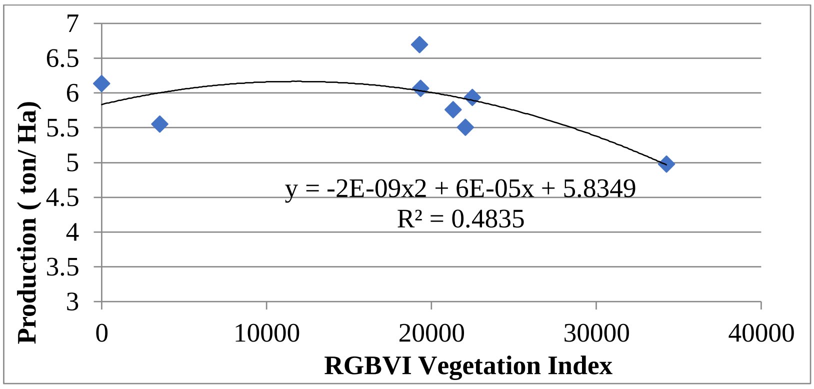

Figure 4. Correlation between the RGBVI Vegetation Index and Rice Production.

Based on Figure 4, the correlation equivalent between RGB VI Index and Rice production in the field was -2E-09(RGBVI)^2 + 6E-05(RGBVI) + 5.8349 with a coefficient of determination (R^2) equals 0 .4835. This means that 48.35% of the RGBVI contributed to rice production. This result showed that the relationship between GBVI vegetation index and rice production was 0.69534, and can be categorized as strong. According to Jumaigra (2019) interval table, which said that correlation interval values (r) with intervals above 0.60 to 0.799 identified as a strong relationship between the two variables. One outlier data was found in plot 150, thus it was not included in the graph.

3.5. Correlation between NGRDI Vegetation Index and Rice Production

The relationship between *Normalized Green Red Difference Index* (NGRDI) vegetation index and rice production is shown in Figure 5.

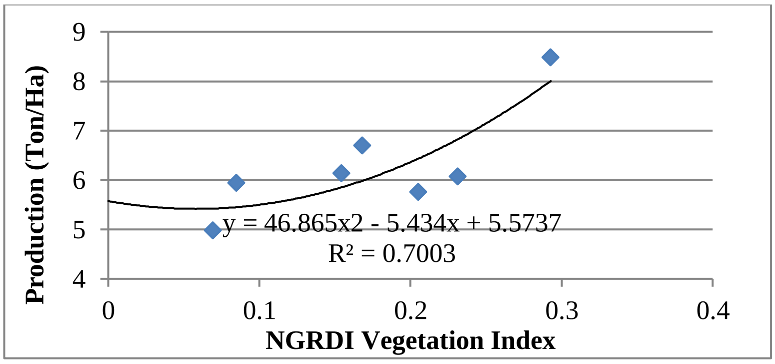

Figure 5. Correlation between the NGRDI Vegetation Index and Rice Production.

Figure 5 explained that the correlation between the NGRDI vegetation and rice production in the field, showed equation of 46.865(NGRDI)^2 – 5.434(NGRI) + 5.5737 with a coefficient of determination (R^2) of 0.7003. This means that 70.03% of the NGRI contributed to rice production. This result was recorded as a very strong correlation between the NGRDI vegetation index and rice production; it was 0.8368. Jumaigra (2019) interval table showed that correlation interval values (r) within intervals above 0.80 to 1.000 identified as a very strong relationship. In this linear regression there was one outlier data in plot 277, thereby the data was not included in the graph.

3.6. Correlation between ExG Vegetation Index and Rice Production

The relationship between *Excess Green* (ExG) vegetation index and rice production can be seen in Figure 6.

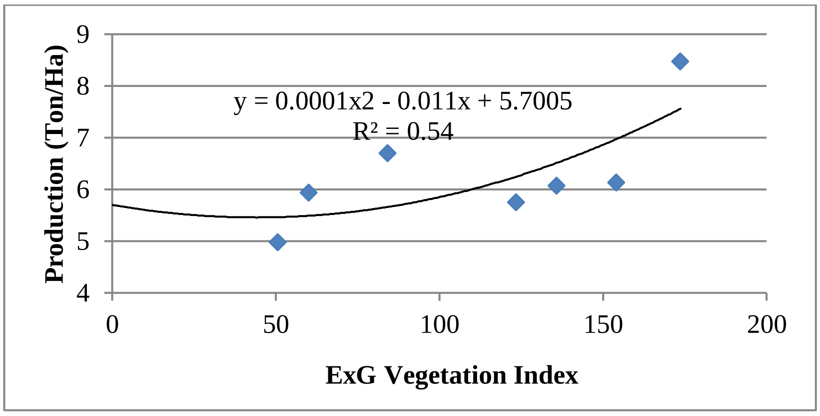

Figure 6. Correlation between ExG Vegetation Index and Rice Production.

Figure 6 shows that the correlation equation between the RGB (ExG) value and rice production was $0.0001(ExG)^2 - 0.011(EXG) + 5.7005$. This equation resulted in determination (R^2) of 0.54, which means that 54% of ExG contributed to rice production. Therefore, the correlation between the ExG vegetation index and rice production was 0.7348, and can be categorized as strong (Jumaigra interval table, 2019). One outlier data was found in plot 277, thus it was not included in the graph.

3.7. Correlation between NDVI Vegetation Index and Rice Production

The relationship between *Normalized Difference Vegetation Index* vegetation index and rice production can be seen in Figure 7.

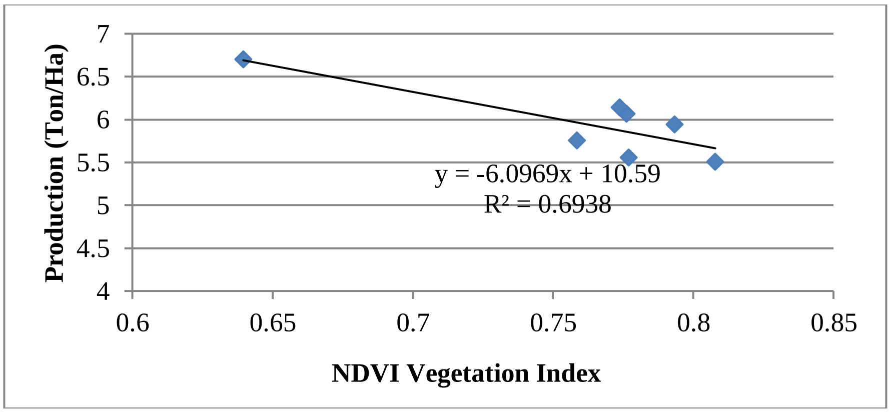

Figure 7. Correlation between the NDVI Vegetation Index and Rice Production.

Figure 7 shows the correlation equation between NDVI value and rice production in the field was $-6.0969(NDVI) + 10.59$, with a coefficient of determination (R^2) of 0.6938. This means that 69.38% of NDVI contribute to rice production. The correlation value (r) from the relationship between the NDVI vegetation index and rice production above was 0.8329, and can be categorized as very strong . In this linear regression there were two outlier data, namely in plots 150 and 128. As a result, these data were not included in the graph.

3.8. Correlation between NDRE Vegetation Index and Rice Production

The relationship between *Normalized Difference Red Edge* vegetation index and rice production can be seen in Figure 8.

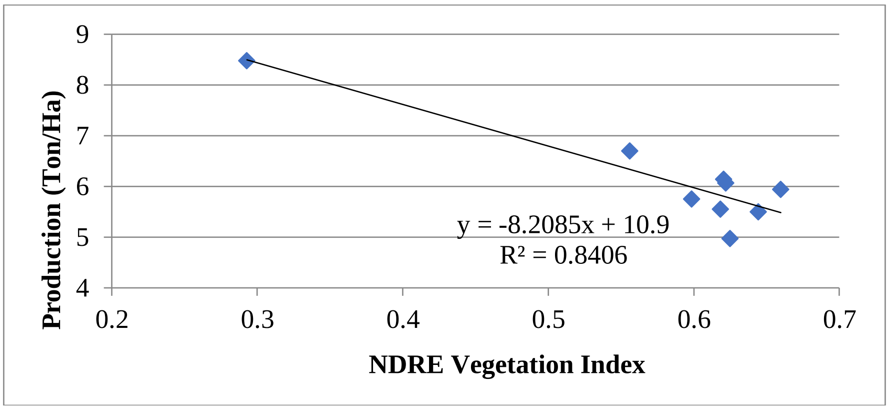

Figure 8. Correlation between the NDRE Vegetation Index and Rice Production.

Based on the correlation between NDRE value and rice production in the field, the production equation was -8.2085(NDRE) + 10.9 with a coefficient of determination (R^2) of 0.8406. This means that 84.06% of NDRE contributed to rice production. The correlation value (r) from the relationship between NDRE vegetation index and rice production above was 0.91684, and was categorized as very strong (Jumaigra interval table, 2019).

3.9. Validation of Production Estimation Equation

In this study, a regression analysis was performed to determine the relationship between several vegetation index and rice crop production. Vegetation index with the highest determination value was NDRE. Thus, this index was used for validation.

Table 2. Test of Rice Production Estimation Equation.

No. Plot	Field Production (Tons/Ha)	Estimation (Tons/Ha)	Difference
78	5.9	5.4	0.5
128	4.9	5.7	0.8
129	5.5	5.8	0.3
132	5.7	5.9	0.2
151	6.0	5.8	0.2
153	6.6	6.3	0.3
277	5.5	5.6	0.1
282	6.1	5.8	0.3
89	6.1	5.9	0.2
125	5.9	5.5	0.4
214	5.6	5.9	0.3
Average	**5.8**	**5.7**	

Based on Table 2, it can be seen that the estimation of processed imagery data of NDRE vegetation index was not very different with the field production data.

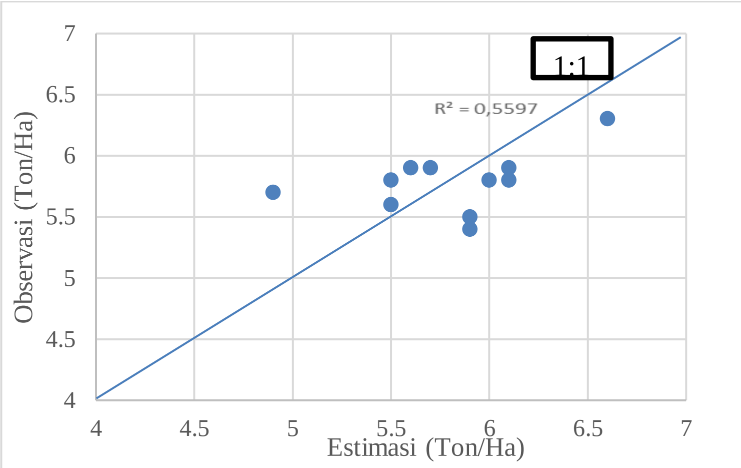

Figure 10. Correlation Between Production Estimation and Field Production.

Based on the graph in Figure 10, the accuracy of rice production estimation was 55.97%. The graph shows that more data were underestimate (below the straight line). This means that the results of the estimation are smaller than the results obtained in the field.

4.CONCLUSION

The conclusions from this study are as follows:

1. Three levels of relationship, i.e., moderate, strong, and very strong, were obtained from the correlation analysis between the several vegetation indices used in this study. TGI vegetation index showed a moderate level of relationship, while VARI, ExG, RGBVI and GLI vegetation indices showed a strong relationship. The very strong relationship was indicated by vegetation index of NGRI, NDVI and NDRE.
2. The estimation of rice production can be predicted with the NDRE vegetation index which had the highest determinant value of 84.06%. The validation of the NDRE vegetation index showed result of 55.97%. More data was under estimated which means the results of the estimation are smaller than the results obtained in the field.

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