



## Prediction of rice harvest results based on aerial image segmentation of texture and color features in Nganggil Purwodadi Grobogan village

Eko Supriyadi<sup>1</sup>, Agus Susilo Nugroho<sup>2</sup>, Arindhya Ratna Hayuningtyas<sup>3</sup>, Puput Rismawati<sup>4</sup>, Zahra Fatma Sania<sup>5</sup>  
An Nuur Purwodadi University, Grobogan, Indonesia

### ARTICLE INFO

#### Article history:

Received Nov 08, 2023

Revised Nov 10, 2023

Accepted Nov 15, 2023

#### Keywords:

Area image segmentation;  
Canny algorithm;  
Color hsv algorithm;  
Otsu algorithm.

### ABSTRACT

Rice growth is very unstable in areas with large areas of land. The causes of unstable crop yields are caused by several factors, including natural factors, the type of rice planted, care models and also pests and weeds found in rice fields. Due to the large area of agricultural land, farmers cannot monitor the progress of the rice they plant. Monitoring of farmers is mostly only carried out in the edge areas of the rice fields, while those in the middle areas are most likely not included in monitoring. So this research will carry out a broad monitoring system that covers the entire rice field area. This system is carried out by taking pictures through the air using a drone. By using drones, the area coverage becomes wider and the image data obtained will then be processed to estimate the rice production results that will be obtained. In this imaging process, the k mean method is used to group images of agricultural areas. The identification process used is HSV color and texture using the Otsu and Canny algorithms for each part of the image. The default weight factor is the factor used to convert from RGB to HSV. With line selection, Parameters are culled: angle, length, mean, mode, bounding rectangle and standard deviation, min max values. The land area process where in this study there were 624 land images, this grouping produced areas that determined the shape of the rice or non-rice type images. From the table above, look for the average value of weight per kilogram and get predicted results with an average harvest area of 21,078 quintals or 2.32 tons with an error rate of 0.82%

*This is an open access article under the [CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/) license.*



#### Corresponding Author:

Eko Supriyadi,  
computer science study program,  
An Nuur Purwodadi University,  
Majenang, Kuripan, Kec. Purwodadi, Kabupaten Grobogan, Jawa Tengah 58112, Indonesia  
Email: [ekosupriyadi@anuur.ac.id](mailto:ekosupriyadi@anuur.ac.id)

### 1 INTRODUCTION

One of the Indonesian people's economies is agricultural commodities with an agricultural land area of 15.99 million hectares with a yield of 83.037 million tons in 2018 which was rice production (Mahananto, Sutrisno Salyo, 2009). The non-optimal rice growth process is a serious problem in the agricultural sector, so it greatly affects the development of rice production. This influence is caused by several factors, including natural factors, the type

of rice planted, the care model and also pests and weeds found in the rice fields. (Arifin et al., 2021).

Due to the large area of agricultural land, farmers cannot keep up with the growth of rice planted. Most farmer monitoring is only in areas on the edge of rice fields, while it is very possible that monitoring can not reach the middle areas. In carrying out aerial monitoring, tools are needed in the form of technology that can take aerial images (Saputri & Amalita, 2020). The use of aerial photography is becoming easier to implement as the price of drones becomes more affordable, however the price of drones equipped with special agricultural sensors such as Near Independent (NIR) cameras is still not affordable (Maspiyanti et al., n.d.).

Technological developments in digital image processing vary greatly to combine the development of rice plants using drones with RGB format cameras. This research uses a technique to segment K-Means clustering of rice growing areas based on color features and texture features, producing rice growing areas on agricultural land. From these results, a reference is used as a basis for calculating harvest results (Reza et al., 2019).

Previous research created a system for predicting the area of rice fields and rice harvests based on drone images. This system uses threshold and filtering methods. The feature used is the HSV yellow value (hue, saturation, value) in rice. This study produced 4 data with error ratios of 3.1%, 8.7%, 4.9%, and 248% respectively (Reza et al., 2019). Fuzzy Logic modification for classification of nine rice growth phases based on hyperspectral images was carried out (Maspiyanti et al., 2013). Fuzzy Logic Modification can increase accuracy by up to 10% when compared to Fuzzy Logic (Maspiyanti et al., n.d., 2013). The MODIS-based rice growth phase accuracy model was tested on the island of Lombok against multi-time Landsat images and field data. Model consistency shows that the results of the phase analysis resulting from MODIS image refinement show a consistent pattern as well as 86% accuracy of rice plants using the EVI pattern, while the EVI pattern of the MODIS image which is not smoothed is inconsistent (Made Parsa et al., n.d.; *PEMETAAN POLA TANAM DAN KALENDER TANAM*, n.d.).

UAV (Unmanned Aerial Vehicle) is an unmanned aircraft that is controlled remotely or flown independently and is programmed in advance or automatically. Aerial photography with this UAV can be controlled remotely (Hall et al., 2018a, 2018b; Jin et al., 2017). To make this photography activity easier as mapping, an unmanned aircraft carries camera hardware to take pictures. The images obtained from the camera in the form of images are still not enough to cover the area that will be used as the object of aerial photography. To get wider image results, image stitching or image merging is used (Pratama et al., 2022). After combining the images, there is still information that can be added, such as the area of the area photographed. Such as information on the area of rice fields. Because Indonesia is an agricultural country, information on the area of rice fields planted with rice is needed and from this extensive information it can be used to predict rice crop yields so that one solution that can be used is to use rice fields containing ready-to-harvest rice as aerial photography objects (Holik et al., 2019). Aerial photography is used as a way to measure the area of rice fields planted with rice because it can save measurement time, is easier and the data obtained is more accurate (Adi et al., n.d.).

This research contributes to the analysis of improving the performance of rice harvest predictions in the Nganggil Purwodadi area by applying the Otsu and Canny algorithms and other algorithms in the segmentation process to obtain fast and maximum accuracy results. And it is hoped that this modeling can be applied to help farmers predict the yield of rice that will be harvested.

## 2 RESEARCH METHOD

### 2.1 Research Stages

The flow diagram of the stages in the research is in the following picture. An explanation of the research method flow diagram will be explained further.

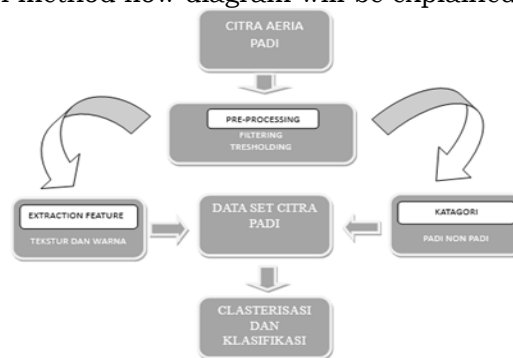


Figure 1. System design

### 2.2 Rice Area Image

Aerial pictures of rice fields were taken in one of the agricultural fields in Nganggal Hamlet, Karanganyar Village, Purwodadi District, Grobogan Regency, Central Java. The research was conducted in July 2023 with a rice field measuring 32 meters wide and 84 meters long. Aerial photography was taken using a DJI Mini Se drone equipped with an RGB camera which produces an image resolution of 4864 x 3648 pixels in JPG format. The images were taken in the afternoon between 14.00-16.00 with the drone height above the target rice area of 20 meters.



Figure 2. taking pictures using a drone

### 2.3 Pre-Processing

At the pre-processing stage, 3 stages are carried out, the first is a filtering process using the Otsu Filter method. Next, the process of resizing the image size is carried out from 3264 x 1348 pixels to 320 x 130 pixels. And finally, the cropping process is carried out with a data size of 10 x 10 pixels. So from each image we get a dataset of 172. After the cropping process, the filtering process and also the feature extraction process are carried out. This process produces data which will later be used for the next process.



Figure 3. rice field area ready for harvest



Figure 4. Image cropping results

### 2.1 Feature Extraction

At the thresholding stage for color separation. The feature extraction stage is carried out using 2 parameters, namely color and texture. Each parameter is processed to get a value from each data from rice and non-rice. To produce the desired color, the average hue color value is added to the standard deviation in the dataset. The HSV color model consists of 3 compositions, namely Hue with a scale of 0-360, Saturation with a level of 0-100 percent, and Value with a brightness of 0-100. Of the 3 compositions, the Hue value is used. This method is used to obtain data on mean, max, and min values in RGB and HSV values in the image Formula used:

$$H = 60x \begin{cases} 0 + \frac{(G-B)}{\max-\min} \text{ if } \max = R \\ 2 + \frac{(B-R)}{\max-\min} \text{ if } \max = G \\ 4 + \frac{(R-G)}{\max-\min} \text{ if } \max = B \end{cases} \quad (1)$$

Where:

R= Red value

G = Green's value

B = Blue value

From the color segmentation process the RGB histogram values are displayed.

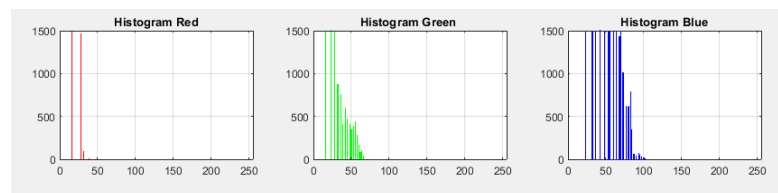


Figure 5. RGB hitogram

The RGB values are converted into Lab images after the image and background extraction process is carried out. The Lab space consists of luminosity layer L as well as chromaticity layers a and b, which shows where the colors are along the blue yellow axis and the green red axis. Conversion formula:

$$L^* = 166 f \left( \frac{y}{y_n} \right) - 16 \quad (2)$$

$$a = 500 \left( f \left( \frac{x}{x_n} \right) - f \left( \frac{y}{y_n} \right) \right) \quad (3)$$

$$b = 200 \left( f \left( \frac{y}{y_n} \right) - f \left( \frac{x}{x_n} \right) \right) \quad (4)$$

Being  $t = \frac{x}{x_n}, \frac{y}{y_n}, \text{ or } \frac{z}{z_n}$

$X, Y, Z$  describe the color stimulus considered and  $X_n, Y_n, Z_n$  describe a specified white achromatic reference illuminant.

## 2.2 Texture

Texture parameters are calculated based on the texture value of each resulting dataset starting with a Gaussian filtering process to smooth the image, the next process uses the otsu and canny filter methods. To get a gray image histogram into two different areas automatically without entering a Threshold value. The approach used uses the Otsu method by carrying out discriminant analysis to determine a variable so that it can differentiate between two or more groups that arise naturally (Putri & Sumiharto, 2016). Discarding objects in the background of discriminant analysis will maximize that variable.

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t) \quad (5)$$

$\sigma_w^2$  called WCV (Within Class Variance) and  $\sigma_0^2$  called BCV (Between Class Variance)

After the median filter process is carried out, the next stage is to detect edges using the canny method. The results obtained from several applications of the basic Canny algorithm are that noise signals in the image are removed by applying a Gaussian filter. The image produced in this process will be slightly blurry. This is intended to obtain true image edges. If the procedure is ignored, fine lines will be detected as edges. Edge detection of objects is carried out using one of the operators such as Roberts, Prewitt, or Sobel by carrying out a search horizontally (Gx) and vertically (Gy), the direction of the edge is determined by the equation formula:

$$\theta = \arctan \left( \frac{G_x}{G_y} \right) \quad (6)$$

$\theta$  = Angle (edge direction)

Gx= Gradient x

Gy= Gradient y

The texture segmentation process produces labeled images, which will later be used in the resulting analysis process.

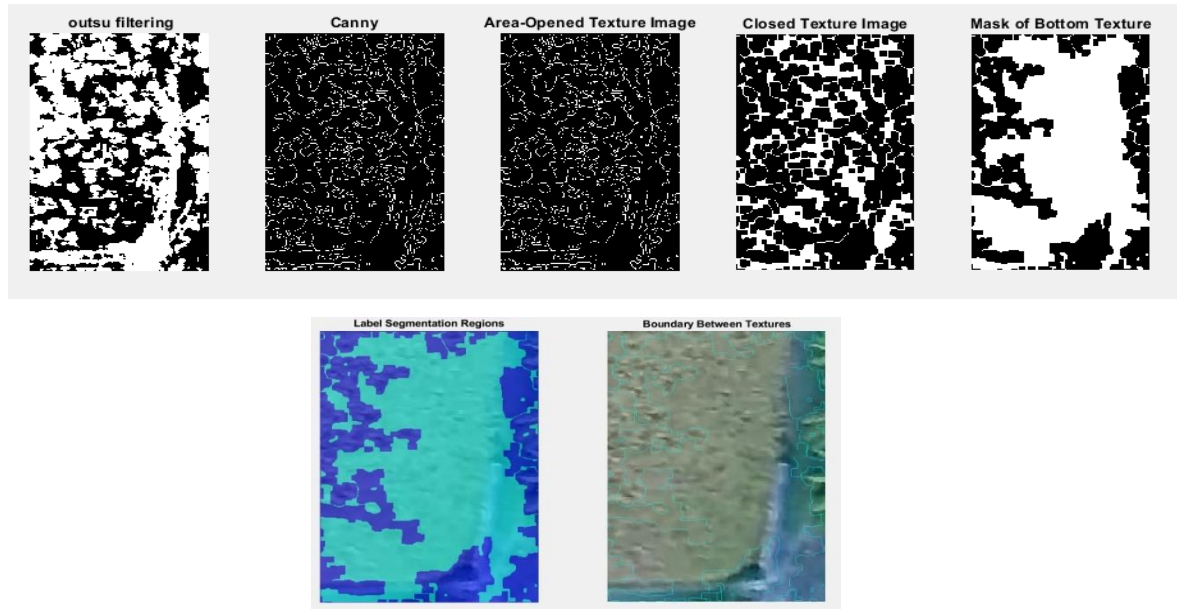


Figure 6. Texture segmentation

To sharpen edge detection, non-maximal suppression is needed and then thresholding is needed using two thresholds which aim to determine the lower and upper thresholds.

### 2.3 K-Means Clusterization

At the clustering stage, by converting the color in the image, from RGB to L\*a\*b color, then components a and b in the L\*a\*b image are used as a reference for k-means processing. In the k-means grouping process, by separating objects based on location distance. The distance between objects, the number of clusters must be determined. The color information is located in space a-b, then the object values are channels a and b. By using the Euclidean distance matrix, the objects are divided into three clusters.

$$d(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (7)$$

D (x, y) = Distance of data from x to the center of cluster y

$x_i$  = x data in i data attribute

$y_i$  = The y-th center point on the i-th attribute

Determine the value of k, determine the initial centroid value randomly, calculate the distance of each data to the centroid. group each data based on the data and its centroid center, recalculate the centroid value with the mean value of each cluster. Perform steps 3 to 5 times until the centroids do not change.

## 3 RESULTS AND ANALYSIS

From images taken by air at a height of 15 to 25 meters from the ground, the images were cropped into 8 aerial images of rice fields measuring 50 x 100. Then the feature extraction and segmentation process is carried out to obtain a data set which will later be analyzed.

### 3.1 Feature and Dataset Extraction

At this stage, the process of resizing the image is carried out from its actual size of 1280 x 720 pixels to a size of 519 x 509 pixels. This process is carried out to speed up the data processing process. Next, the results of the resizing were carried out by a cropping process with a size of 8 x 10 pixels so that 536 data were obtained and the color and texture feature extraction process was carried out by looking for the mean value and standard deviation of RGB, HSV and Canny.

### 3.2 Image Clusterization

The next process is K-means Pixel Segmentation on the cropped rice image. Here it is assumed that the cropped image has the same resolution. K-means segmentation aims to group the same pixel values in the image. In the segmentation process, it is useful to group colors in similar rice images according to the specified class. Because in grouping the RGB and HSV values will be used as the next process.

The aim of this clustering process is to process any unsupervised data from the extraction results using color, texture and label parameters for rice and non-rice segments. Area segmentation process.

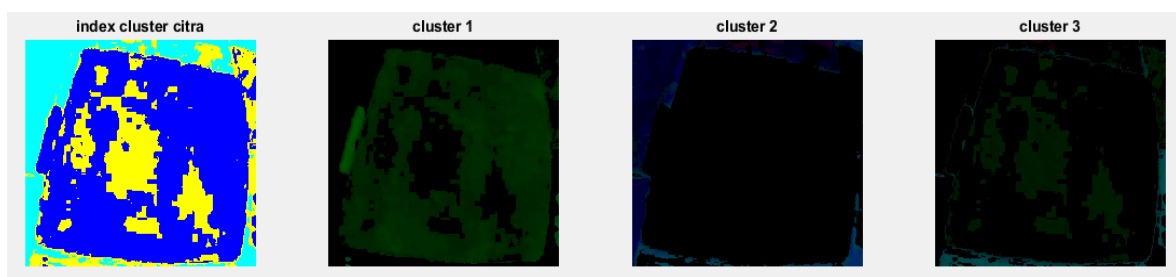


Figure 7. Image clustering process

### 3.3 Results and analysis

The data generated from the image clustering process above produces image data taken for each image processed. In the image clustering process, 3 processes are carried out to obtain RGB and HSV values, the RGB values are converted to brightness values using the default weight factor values. parameters are carried out by selecting a line: from the straight line angle, length, standard deviation, average, min max value, mode, and bounding rectangle. The data generated from the image process above is mentioned in the table below.

No	Color mean	Color deviation	Mean texture
1	1.01	6.39	0.0516
2	0.72	5.54	0.0411
3	1.38	8.03	0.0649
4	2.26	8.38	0.0655
5	1.02	5.72	0.0610
	.....	.....	.....
	.....	.....	.....
	.....	.....	.....
620	2.91	3.16	0.0489
621	1.46	9.28	0.0568
622	4.53	8.77	0.0349
623	0.80	5.43	0.0382
624	2.07	7.88	0.0354

The land region process where in this study there were 624 land images, in the grouping a region was produced that determined the shape of the image type of rice or

non-rice. Column 1 is the farmer's land area data and the column below is the standard deviation of the location of the rice field area that will later be harvested. The results of the regional process to find the location of rice crop areas that are ready to be harvested are shown in the following table.

The following image is the result of the process of using areas to find locations for rice planting areas that are ready to be harvested.

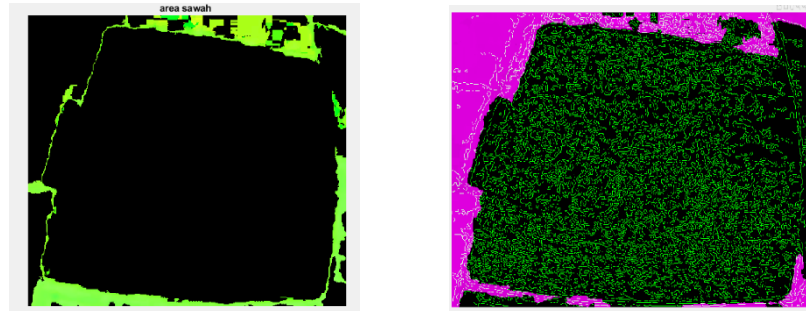


Figure 8. Area ready for harvest

The table below is the result of the above process:

Table 2. Region prediction results

Predict the results from each image				
Image	Sample picture no.	Wide land (mm) <sup>2</sup>	measured land (mm) <sup>2</sup>	Relatively error (%)
1		16326	757,38	78%
2		6051	384,55	86%
3		7565	585,97	96%
4		28629	812,83	94%
5		10629	1120,94	97%
...	...	...	...	...
618		10629	1120,94	97%
619		12861	1024,26	99%
620		6931	864,04	90%
621		4321	449,04	99%
622		1537	276,87	99%
623		2781	403,26	97%
624		2029	754,64	92%

### 3.4 Harvest Predictions

The next process is a polygonal area search for each rice area in the image to calculate the area of each part of the rice. In this process, we differentiate between rice and leaves and others, therefore applying algorithms to images is very important to be able to select the desired chart type.

This process produces data:

Table 3. Prediction results for rice harvest

Estimasi hasil informasi luas butiran padi yang diperoleh				
Image	Actual yield kg / m	predicted results kg / m	actual and predicted differences kg/m	error
1	3	3,92	-0,92	0.9428
2	1119	1177,07	-58,07	0.5914
3	25	25,05	-0,05	0.9802
4	382	396,88	-14,88	0.9724
5	1750	1866,53	-116,53	0.6653
.....	.....	.....	.....	.....

.....	.....	.....,	.....	.....
.....	.....	.....,	.....	.....
618	1676	1851,65	-175,65	0.9032
619	44	45,72	-1,72	0.8936
620	3093	3300,39	-207,39	0.7484
621	63	80,35	-17,35	0.9861
622	1212	1198,01	13,99	0.6289
623	1227	1215,57	11,43	0.6220
624	1221	1208,35	12,65	0.6211

From the rice harvest prediction process, a comparison and linearity graph was created between the actual data and the predicted data as shown in the image below :

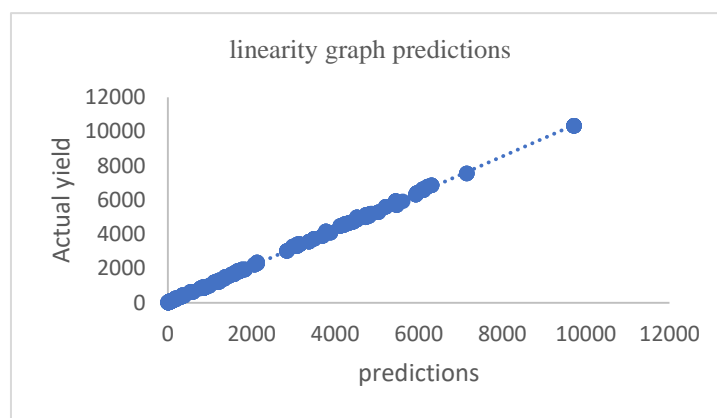


Figure 8. linearity graph predictions

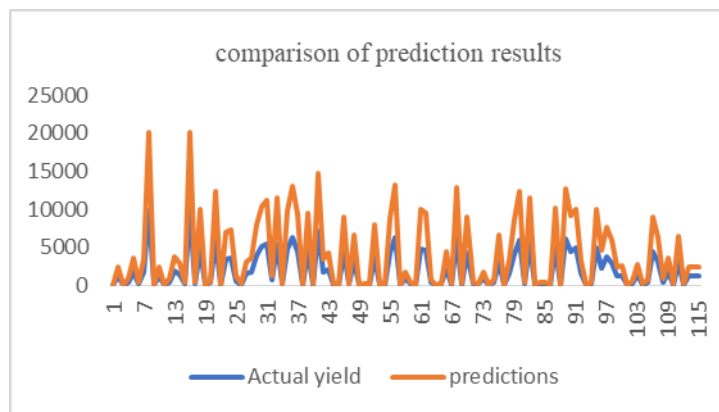


Figure 9. comparison of prediction results

The data from each group of images in each cluster is then taken as an average value which will later be used for the next iteration. The results obtained from the comparison between the actual weight and the predicted weight are used to see the reliability of the predicted data.

From the table above, look for the average value of weight per gram and get predicted results with an average harvest area of 21,078 quintals or 2,32 tonnes with error levels 0,82. The data error is caused by more light than the land image, so that during the detection process, many green rice fields are detected to be yellow due to the different light conditions in the image. And there are also trees and noise caused by rice fields with yellowing rice mixed with the green color of the rice and detected by the system.

#### 4 CONCLUSION

Based on the research results, the implementation of several processes to obtain results: Using drones is very effective and efficient because it can reach difficult areas. The binarization process using the Otsu and Canny methods is able to produce binary images that are very satisfactory and very helpful in determining the process. In the image clustering process, data on the area of farmers' land area and prediction results can be generated from the average value of production results.

The implication of this research is that it is important for rice harvest detection which farmers can later use to predict their rice harvest. The use of this algorithm is very helpful in processing quickly and producing precise accuracy. There were many obstacles faced in this research, both from weather factors when taking pictures with very strong winds, and also other factors in image to image processing, because the data obtained contained data that was almost the same from one image to another. And it is hoped that it can be developed by creating a more sophisticated and accurate system in the future.

#### ACKNOWLEDGEMENTS

The researcher would like to thank the Directorate of Research and Community Service, Directorate General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia for the support given to the researcher in the form of research funds which supported the progress of this research well. We would also like to express our thanks to An Nuur University for providing support to support the ongoing research.

#### REFERENCES

- Adi, M., Hutabarat, P., Julham, M., Wanto, A., Studi, P., Informatika, T., Tunas, S., & Pematangsiantar, B. (n.d.). *PENERAPAN ALGORITMA BACKPROPAGATION DALAM MEMREDIKSI PRODUKSI TANAMAN PADI SAWAH MENURUT KABUPATEN/KOTA DI SUMATERA UTARA*. 4(1), 77–86.
- Arifin, M. J., Basuki, A., Sena, B., Dewantara, B., & Korespondensi, P. (2021). *Segmentasi Pertumbuhan Padi Berbasis Aerial Image Menggunakan Fitur Warna Dan Tekstur Untuk Estimasi Produksi Hasil Panen Segmentation of Paddy Growth Area Based on Aerial Imagery Using Color and Texture Feature for Estimating Harvest Production*. 8(1), 209–216. <https://doi.org/10.25126/jtiik.202183438>
- Hall, O., Dahlin, S., Marstorp, H., Bustos, M. F. A., Öborn, I., & Jirström, M. (2018a). Classification of maize in complex smallholder farming systems using UAV imagery. *Drones*, 2(3), 1–8. <https://doi.org/10.3390/drones2030022>
- Hall, O., Dahlin, S., Marstorp, H., Bustos, M. F. A., Öborn, I., & Jirström, M. (2018b). Classification of maize in complex smallholder farming systems using UAV imagery. *Drones*, 2(3), 1–8. <https://doi.org/10.3390/drones2030022>
- Holik, A., Rahimi Bachtiar, R., Studi Agribisnis Politeknik Negeri Banyuwangi Jl Raya Jember Km, P., & Kabat Banyuwangi Jawa Timur, L. (2019). *PREDIKSI HASIL PANEN PADI MENGGUNAKAN PESAWAT TANPA AWAK Prediction of Rice Harvest Using Unmanned Aircraft*. *Jurnal Ilmiah Rekayasa Pertanian Dan Biosistem*, 7(2), 249–257. <https://doi.org/10.29.303/jrpb.v/7i2.139>
- Jin, X., Liu, S., Baret, F., Hemerlé, M., & Comar, A. (2017). Estimates of plant density of wheat crops at emergence from very low altitude UAV imagery. *Remote Sensing of Environment*, 198, 105–114. <https://doi.org/10.1016/j.rse.2017.06.007>
- Made Parsa, I., Dirgahayu, D., Manalu, J., Carolita, I., Pusat Pemanfaatan Penginderaan Jauh, W. K., & Jln Kalisari, L. (n.d.). *UJI MODEL FASE PERTUMBUHAN PADI BERBASIS CITRA MODIS MULTIWAKTU DI PULAU LOMBOK (THE TESTING OF PHASE GROWTH RICE MODEL BASED ON MULTITEMPORAL MODIS IN LOMBOK ISLAND)*. <http://MODIS.gsfc.nasa>
- Mahananto, Sutrisno Salyo, A. C. F. (2009). *FAKTOR-FAKTOR YANG MEMPENGARUHI PRODUKSI PADI Studi Kasus di Kecamatan Nogosari , Boyolali , Jawa Tengah*. *Wacana*, 12(1), 179–191. <http://wacana.ub.ac.id/index.php/wacana/article/view/181>

- Maspiyanti, F., Fanany, M. I., & Arymurthy, A. M. (n.d.). *KLASIFIKASI FASE PERTUMBUHAN PADI BERDASARKAN CITRA HIPERSPEKTRAL DENGAN MODIFIKASI LOGIKA FUZZY (PADDY GROWTH STAGES CLASSIFICATION BASED ON HYPERSPECTRAL IMAGE USING MODIFIED FUZZY LOGIC)*.
- Maspiyanti, F., Fanany, M. I., & Arymurthy, A. M. (2013). Klasifikasi Fase Pertumbuhan Padi Berdasarkan Hiperspektral Dengan Modifikasi Logika Fuzzy. *Jurnal Penginderaan Jauh & Pengolahan Citra LAPAN*, 10(1), 41–48.
- PEMETAAN POLA TANAM DAN KALENDER TANAM. (n.d.).
- Pratama, R. A., Nur Iman, B., Arifin, F., Negeri, P. E., Politeknik, S., Negeri, E., Kampus, S., Raya, J., Sukolilo, K., Sby, K., & Timur, J. (2022). *CYCLOTRON: Jurnal Teknik Elektro Penerapan Wahana Terbang Tanpa Awak untuk Memprediksi Waktu Panen pada Lahan Pertanian Berbasis Pengolahan Citra Digital*.
- Putri, A. Y., & Sumiharto, R. (2016). Purwarupa Sistem Prediksi Luas dan Hasil Panen Padi suatu Wilayah menggunakan Pengolahan Citra Digital dengan Metode Sobel dan Otsu. *IJEIS*, 6(2), 187–198.
- Reza, M. N., Na, I. S., Baek, S. W., & Lee, K. H. (2019). Rice yield estimation based on K-means clustering with graph-cut segmentation using low-altitude UAV images. *Biosystems Engineering*, 177, 109–121. <https://doi.org/10.1016/j.biosystemseng.2018.09.014>
- Saputri, W., & Amalita, N. (2020). *Analisa Tentang Luas Tanam dan Luas Panen di Bidang Komoditi Perkebunan di Provinsi Sumatera Barat dengan Menggunakan Analisis Profil* (Vol. 3, Issue
- Ahmad Revil., Iin Parlina2 ., M. Safii. (2018). MODEL JARINGAN SYARAF TIRUAN MEMPREDIKSI PRODUKSI PADI INDONESIA BERDASARKAN PROVINSI. *Jurnal Teknovasi*. Volume 05, Nomor 02, 1 – 13.
- Meychael Adi Putra Hutabarat., Muhammad Julham., Anjar Wanto. (2018). PENERAPAN ALGORITMA BACKPROPAGATION DALAM MEMPREDIKSI PRODUKSI TANAMAN PADI SAWAH MENURUT KABUPATEN/KOTA DI SUMATERA UTARA. *semanTIK*, Vol.4, No.1, Jan-Jun 2018, pp. 77-86.
- Gandhi Ramadhona., Budi Darma Setiawan., Fitra A. Bachtiar. Prediksi Produktivitas Padi Menggunakan Jaringan Syaraf Tiruan Backpropagation. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer e-ISSN: 2548-964X* Vol. 2, No. 12, Desember 2018, hlm. 6048-6057. 260.
- Ida Bagus Kade Dwi Suta Negara ., I Putu Kusuma Negara ., Norsa Yudhi Arso . (2023) . PREDIKSI HASIL PANEN PADI DI KABUPATEN JEMBRANA MENGGUNAKAN METODE NAIVE BAYES CLASSIFIER. *Jurnal Teknologi Informasi dan Komputer*, Volume 9, Nomor 3.
- Willmen TB Panjaitan., Ema Utami., Hanif Al Fatta. (2018). PREDIKSI PANEN PADI MENGGUNAKAN ALGORITMA K-NEAREST NEIGHBOUR. *Prosiding S N A T I F K e - 5*.
- Fitri Hidayah., S. Santosa , Renny Eka Putri. (2019). Rice Yield Prediction Model Based on Nondestructive Measurements of Rice Chlorophyll Values Paddy Leaf. *Agritech*, 39 (4).
- Rudi Hariyanto., Anang Aris Widodo. (2019). KLASIFIKASI HASIL PREDIKSI PANEN PADI BERDASARKAN FISILOGIS MENGGUNAKAN *METODE NAÏVE BAYES CLASSIFICATION*. *Conference on Innovation and Application of Science and Technology (CIASTECH 2019)*.
- Supriyanto., Sudjono., Desty Rakhmawati. (2012). Prediksi Luas Panen dan Produksi Padi di Kabupaten Banyumas Menggunakan Metode Adaptive *Neuro-Fuzzy Inference System (ANFIS)*. *Jurnal Probisnis* Vol. 5 No. 2.
- Mohammad Nur Fawaiq., Ahmad Jazuli., Muhammad Malik Hakim. (2019) . PREDIKSI HASIL PERTANIAN PADI DI KABUPATEN KUDUS DENGAN METODE *BROWN'S DOUBLE EXPONENTIAL SMOOTHING*. *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)* Volume 04, Nomor 02.
- Yiru Ma ., Lulu Ma ., Qiang Zhang ., Changping Huang ., Xiang Yi ., Xiangyu Chen ., Tongyu Hou . (2022) . Cotton Yield Estimation Based on Vegetation Indices and Texture Features Derived From RGB Image. *Frontiers in Plant Science* | [www.frontiersin.org](http://www.frontiersin.org) 1 June 2022 | Volume 13 | Article 925986 ORIGINAL RESEARCH.
- Wenan Yuan ., nuwan Kumara Wijewardane., Shawn Jenkins., Geng Bai., Yufeng . (2019). early prediction of Soybean traits through color and texture features of canopy RGB imagery. *Scientific RepoRtS* | (2019) 9:14089 | <https://doi.org/10.1038/s41598-019-50480-x>