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Agricultural Land Cover change Analysis Using Remote Sensing and Geographic Information System in Semarang City

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Abstract

The purpose of this study was to find out how much area of agricultural land was converted because of the high property business activities in Semarang City, the data used for this study were taken from 1999 to 2018. The classification method used in this study was the remote sensing method using the unsupervised classification technique. Output of this study is the extensive data of agricultural land cover change obtained from 1999 to 2018. The results of this study can prove that the Geographic Information System can be used to find out how much agricultural land cover change in Semarang City from 1999 to 2018. The area of agricultural land that has been converted is from 1999 to 2009 around 3072 ha and from 2009 to 2018 around 1071.4 ha.

Keywords: High Property Business Activities, Remote Sensing, Unsupervised Classification, Agricultural Land Cover Change, Geographic Information System Semarang

1. Preliminary

The demand for land for development is so strong, while the land area is not increasing or limited. So far, agricultural land has a low value compared to other land uses (non-agricultural), consequently agricultural land will continuously experience land conversion to non-agriculture. Even though agricultural land (rice fields) besides having economic value as a buffer for food needs, also ecological functions such as regulating the water system, absorption of carbon in the air and so on. (Hariyanto, 2010)

Geographic Information System (GIS) is a geographical technology that has the ability to collect, manage, manipulate and visualize spatial data (spatial) that relates to the position on the surface of the earth on a map according to the position of the actual surface of the earth with its coordinates. In general, the application of Geographic Information Systems (GIS) can be applied to various fields, such as the fields of utilities, health, telecommunications, transportation and so on (Eddy, 2001).

The high activity of the property business in the city of Semarang makes agricultural land narrower. In the last five years from 2011 to 2016, there have been 1,000 hectares (ha) of agricultural land that have changed function. Head of the Semarang City Agriculture Service Rusdiana revealed, of the total 3,700 ha of agricultural land in 2015, there was only 2,600 ha left now (Rai, 2017). In accordance with law No. 41 of 2009 article 44 paragraph 1 part 3 over functions said that "Land that has been designated as Sustainable Food Farmland is protected and prohibited from being converted" (Pusdatin dan Biro Hukum & Informasi Publik, 2009).

The negative impact of the conversion of agricultural land is one of them for the environment which can threaten the balance of the ecosystem. Population diversity in it, rice fields or other agricultural lands is a natural ecosystem for some animals. So that if the land experiences a change of function, the animals will lose their homes and can interfere with the residents' settlements. In addition, the presence of agricultural land also makes rainwater well utilized so as to reduce the risk of causing flooding during the rainy season (Maya, 2016).

From this point of view, it is necessary to analyze land use change with a remote sensing approach and geographic information system using an unsupervised classification or non-guided classification method, namely classes can be automatically determined based on grouping algorithms that choose how a pixel is. Generally, the only input from the user into this process is to select the image band that will be used in the grouping process and the final number of output classes (Fisher Rohan, 2017).

The purpose of this study is to classify Landsat imagery in the city of Semarang. It is expected that changes in land cover area can be seen and also can be calculated area of agricultural land in the city of Semarang. So that it can be a concern of the people in Semarang City if the conversion of agricultural land continues then it can have a negative impact on the environment in the city of Semarang.

2. **Literature Reviews**

As a reference from this study, using previous research, namely from a journal entitled "Analysis of Forest Function Transfer to Plantation Land Through Landsat Satellite Image Data with Supervised Classification Method (Area Study: Southeast Minahasa Regency, North Sulawesi Province)". This study discusses the distribution pattern of plantation land in the Southeast Minahasa regency region which converts forest areas into plantation land in Southeast Minahasa Regency. This has an impact on forest loss or deforestation. One of the crucial causes of forest destruction is the conversion of forests to plantations and agriculture (Hanindito, 2015).

The second previous study was from journal entitled “Analysis of Rice Field Area Conversion in Sleman Regency from 2000 to 2015, Using High-Resolution Satelite Imagery (Case Study: Ngaglik, Mlati and Depok Sub-District)”. This research discusses about how much conversion of rice fields area are reduced caused by the speed of develpoment in DIY Province. This encourages high competition for residential land use. In this research took a case study in area Ngaglik, Mlati and Depok. Method in this research is using classification method visual interpretation which utilized on-screen digitization. The results of this study are to prove that GIS can be used to determine the level of change in rice fields in Ngaglik sub-district, Depok and Mlati in DIY from 2000 to 2015. (Leunupun, 2019)

The research that will be made is "Analysis of the conversion function of agricultural land into a residential area in the city of Semarang with the Semarang City's Remote Sensing and Geographic Information System approach using the remote sensing method, namely the processing of Landsat 8 and Landsat 5 satellite images using ArcMap software. Remote Sensing is science (and art) in obtaining object information, area (or area), or even a natural phenomenon through an analysis of data obtained from devices (sensors & platforms) without direct contact (Eddy, 2008).

Image

Image is a two-dimensional representation of an object in the real world. Especially in the field of remote sensing, the image is a picture of the surface of the earth as seen from space (satellite) or from the air (airplane). This image can be implemented in two general forms: analog or digital. Aerial photos or photo maps (hardcopy) is one form of analog imagery, while satellite images that are data recorded by sensor systems (radar, detector, radiometer, scanner, and the like) are forms of digital imagery (Eddy, 2008).

Classification Techniques

There are 3 Classification Techniques in Remote Sensing namely (1) Unsupervised classification, (2) Supervised classification, (3) The most commonly used object-based image analysis is Unsupervised classification and Supervised classification, but Object-based image analysis is also often used at the end - this end because it is useful for data that has high resolution (Gisgeography, 2015).

Image Classification

Image classification is the process of grouping pixels into classes or categories that have been determined based on the brightness value (digital number / DN) of the pixel in question (INS, 2002).

Spectral Value

Spectral value is when electromagnetic waves interact with an object on the surface of the earth will produce a value known as spectral (Danoedoro, 2012). The process of obtaining spectral values by means of electromagnetic waves that hit objects will be dissipated, absorbed and reflected back and recorded by satellite sensors with the help of the sun (Figure 1)

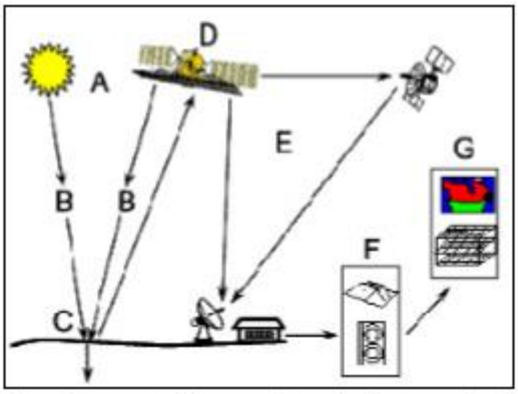

Figure 1. Remote Sensing System (Canada, 2016)

Unsupervised Classification

Unsupervised Classification is a method for identifying, classifying, and labelling images according to their spectral values. In unsupervised classification, pixels are grouped together based on their spectral values and spectral distances. An analyst can choose from a variety of techniques for measuring the distance (Danoedoro, 2012). Unsupervised Classification consists of 2 stages, among others: (1) Generate clusters (classes), (2) Assign classes (Figure 1) (Gisgeography, 2015).

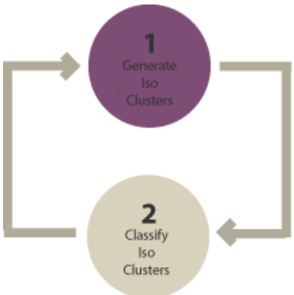

Figure 2. Diagram of Unsupervised Classification stages (Gisgeography, 2015)

Unsupervised Classification has the two most commonly used algorithms, K-means and ISODATA clustering algorithm. Both of these algorithms are iterative procedures. In general, both of them determine the initial cluster vector (class group) first. The second step classifies each pixel into the closest cluster. In the third step, the new cluster means that the vector is calculated based on all pixels in a group. The second and third steps are repeated until the "change" between the iterations becomes small. "Change" can be defined in a number of different ways, either by measuring the distance of the average cluster vector that has changed from one iteration to another iteration or by the percentage of pixels that have changed between iterations. The ISODATA algorithm has several further improvements by separating and combining clusters (Jensen, 1996).

Weaknesses Unsupervised Classification

Weaknesses Unsupervised Classification is of low accuracy and the likelihood of reading errors is very high. The advantages of Unsupervised Classification are good for areas that are not too recognizable and access that is difficult to enter terrestrial (Tomi, 2017).

Combinations band

Combination band for Landsat 5 use band 5,4 and 1 vegetation band while Landsat 8 uses band 7,5 and 3. Combinations 7,5, and 3 for landsat 8 similar to combinations of band 5.4, and 1 for landsat 5 which will showing "natural likes" such as a combination of band 4-3-2 (Landsat 8) or 3-2-1 (Landsat 5/7) (TUSGS, n.d.).

3. Research Method

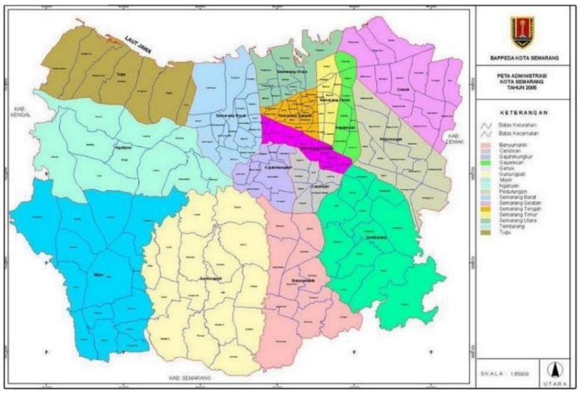

Figure 3. Map of Semarang City

The study took place in the city of Semarang between the lines of 6 ° 50 'LS - 7 ° 10' LS and 109 ° 35 'BT -110 ° 50' BT. Data can be obtained from the digitization of the map of Semarang City (Pevitanada, 2018). The research method uses quantitative methods with data obtained in the form of numbers and mapping. Research on the conversion of agricultural land into residential areas in the city of Semarang was carried out using several stages.

In general, the research is divided into 7 stages, including (1) formulation of function transfer problems, (2) the stage of determining research objectives, (3) data collection stage, (4) satellite image processing stage by classifying land cover using Landsat satellite images as a data source (5) conduct spatial analysis of the results of land cover classification to find out what factors cause the conversion of agricultural land, (6) make a report on the results of research and (7) the conclusion of the results.

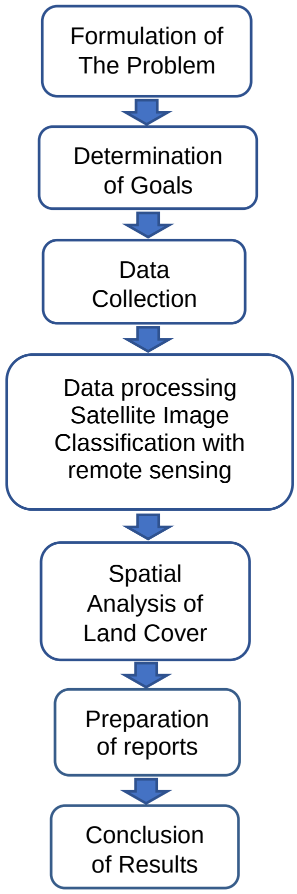

Figure 4. Research Flow

At the stage of Data Processing and Spatial Analysis of Land Cover (Land Cover in 1999, 2009, 2018), the remote sensing method is used. This method uses Landsat 5 and 8 satellite images which are processed into maps that can be classified, so that changes can be analyzed year after year. At the stage of data collection, what was done was looking for data in the form of Landsat 5 and Landsat 8 satellite images in Semarang city on the Earthexplorer.usgs.gov website for Landsat 5 satellite images, on the remotepixel.ca website for Landsat 8 satellite images and using polygon data with formats .shp Semarang city area. After all the data has been collected, data processing will be carried out, namely where Landsat 5 and 8 satellite image data (in the form of TIF files) are processed into maps that can be classified based on color using ArcMap software, after the calcification is complete, the classification of the classified areas will be carried out.

4. Result and Discussion

Map Analysis of Landsat 5 / TM for data 1999, 2009 and Landsat 8 / TM for data 2018 satellite imagery can be seen in figure 5 below. In conducting the classification in this study using two versions of Landsat imagery (Landsat 5 and Landsat 8) because

Landsat 8 was launched by NASA on February 11, 2013, and began providing open access image products since May 30, 2013 (Setiawan, 2015). So that Landsat 8 does not provide open access image products for 1999 and 2009. Classification is done by a combination of band 5,4 and 1 for Landsat 5 / TM while Landsat 8 uses band 7,5 and 3 which show changes in land cover in figures a, b, and c in the time span from 1999 to 2018. Semarang City experienced the conversion of forest vegetation and agricultural land into residential and industrial areas.

Land classification is divided into several classes (1) dark blue water area, (2) forests are dark green, (3) residential areas are pink (4) industrial are white, (5) rice fields are which is slightly bluish green, (6) empty land and moor are gray and green faded, (7) the garden is colored with a slightly brownish grey (8) the mangrove area is a light green.

(a) 1999 (b) 2009 (c) 2018

Figure 5. Map of Classification of land cover

The map in 1999 can be seen as green which appears more dominant consisting of forests, plantation areas, agriculture, and moorings in this area of settlements and industry have not seen much development. In 2009, residential and industrial areas were seen to increase. In 2018 it was seen that residential areas were becoming increasingly congested, water area was seen to have expanded widely at some point but not exceeding the area in 2009 and in 1999, the industrial area was increasing and the area of vegetation including green agricultural areas had diminished.

Results of Calculation of Land Cover Area from 1999 until 2018

Class	Area Based on Year (Hectare)		
	1999	2009	2018
Water Area	2.142	2.243,8	1.935,5
Mangrove Area	933,5	913,2	1.027,5
Empty Land and Moor	8.272,7	11.528	12.929,5
Forests	6.828,3	5.020,6	3.160,4
Residential Area	6.608,4	7.680,9	11.750,3
The Gardern	6.208,2	5.959	3.532,2
Rice Fields	5.880,5	2.808,5	1.737,1
Industrial	506,4	1.226	1.307,5

Table 1. Results of Calculation Land Cover Area

Table 1 above is the result of classification calculation from Landsat 5 images for 1999, 2009 and Landsat 8 images for 2018 using unsupervised classification method. In the table is data land cover area based on classes in hectares.

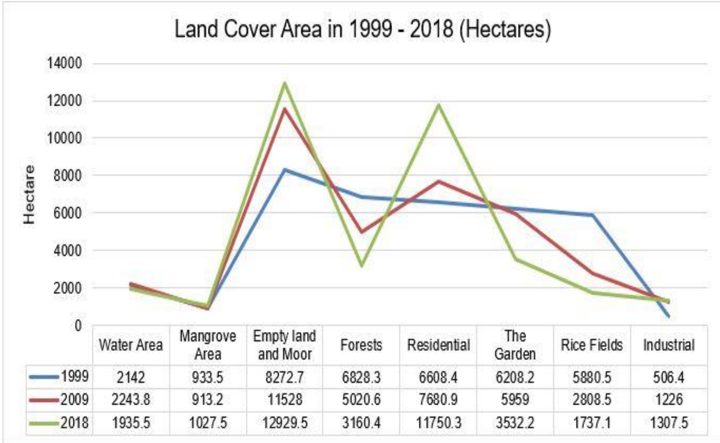

Figure 6. Graph of Land Cover Area Statistics

Based on Figure 6, the statistics of the land cover area above can be seen the changes in land cover area that occurred in Semarang in 19 years. There have always been widespread changes from 1999 to 2018.

Land Cover Area in 1999 - 2009 (Hectares)

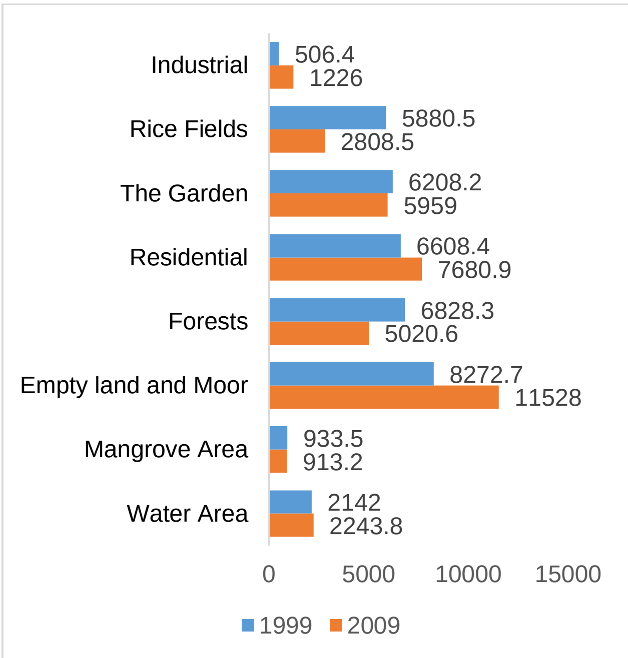

Figure 7. Comparison Diagram of Land Cover Area in 1999 and 2009

Figure 7 above shows a comparison diagram of land cover area in 1999 Industrial area has a cover area of 506.4 hectares, in 2009 the area increased to 1,226 hectares so that the Industrial Area had an additional area of 719.6 hectares in 2009. Rice Fields has Covered area of 5,880.5 hectares, in 2009 the area was reduced to 2,808.5 hectares so that the Rice Fields experienced a narrowing of 3,072 hectares in 2009. The Garden has an area of 6,208.2 hectares, in 2009 the area was reduced to 5,959 hectares so that the Garden experienced a broad narrowing of 249.2 hectares in 2009. Residential has a cover area of 6,608.4 hectares, in 2009 the area increased to

7,680.9 hectares so that Residential expanded by 1,072.5 hectares. In 2009 Forests have a cover area of 6,828.3 hectares, in 2009 the area was reduced to 5,020.6 he so that the area of forest experienced a narrowing of 1,807.7 hectares in 2009. Empty land and Moor has an area of 8,272.7 hectares, in 2009 the area increased to 11,528 hectares so that Empty land and Moor area increased by 3,255.3 hectares in 2009. The Mangrove area has an area of 933.5 hectares, in 2009 the area was reduced to 913.2 hectares so that the Mangrove Area had a narrowed area of 20.3 hectares in 2009. The Water Area has an area of 2,142 hectares, in 2009 the area increased to 2,243.8 hectares so that the Water Area expanded by 101.8 hectares in 2009.

Land Cover Area in 2009 - 2018 (Hectares)

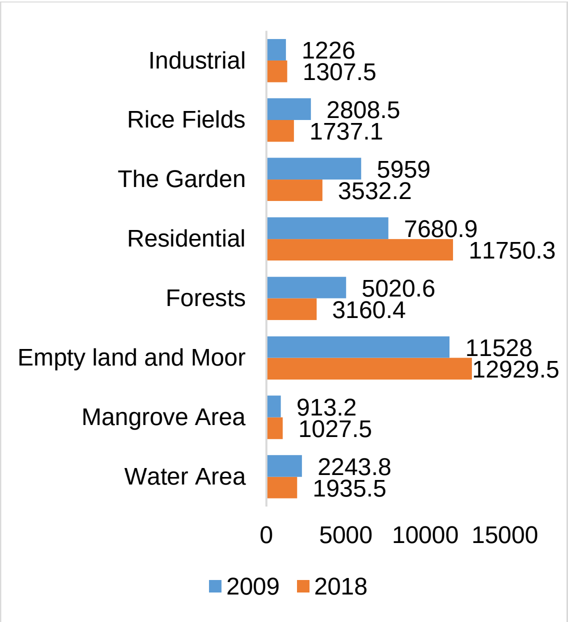

Figure 8. Comparison Diagram of Land Cover Area in 2009 and 2018

Figure 8 above shows a diagram of the comparison of land cover area in 2009 The Industrial has a cover area of 1,226 hectares, in 2018 the area increases to 1,307.5 hectares so that the Industrial Area has an additional area of 815 hectares in 2018. Rice Fields has a cover area covering an area of 2,808.5 hectares, in 2018 the area was reduced to 1,737.1 hectares so that Rice Fields had a narrowing of 1,071.4 hectares in 2018. The Garden has an area of 5,959 hectares, in 2018 the area was reduced to 3,532.2 hectares so that the Garden has experienced a narrowing of 2,426.8 hectares in 2018. Residential has an area of 7,680.9 hectares, in 2018 the area has increased to 11,750.3 hectares so that Residential has increased by 4,069.4 hectares in 2018 Forests have a cover area of 5,206 hectares, in 2018 the area is reduced to 3,160, 4 hectares so that the area of forest has a narrowed area of 1,807.7 hectares in 2018. Empty land and Moor has an area of 11,528 hectares, in 2018 the area has increased to 12,929.5 hectares so that the land is empty and Moor has increased by 1,404.5 hectares in 2018. The Mangrove area has an area of 913.2 hectares, in 2018 the area has increased to 1,027.5 hectares so that the Mangrove Area has increased by an area of 114.3 hectares in 2018. The Water Area has a cover area of 2,243.8 hectares, in 2018 the area increased to 1,935.5 hectares so that the Water Area experienced a decrease in the area of 308.3 hectares in 2018.

Land Cover Area for Rice Fields, Industrial and Residential in 1999 (Hectares)

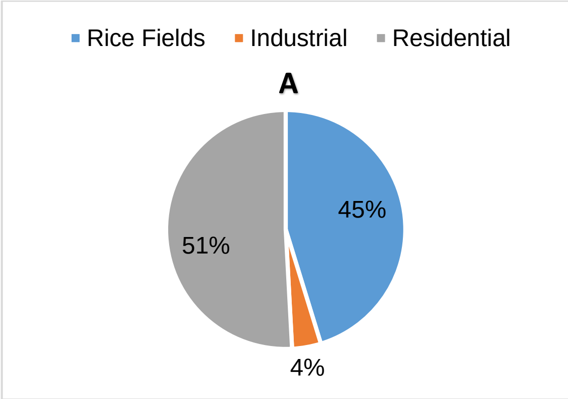

Figure 9A. Statistical Chart of Land Cover Area for Rice Fields, Industry and Settlement Areas in 1999

Land Cover Area for Rice Fields, Industrial and Residential In 2009 (Hectares)

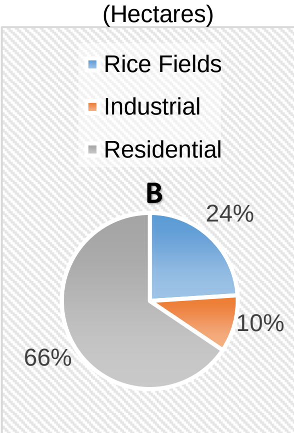

Figure 9B. Statistical Chart of Land Cover Area for Rice Fields, Industrial and Residential in 2009

Land Cover Area for Rice Fields, Industrial and Residential in 2018 (Hectares)

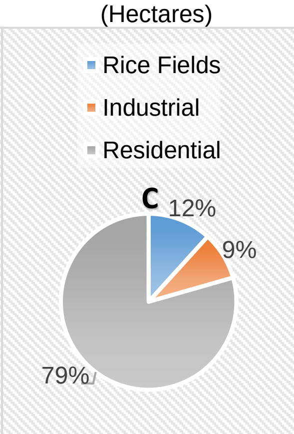

Figure 9C. Statistical Chart of Land Cover Area for Rice Fields, Industrial and Residential in 2018

Figure 9A above is a statistical diagram comparing the area of land cover for Rice Fields, Industrial and Residential in 1999. Rice Fields has an area of 5,880.5 hectares and has a percentage of 45% of the three. Industrial has an area of 506.4 hectares and has a percentage of 4% of the three. Residential has an area of 6,608.4 hectares and has a percentage of 51% of the three.

Figure 9B is a statistical diagram of the comparison of the area of land cover for Rice Fields, Industrial and Residential in 2009. Rice Fields experienced a broad decline of 3,072 hectares so that the area of Rice Fields became 2,808.5 hectares which was previously 5,880.5 hectares in 1999 and the percentage area 24% of all three, Industrial has increased widely by 719.6 hectares so that Industrial becomes 1,220.6 hectares, which was previously 506.4 hectares in 1999 and the percentage of area is 10% of all three. Residential has increased widely by 1,072.5 hectares so that Residential becomes 7,680.9

hectares, which was previously 6,608.4 hectares in 1999 and a percentage of the area of 66% of the three in 2009.

Figure 9C is a statistical diagram comparing the area of land cover for Rice Fields, Industrial and Residential in 2018. Rice Fields experienced a broad decline again, amounting to 1,071.4 hectares so that Rice Fields became 1,737.1 hectares which was previously 2,808.5 hectares in 2009 and the percentage of the area of 12% of all three, the Industrial has increased widely by 815 hectares so that Industrial becomes 1,307.5 hectares which was previously 1,220.6 hectares in 2009 and the percentage of 9% of all three. Residential has increased widely, amounting to 4,069.4 hectares so that the Residential has become 11,750.3 hectares, which was previously 7,680.9 hectares in 2009 and the percentage of area is 79% of the three in 2018.

Changes in Land Cover Area
Agriculture, Industry and Settlement Areas
in 1999 - 2018

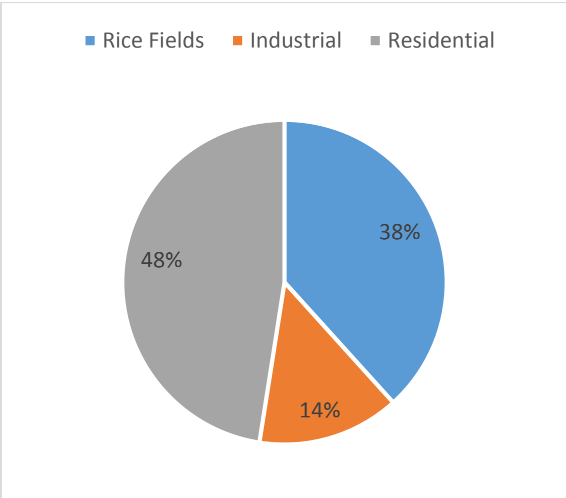

Figure 10. Statistical diagram of changes in land cover area Rice Fields, Industrial and Residential in 1999 - 2018

Figure 10 is a statistical diagram of the comparison of land use functions of Rice Fields, Industrial and Residential as a whole from 1999 to 2018. Rice Fields has a percentage of land use conversion of 38% of the three which originally in 1999 Rice Fields had an area of 5,880.5 hectares change to 1,737.1 hectares in 2018. Industrial has a percentage of 14% of the three which originally in 1999 industrial has an area of 506.4 hectares which has changed to 1,307.5 hectares in 2018. Residential has a percentage of land conversion 48 % of the three originally in 1999 Residential had an area of 6,608.4 hectares which had changed to 11,750.3 hectares in 2018.

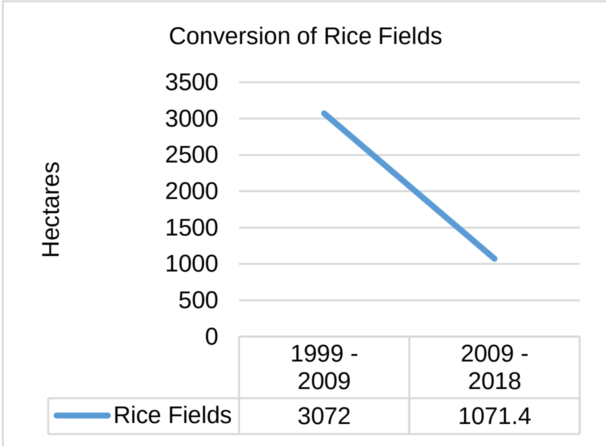

Figure 11. Graphs Extensive statistics on functions of agricultural areas

Figure 11 above shows a graph of statistical changes in Rice Fields that have been converted within a time span of 19 years, from 1999 to 2018. In 1999 to 2009 the converted agricultural area was 3,072 hectares. In 2009 until 2018 Rice Fields was 1,071.4 hectares.

5. Conclusion

The conclusions obtained were the function conversion of the city of Semarang from 1999-2009, and from 2009-2018 the conversion of agricultural land into residential and industrial areas was seen to be decreasing from the data transfer function, but the land conversion function continued over a period of time that is. The results of the analysis that caused urban areas to increase, namely the high activity of property businesses in the city of Semarang made agricultural land narrower. To reduce the occurrence of land conversion in the city of Semarang, the division of special areas for sustainable food agricultural land is not allowed to be used as residential or industrial areas. The disadvantages of this study are that Landsat imagery used is different (1999 and 2009 using Landsat 5 while 2018 uses Landsat 8) because Landsat 7 satellite imagery in 1999 and 2009 until now which is free to download has a gap in its image (slc-off (Scan Line Corrector-off)) Whereas the slc-on (Scan Line Corrector-on) is difficult to get the data, it can be overcome by looking for satellite images that have no gaps. In addition, there are several colors that are not classified because they are covered in clouds.

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