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Land Cover Segmentation of Multispectral Images Using Multiresolution Algorithm

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Abstract: Semantic segmentation is needed by regional planners to know the composition of land cover in their area, so that they can take the right policy. Several methods from manual to automatic have been researched, both based on colour and pattern. Each method has their strong and weakness, so it is necessary to make the right choice when applying the method. Currently, multispectral imagery is still very rarely used, even though sources of information from the internet are easy to find, i.e. Landsat imagery from the United States Geological Survey. This study uses two methods for segmenting three-channel multispectral images (red, green, and blue), namely iterative self-organizing clustering (ISOCLSUT), which is based on a colour sensor, and a multiresolution algorithm, which is based on colour and pattern. For the experiment, the pre-processed satellite image of Karawang district was segmented using the ISOCLUST as well as multiresolution algorithm. The experimental results show that land cover segmentation with multiresolution algorithm is better than ISOCLUST for RGB but for more than three channels, i.e., seven frequency channels, ISOCLUST shows better performance compared to real image conditions.

Keywords: Satellite Imagery, Multispectral, ISOCLUST, Multiresolution

I. INTRODUCTION

In the Geographic Information System (GIS) there are two land use maps, namely land use and land cover. Land cover describes how a land is covered by a biophysical environment such as buildings, trees, water, and the like, while land use describes how human socio-economic activities on land such as housing, business, industry, schools and the like [3]. A land cover, for example a building, in a land use can be residential, industrial, or business.

For land cover, the term classification is usually given the term segmentation. Moreover, in the computer science literature a similar term to classification and segmentation is object detection. In the segmentation process, each pixel of the satellite image will be segmented into several categories such as buildings, vegetation, waters, and other types of land cover.

Currently, the main source of land cover data is imagery derived from remote sensing such as satellites, drones, unmanned aerial vehicles (UAVs). Image processing is needed to produce a raw image into a segmented image. There are two types of processing involved: colour pixel based and object/pattern based [2], [3].

Initially, the map was made by direct survey to the area. However, since the development of remote sensing, most maps are drawn using satellite imagery. Applications that are currently developing such as Google Map, WAZE, among others, use Global Positioning Service (GPS) on smartphones connected to these applications. These applications work using existing techniques and methods in the field of Geographic Information Systems (GIS). In other words, remote sensing captures images and represents them with GIS tools. [4].

Digital image processing is needed in managing satellite capture from remote sensing. Satellite images have hyperspectral characteristics, namely one image capture has a number of frequency bands, for example Sentinel-2, and Landsat-9 images have 13 frequency bands [5]. Several remote sensing applications are available that are capable of classifying based on colour differences from satellite imagery. The application works well for land cover but is not able to distinguish buildings that have a specific use (land use), whether settlements, factories, roads, terminals, airports, and others. Dyna-Clue and Idrisi/TerrSet are applications that are often used in land cover classification. Other applications then emerged to perform pattern/object-based land cover segmentation known as Object-Based Image Analysis (OBIA), such as eCognition. For example, OBIA can distinguish between a river and a lake, although they are both water because they have different object shapes.

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II. DATA AND METHODS

Satellite images are raster-type spatial data taken from sensor captures on satellites (Landsat, Sentinel, IKONOS, SPOT, and others). On a regular basis, every few days, the satellite records the catch and sends the data back to earth. The sensors provided vary, ranging from high to medium resolution. In addition, each catch produces several frequency channels that are useful for certain land cover types. to process the necessary tools in the form of GIS tools and spatial analysis tools. This research uses ArcMap as GIS tools, IDRISI Selva and eCognition as segmentation tools.

A. Data

Figure 1 shows the study area. It located in latitude and longitude of 107.3375791 and -6.3227303, respectively. Located in the east of Bekasi regency, and the west of Subang. Satellite images of Karawang district can be obtained by downloading via the official website of the United States Geological Survey (USGS). Furthermore, the image with a resolution of 30 meters is ready to be downloaded. Figure 1 also shows the clipping result from Landsat image in one tile following the study area. One tile contains some regencies/cities. We actually can see the vegetation, urban, and wetland areas through the satellite imagery, in this study we use two segmentation method that can segment the satellite image into some land cover classes.

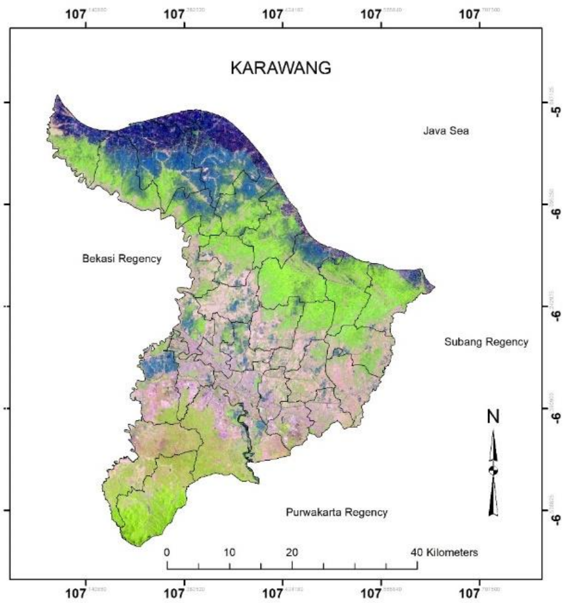

Fig. 1 Bekasi, West Java, Indonesia

The available frequency channels are channels 1 to 13 with details of channel 1 being for the coastal area, channels 2, 3 and 4 are for blue (blue), green (green), and red (red) images, respectively. Furthermore, the channels above 5 (near infrared) are infrared channels [9]–[11]. The combination of these channels is known as composite band with the well-known composite channel is Red-Green-Blue (RGB) which is a combination of 4, 3, and 2 channels. RGB channel is a visible (natural color) channel where almost Most cameras used to capture images produce this RGB channel. Other composite channels are Infrared (channels 5,4, and 3) for vegetation detection, Urban Areas (channels 7,4, and 2), agriculture (channels 5,4, and 3), and others as needed [12], [13].

Table 1 shows the information of the downloaded satellite imagery. There are 11 bands in the downloaded data after decompressing. IDRISI 19.3 was used to import these datasets. One true colour for each date was also downloaded and imported to help in re-classification using RECLASS function.

TABLE 1. LANDSAT SATELLITE IMAGERY

No.	Date	Sensor
1.	15 August 2021	Landsat 8 OLI/TIRS

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After downloading the satellite image, it is necessary to do pre-processing such as clipping and conversion according to the application format, for example from raster to ASCII. Geographic Information System (GIS) software is required to perform the cutting process according to the research area (Karawang district) with certain functions (in ArcGIS with the 'raster clip' function). Besides ArcGIS, other software that will be used is E-Cognition. This application has tools that can be used for the land cover classification/segmentation process. After the satellite image is cropped according to the research area, the E-Cognition software imports the Red-Green-Blue (RGB) image from ArcGIS.

B. Methods

Multi-resolution algorithm is a segmentation algorithm that combines pixel-based processing with object characteristics/patterns. This algorithm is an improvement from the pixel-based algorithm because certain conditions require a combination of high resolution focusing on pixels with low resolution based on a wider object/pattern.

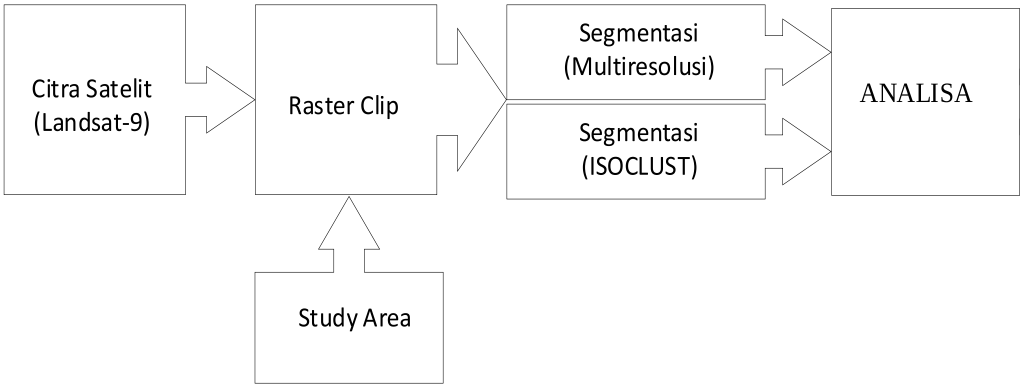

Fig. 2 Segmentation Process

Figure 2 shows the research flow. The satellite image is cropped based on the study area, namely Karawang district. Two methods are used for segmentation followed by analysis of the results. In addition to RGB images, this study also compares the results of eCognition segmentation with multispectral images with seven frequency channels.

As a comparison, another software, namely IDRISI/TerrSet will be used with the Iterative Self-Organizing Clustering (ISOCLUST) function which is one of the Hard Clustering methods. Both ISOCLUST and Multiresolution still require a manual guiding process so they are said to be semi-automatic. Although semi-automatic, the results of the two methods are quite accurate and sometimes become ground truth data in calculating the accuracy of Deep Learning/Machine Learning models.

Currently, the latest research on satellite image processing is multispectral and hyperspectral imagery [14], [15]. Although it has a low resolution (30 meters) but Landsat has been widely used by geospatial researchers, especially in analyzing land use and cover changes. In other words, the state of the art research is on the side of multispectral image processing and the application of pattern/object-based segmentation with multiresolution algorithms [16].

III. RESULT AND DISCUSSION

This study uses several supporting tools, including ArcMap version 10.1 as a Geographic Information System (GIS) tool and eCognition version 9 as a semantic segmentation tool. As a comparison, Idrisi Selva version 17 is also used.

A. Iterative Self Organizing Clustering (ISOCLUST)

This built-in method inside IDRISI Selva applies hard clustering with iterative self-organizing clustering (ISOCLUST) method. This method is very good for creating satellite image segments with multiple frequency channels (up to seven channels). These frequency channels have their own characteristics, for example, specifically for vegetation, buildings, infrared and high resolution. Figure 3 shows the results of segmentation with ISOCLUST.

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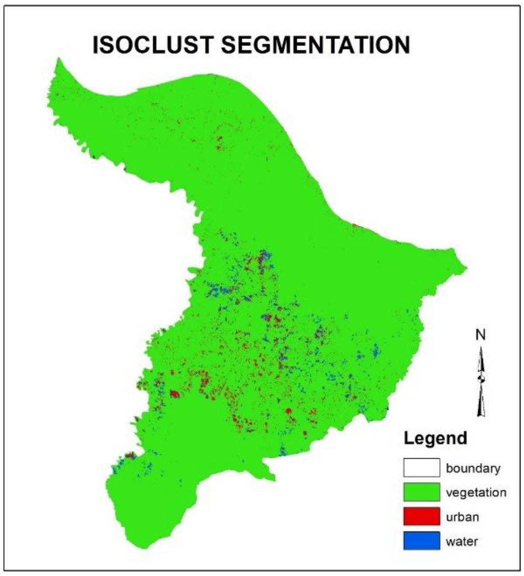

Figure 3. Results of RGB Image Segmentation with ISOCLUST

B. Importing to IDRISI

Geo-TIFF data should be converted into RST file in IDRISI using importing window. Geo-TIFF is a file TIFF with proper geospatial information, i.e. geographic coordinate and projection. The default projection from USGS for the study area, Bekasi, West Java, Indonesia is UTM 48N. There are 11 RST files after import process.

C. Multiresolution Segmentation

The multiresolution segmentation method combines colour features with patterns. By combining colour features with patterns, it is believed that this method can produce better segmentation accuracy. One of the applications used for multiresolution segmentation is eCognition. In this study, eCognition version 9. was used. Figure 4 shows the results of segmentation using the multi-resolution method.

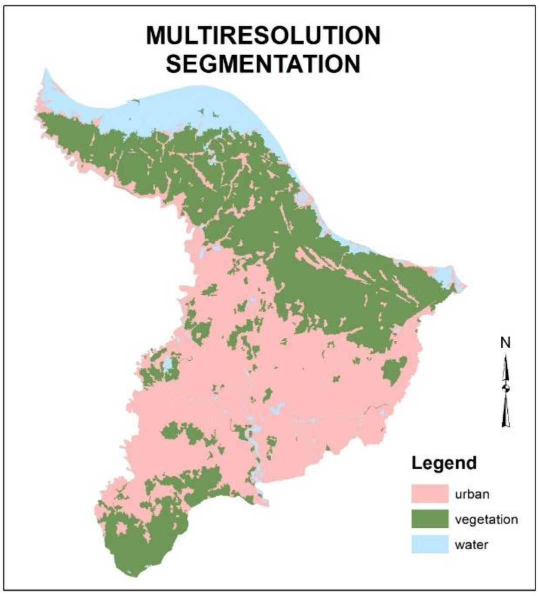

Figure 4. Results of RGB Image Segmentation with Multiresolution Method

The segmentation results show that eCognition produces vector-based classification while ISOCLUST is in the form of raster data. Each data has strengths and weaknesses. Vector data has a smaller number of memory bytes than raster data.

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Vector data is preferred by web-based GIS tools while raster data is easier to process further, for example for land cover change analysis.

For RGB images, the multiresolution algorithm has better results than ISOCLUST after the adjustment process on eCognition has previously produced worse results than ISOCLUST Idrisi Selva. Figure 5 shows segmentation with ISOCLUST on Idrisi Selva for seven frequency channels.

D. Discussion

For the same number of channels, eCognition showed better result because the multiresolution algorithms not only consider colour but also the pattern. The use of mean and standard deviation adds the clustering process more accurate, especially for the satellite with 30-meter resolution. For small number of channels, the use of high resolution image should be prepared using Unmanned Aerial View (UAV).

IV. CONCLUSION

The results of the study show differences in the characteristics of semantic segmentation between multi-resolution algorithms and Iterative Self Organizing Clustering (ISOCLUST). For multispectral images with less than three channels, e.g., red-green-blue (RGB) images are more suitable for resolution algorithms. Meanwhile, the multispectral image with the right number of more than three is more suitable with ISOCLUST which focuses on the color sensor type from the Landsat satellite. For segmentation RGB images are more suitable with the multi-resolution algorithm, while images with seven channels use ISOCLUST. Further research needs to apply deep learning methods to perform the semantic segmentation process automatically so that the process is faster and does not require user spatial analysis skills such as eCognition and Idrisi Selva.

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BIOGRAPHY

Herlawati earned Magister Management and Magister of Computer Science. She has been published some books and papers in Data Mining, Machine Learning, and Geographic Information Systems. She is also a doctoral student of Computer Science in Universitas Bina Nusantara. She is still active as lecturer at Universitas Bhayangkara Jakarta Raya.

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