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SMALL FORMAT AERIAL PHOTOGRAPHY TO CONTROL *CHROMOLAENA ODORATA* WEED

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Abstract. *Chromolaena odorata is a weed that interferes with oil palm plantation activities. Chromolaena odorata /kirinyuh/ Siamese weed easily grows anywhere, experiences very fast growth, and forms a tight-knit community. This weed has a competitive character that grows faster than the native plant species and may become invasive in the future. Information on the distribution pattern of these weeds has not been done much. Small-format aerial photography technology is expected to be able to trace the distribution pattern of Chromolaena odorata as information for decision-making to deal with this weed. This is due to the presence of invasive plants such as C. odorata in an ecosystem which will expand more and more, threatening the existence of endemic plants. the presence of these weeds is likely to hinder the restoration of the rehabilitation land ecosystem into a forest ecosystem. Small-format aerial photography technology takes pictures from the air and produces orthophoto images. The results of orthophoto images are processed to process requests. KMeans Clustering is used to generate call results. Parameter k is 2 to produce the desired cluster, namely the Chromolaena odorata cluster and not the Chromolaena odorata cluster. The clustering results are expected to be a reference for the map of the distribution pattern of Chromolaena odorata weeds.*

Keywords: *drone, control, weeds, UAV, Agisoft*

1. INTRODUCTION

Kirinyuh (*Chromolaena odorata L.)* is one of the dominant weeds in oil palm plantations(Harjaka, 2010). *Chromolaena odorata* is a woody shrub weed that can grow quickly making it difficult to control. This weed has a competitive character that grows faster than native plant species and can become invasive in the future(Idum Satia Santi, Bambang Sumaryo, 2008). There is not much information on the distribution pattern of this weed. The first step in controlling *Chromolaena odorata* is to recognize weed species in cultivated crop fields. Weed species recognition methods usually take a relatively long time and require a lot of human resources[3,4]. Small Format Aerial Photography is expected to be able to identify weeds, especially *Chromolaena odorata*, quickly, in a relatively large area, and accurately. Determination of weed distribution is done by creating clusters(Lottes et al., 2017). Clustering can be said to be the identification of classes of objects that have similarities. By using clustering techniques, we can further identify the density and distance of regions in object space and can find overall distribution patterns and correlations between attributes(Elfatma et al., 2021). Classification approaches can also effectively be used to distinguish groups or classes of objects(Buters et al., 2019). K-means is a clustering method that is easy and fast to use. The combination of these two technologies is expected to produce an accurate and detailed map of *Chromolaena odorat*a weed distribution patterns(Joshi et al., 2006). This research opens up opportunities to identify other weeds. Weed distribution mapping is important to use as a reference for weed control in the future.

2. LITERATURE REVIEW

2.1 Small Format Aerial Photography (SFAP)

A small format aerial photograph is a photograph produced by shooting with a camera whose film size is approximately 24 mm x 36 mm with a focal length of 35 mm. The camera lens system is not designed for mapping purposes (no fiducial marks and inner orientation prices such as fiducial mark coordinates, calibrated focal length, and location of the main point are unknown) and can be either analog or digital. The advantage of this technology is that it is easy to operate because it can utilize non-metric photographic equipment. The scale of the photo can be made very large and the flying height is quite low, the latest information on the photographed area is obtained, the price, camera, and aircraft rental are quite cheap and the equipment is quite easy to obtain on the market. The disadvantage of this technology is the imperfection of the camera lens system for mapping purposes and is not suitable for large coverage areas(Afriansyah et al., 2019; Elfatma et al., 2021; Iqbal et al., 2019; Zul Fahmi, L.P. and Widartono, 2019).

2.2 Chromulena odorata

Kirinyuh (*Chromolaena odorata L.)* in English called Siam weed, is a shrub flowering species in the sunflower family. This plant is a grassland weed whose distribution is very wide in Indonesia not only in dry or mountainous lands, but also in swamplands and other wetlands. This weed has characteristic oval-shaped leaves and the lower part is wider, leaf length is 6-10 cm, petiole length is 1-2 cm and width is 3-6 cm, has three visible leaf bones, an upright stem, woody, overgrown with fine hairs, patterned with parallel longitudinal lines, can reach 5 meters in height and even more, branched(Idum Satia Santi, Bambang Sumaryo, 2008). The base is slightly rounded and the tip is blunt, the edges are serrated, has three to five leaf bones, and the surface is short and stiff hairy. and when squeezed feels a very pungent smell, branching is opposite, compound flowering which looks dirty white. In addition, this weed is able to produce many seeds and is easily dispersed with the help of the wind because of the palpus hair. Breeds by seed and stem cuttings(Joshi et al., 2006; Karim, 2016).

2.3 K-Means algorithm

K-means clustering as one of the non-hierarchical data clustering methods partitions existing data into the form of one or more clusters or groups so that data that has the same characteristics is grouped into the same cluster and data that has different characteristics is grouped into other groups(Özgüven, 2018). The groups or clusters obtained are knowledge/information that is useful for policy users in the decision-making process(Mulia, 2021).

3. RESEARCH METHODS

The research site was in an open field in the area of Timoho, Yogyakarta. *Chromolaena odorata* weeds were found in the area. The field data acquisition stage included sampling weed locations using GPS and Small format aerial photography (SFAP). The location points of the GPS weed samples were converted into shapefiles. The conversion was done using the Coordinate geometry (COGO) method in Arcgis(Dale P. F., 1988).

SFAP was carried out by making premarks (marking ground control points) and measuring the coordinates of the premark points using GPS(Elfatma et al., 2021)(Jaakkola et al., 2010). Premarks are made in a rectangular shape with a size of 50 cm x 100 cm(Elfatma et al., 2021; Oniga et al., 2017). The premarks are arranged in a cross shape. The premark was located right at the intersection of the marks. Premark has a striking color so that it is easily visible during the processing of aerial photographs. The SFAP tools of this research are the DJI Mavic Air 2 drone and DJI Fly software. The Dji Fly software does not support automatic flight path settings, so the path setting is done manually with the grid method(Luna et al., 2016). The grid flight path was chosen because it is more flexible in exploring the land and efficient in battery usage. Mosaic photo processing was done using *Agisoft* software. The output of Agisoft is an orthomosaic image in tif format. QGIS version 3.18 was used for processing the orthophoto dataset. The K-means method was used to process the dataset. The calculation of the results in data clustering. The stages of the K-Means method include: 1) determine the number of clusters, 2) determine the centroid point k (cluster center) randomly, 3) calculate the distance of each point to the cluster center, the distance between one data and one cluster will determine which data is included in which cluster, 4) calculate the new cluster center with the current cluster membership, by way of finding the average (mean) of all objects or data in the cluster(Agusta, 2007; Septiani et al., 2019)(Sinaga et al., 2020; Yuan et al., 2019). The location of the weed sample is used as a reference for the new cluster. The new clusters are non-vegetation, *Chromolaena odorata* weed, and vegetation other than *Chromulena odorata*. The last stage is the visualization stage of the data that has been evaluated. The evaluation is done using the kappa accuracy test.

4. RESULTS AND DISCUSSION

The SFAP acquisition took place in February 2023 on open land in the Timoho neighborhood. Twenty decades earlier, this location was used to release Argentine flies for *Chromolaena odorata* weed control. Weed location acquisition in the study area was conducted randomly. Weed coordinate location acquisition was carried out using a GPS handle. The coordinate point results were processed using the COGO method. COGO is a data conversion process where digital data is created from written descriptions that can be in the form of length, direction, and point location, relative to a specific point such as a control point. COGO is the process of converting survey data, which usually cannot be easily mapped like XY coordinate plotting. Shapefiles of weed point distribution were used as a reference for clustering. A sample of weed distribution in the study area is presented in the following figure.

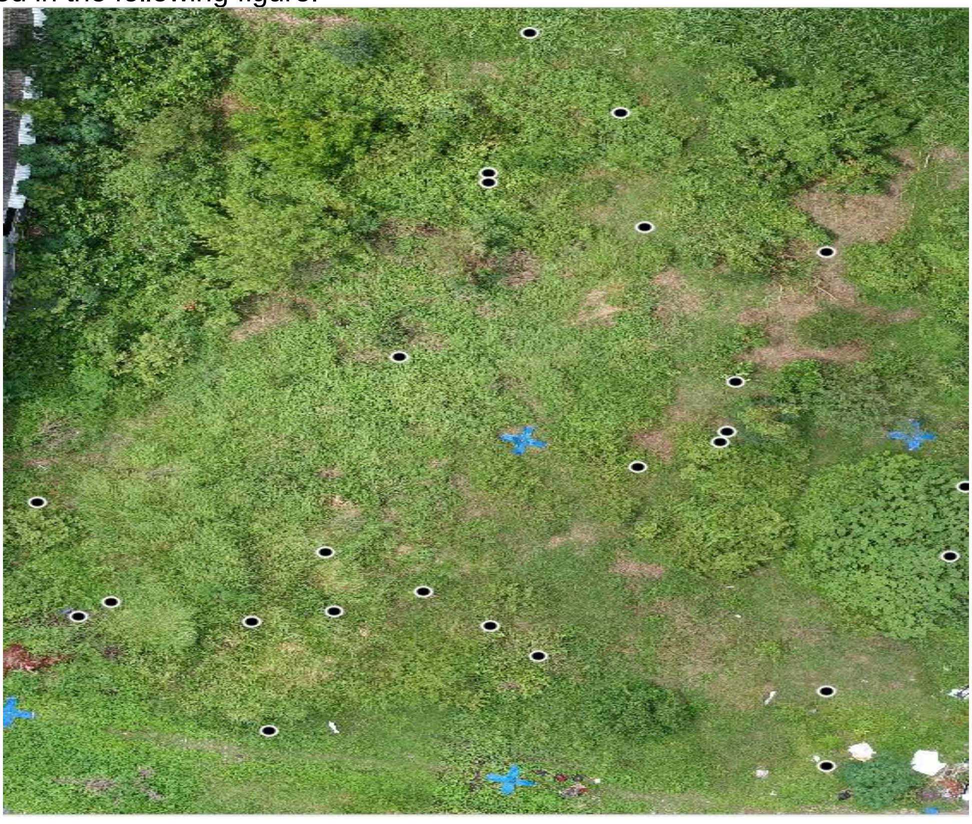

Figure 1. *Chromolaena odorata* weed distribution in the study area is shown with black dots

The results of the field survey, weeds were mostly found growing in groups. Other vegetation found in the field included reeds, banana trees, randu alas, ferns, coconut trees, and others.

Figure 2. Chromolaena odorata weed in the study area

SFAP acquisition using the grid method resulted in 52 images with a total area of 8130.27 square meters. The photos were sorted to obtain precision images. Processing using the Agisoft method produced ortho-mosaic photos with a pixel value of 1.47 centimeters. The results of the SFAP acquisition are presented in the figure below.

Figure 3. The ortho-mosaic photos

The ortho-mosaic photos are clustered from the processing of the image dataset. This research does not perform classification, because classification groups data based on the similarity of labels. Classification produces new data from the prediction of classes based on previous classification data. In this research, classification cannot be done because there is no previous classification. So, this research uses clustering, namely grouping based on data similarity. Data similarity is seen from the raster data value of aerial photography. Determination of data similarity is carried out using data distance / Euclidean distance measurements. The benefits of clustering are helping data segmentation automatically, helping the automatic data labeling process, and compressing color identity in digital images, this is beneficial in data storage.

The most commonly used and simplest data clustering is K-means. An algorithm for data clustering based on the distance of data to the nearest cluster center. The way to determine the position of the cluster center point is by first determining the number of cluster centers that you want to use. The initial cluster center is determined randomly. Random class determination in this study is limited to 10 clusters. The determination of the cluster value is done by QGIS using the K-means algorithm automatically. The results of random cluster determination in this study are presented in the following figure.

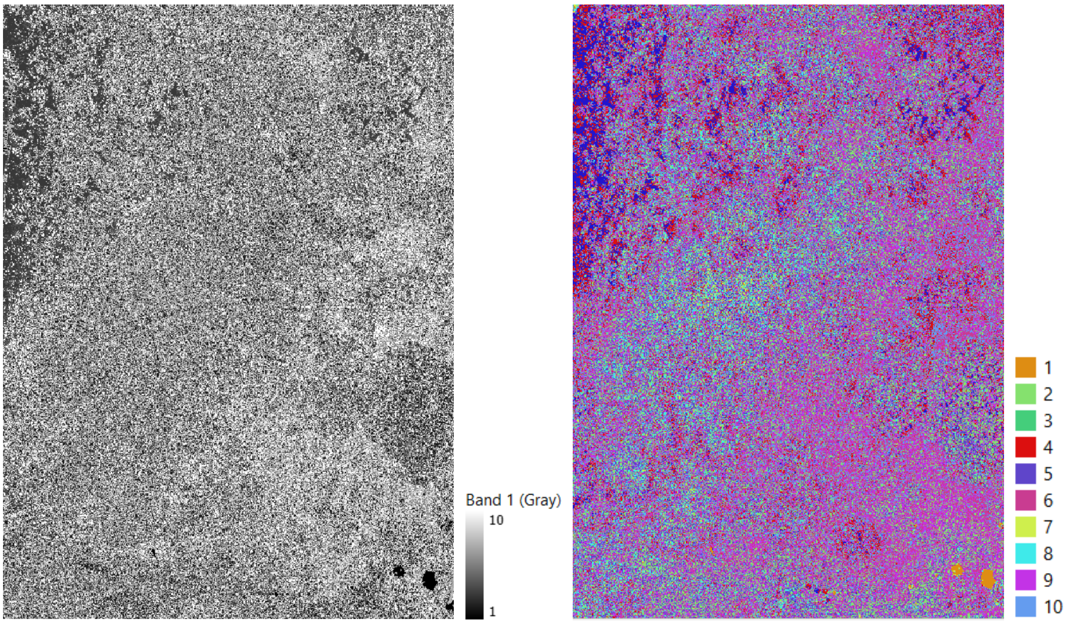

Figure 4. K-means results with 10 classes (a) black and white and (b) color based on cluster.

The processing stage of the new cluster center with the current cluster membership is done by creating a new cluster. This research uses two clusters, namely vegetation and non-vegetation. The vegetation cluster is further detailed, namely the *Chromolena odorata* weed cluster and the vegetation cluster other than the weed. In the initial stage, the determination of the cluster center is done randomly. During the initial calculation, the value of the raster sample is determined by proximity to the cluster point. Next, it will change to calculate the average value of the closest distance to the cluster point. This average value will determine the results of the new clusterization. The results of the new clusterization are presented in the figure below.

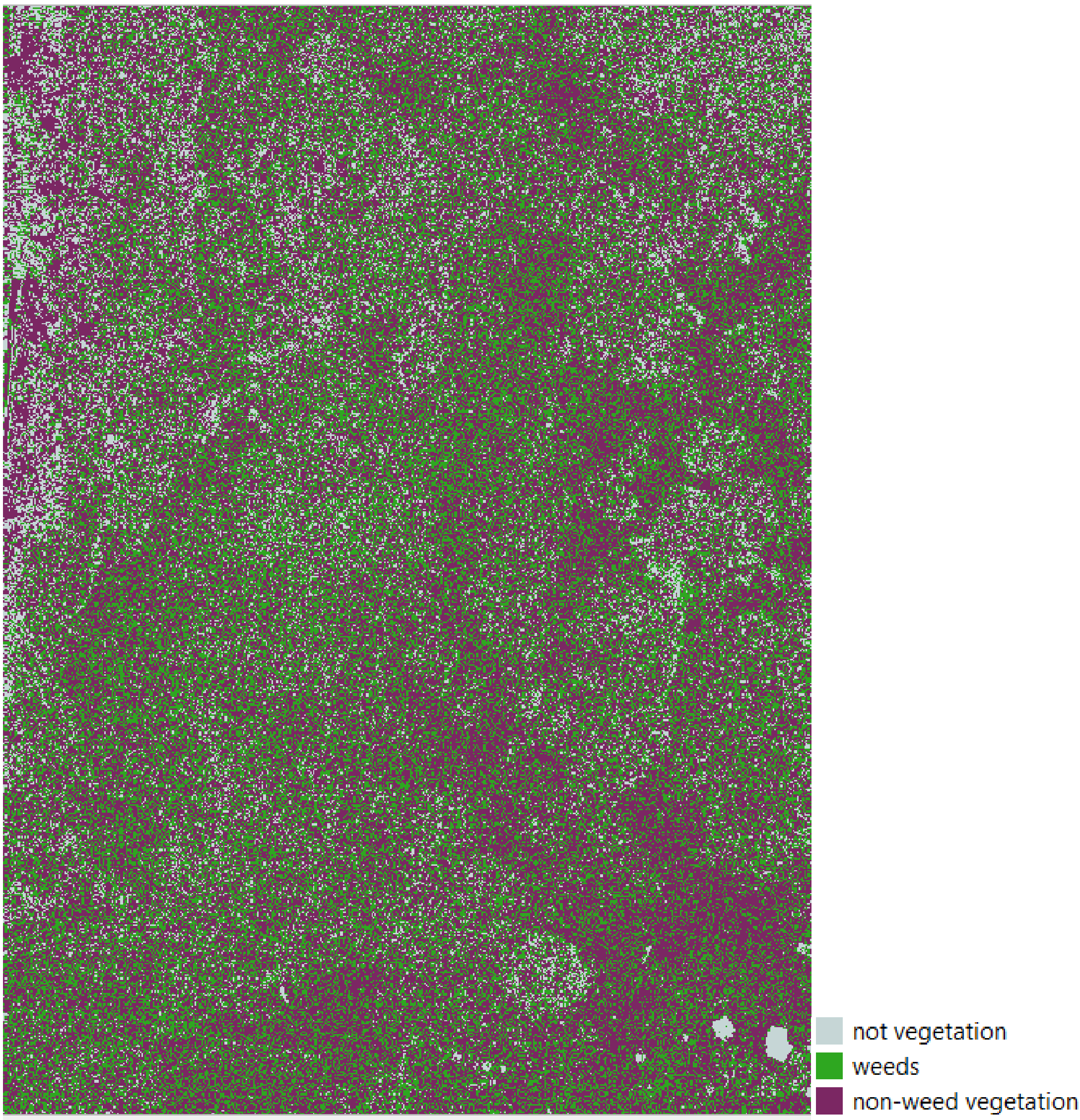

Figure 5. the Chromolaena odorata Weed Distribution Pattern Map in the Study Area.

The clustering results become the *Chromolaena odorata* Weed Distribution Pattern Map in the Study Area. The classification results of the dataset are in the form of raster data. Raster data is represented by pixels. The results of processing the distribution pattern of *Chromolaena odorata* weeds in the study area show that there are three classes. The non-vegetation class has the largest number of pixels which is 21466720 pixels, the pixel value in reality is 3156 square meters. This is about 38.8% of the total pixels in the study area. The weed class has the least number of pixels, 13849476 or 2035.3 square meters in the field. The weed area in the study area is 25%. Finally, vegetation other than weeds has an area of 36.1% of the total number of pixels in the study area. This area has an area of 2939.7 square meters or 19990934 pixels.

Table 1. classification report

Class	PixelSum	Percentage %	Area (m^2)
Not vegetation	21466720	38,8	3156
weeds	13849476	25	2035,2
Non-weeds vegetation	19990934	36,1	2939,07

ErrMatrixCode	Reference	Classified	PixelSum
1	1	1	21466720
5	2	2	13849476
9	3	3	19990934

> ERROR MATRIX (pixel count)
> Reference

V_Classified	1	2	3	Total
1	21466720	0	0	21466720
2	0	13849476	0	13849476
3	0	0	19990934	19990934
Total	21466720	13849476	19990934	55307130

> AREA BASED ERROR MATRIX
> Reference

V_Classified	1	2	3	Area	Wi
1	0.3881	0.0000	0.0000	3156.0433	0.3881
2	0.0000	0.2504	0.0000	2036.1539	0.2504
3	0.0000	0.0000	0.3615	2939.0728	0.3615
Total	0.3881	0.2504	0.3615	8131.2700	
Area	3156	2036	2939	8131	
SE	0.0000	0.0000	0.0000		
SE area	0	0	0		
95% CI area	0	0	0		
PA [%]	100.0000	100.0000	100.0000		
UA [%]	100.0000	100.0000	100.0000		
Kappa hat	1.0000	1.0000	1.0000		

Overall accuracy [%] = 100.0000
Kappa hat classification = 1.0000

Area unit = metre^2
SE = standard error
CI = confidence interval
PA = producer's accuracy
UA = user's accuracy

Figure 6. Accuracy test results of the *Chromolaena odorata* weed distribution map in the study area.

Assessment of classification results can be done by conducting an accuracy test on the classification results. Lillesand and Kiefer emphasized the importance of the accuracy test by stating that digital image analysis is not complete until the accuracy test is conducted(Jiang et al., 2019; Reis et al., 2019; Simamora et al., 2015; Inacio H. Yano et al., 2016). The accuracy of image interpretation results is the conformity between the image interpretation results and the values that are considered correct. The more appropriate or the smaller the difference between the two values, the more accurate the interpretation.

The accuracy of classification results is measured by (Luna et al., 2016), producer's accuracy, and user's accuracy. The overall accuracy shows the percentage of correct classification pixels based on field data. The pixels involved in the calculation are the sampled pixels. If the accuracy is greater than or equal to 85%, the classification result is acceptable. The overall accuracy of the research is 100%. So the results of this study show that the clustering results have a high accuracy value.

Accuracy test results of the *Chromolaena odorata* weed distribution map in the study area resulted in kappa hat classification 1. Furthermore, the calculated value was matched with the level of an agreement made by Landis and Koch(Wongpakaran et al., 2013). Based on the level of agreement in the Kappa coefficient, the level of data agreement >0.8 has a high level of confidence(Jiang et al., 2019; Prabhakar et al., 2019; Wongpakaran et al., 2013; Inacio H. Yano et al., 2016; Inacio Henrique Yano et al., 2017). The results of this study have a value of 1 to have a high level of field interpretation results with clustering results.

CONCLUSION

This research shows that the use of Small Format Aerial Photography data provides good results as *Chromolaena odorata* Weed Control. The use of the K-Means algorithm for cluster analysis of weed mapping provides a solution for automation and speed of data processing time. SFAP produced the orthophoto map with a 1.47 cm/pixel resolution and a coverage area of 8,130.27 square meters. This method is able to classify the *Chromolaena odorata* Weed Distribution Pattern Map with the Overall Accuracy (OA) of 100% and a kappa value of 1. So that the results of this study show the clustering results have a high accuracy value.

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