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Analysis of Rice Field Area Conversion in Sleman Regency from 2000 to 2015, Using High-Resolution Satellite Imagery (Case Study: Ngaglik, Mlati and Depok Sub-District)

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Abstract

The purpose of this research is to find out how much area of rice fields which is reduced due to being converted into built-up land in Sleman Regency, especially in sub-districts which adjacent to Yogyakarta City, such as Depok Sub-district, Mlati Sub-district and Ngaglik Sub-district, from 2000 to 2015. Classification method used in this research is visual interpretation method which utilized on-screen digitization. The output of this research is a Map of Rice Field Conversion into Built-up Land at Depok, Mlati and Ngaglik Sub-district in Sleman Regency from 2000 to 2015. The results of this research prove that GIS can be used to determine the extent of changes in a rice field at Ngaglik, Depok and Mlati sub-districts. The area of rice field that was converted into built-up land in the research area is 864.45 ha.

Keywords : *Rice Field Conversion, Visual Interpretation, On-screen Digitizing*

1. Preliminary

Special Region of Yogyakarta or Daerah Istimewa Yogyakarta (DIY) is one of the provinces in Indonesia that has a tourist attraction, as well as being the choice to obtain an education because of the complete facilities and the relatively low cost of living. Therefore, it cannot be denied that the speed of development in DIY Province is quite high which increased the growth of population. Data on DIY population growth in 2016 reached 1.13% with shrinkage of agricultural land by 1.50% % (BPS : Statistik Perumahan Yogyakarta 2017).

As the capital city of DIY Province, the development in Yogyakarta City is progressing rapidly. This encourages high competition for residential land use. Land needs that are increasing in urban areas are triggering pressure on the availability of land to suburban areas. Mlati, Depok and Ngaglik Sub-district are 3 out of 17 sub-districts in Sleman Regency which are equipped with Yogyakarta City, makes these sub-districts participate in land use conversion, especially agricultural land conversion into industrial areas, settlements, offices, and other built-up areas.

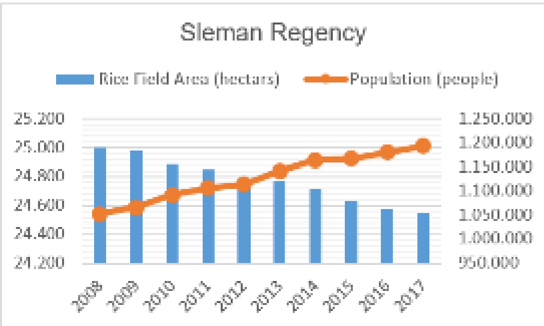


Figure 1. Graph comparison of rice field area and population in Sleman Regency (Source: BPS Kabupaten Sleman)

One of the agricultural lands that were being converted is rice fields. Sleman Regency has the widest rice field in DIY Province with the latest data in 2017 being provided with an area of 24,549 hectares (ha) (BPS: Kabupaten Sleman Dalam Angka 2018). This figure has declined over the past 10 years, in 2008 which was agreed to be 25,003 ha (BPS: Kabupaten Sleman Dalam Angka 2009). Depreciation of rice fields also affected rice production in Sleman Regency in 2012 of 312,815 tons while in 2017 increased to 290,627 tons (BPS: Kabupaten Sleman).

Land use changes in a region will affect the geographical conditions of the region itself. Therefore, the latest information is needed in order to anticipate continuous changes in agricultural land use, especially rice fields, because it will affect food security. Changes in land use can be studied by utilizing the Geography Information System (GIS) and Remote Sensing (RS). GIS is an information system that aims to capture, store, manipulate, analyze, organize and display all types of geographical data. GIS requires data sources both spatial and descriptive data, one of them comes from RS. RS data is represented by various types of raster satellite imagery (Irwansyah, 2013). Satellite imagery makes it easy to carry out research on large areas or in an area which difficult to reach, also could save time and costs, compared to direct surveys to the field as a whole.

The purpose of this study is to find out how much area of rice fields that were reduced because of being converted into built-up land in Sleman Regency from 2000 to 2015. This study wants to prove that GIS can be used to determine the extent changes in rice fields in Sleman Regency. Hope the result of this study would be useful for local government as a recommendation for planning and evaluation of local policy. While for researchers it is expected to be useful as a reference in conducting similar research. The scope of this research is mapping changes in rice fields into a built-up area in Sleman Regency with a case study of Mlati, Depok District and Ngaglik Sub-district. The extensive land conversion map was obtained from the results of the interpretation of high-resolution satellite imagery in Sleman Regency in 2015 compared to the Map of Rupa Bumi Indonesia (RBI) in Sleman Regency in 2000 with an analysis scale of 1: 25,000.

2. Literature Reviews

Research related to rice field conversion has been carried out before, one of them was entitled Analysis of Changes in Rice Field Area in Kendal District Using High-Resolution Imagery (Case Study: Kaliwungu Subdistrict, Brangsong Subdistrict, and Kota Kendal Subdistrict) written by Rista Omega in (Septiofani and Sukromono 2016). The study aims to determine changes in the area of rice fields and patterns of change into other land use classifications in the case studies used two different types of High-Resolution Satellite Imagery (HRSI), 2010 was Quickbird Imagery and 2014 was WorldView 2 Imagery. This study utilizes remote sensing and GIS with on-screen digitizing methods. The results indicate that the converted rice fields were 56,703 Ha with the area of rice fields in 2010 amounting to 4046,049 Ha and in 2014 amounting to 3991,295. The widest conversion of rice fields is the conversion of rice fields into settlements with a percentage of 61.06%. One of the reasons was because most of the case study areas, especially in Kaliwungu, are used for industrial activities that cause a population increased, so residence needs are also increased.

Another study titled Monitoring Changes in Rice Fields with Remote Sensing of Multitemporal Landsat Data (Case Study of Boyolali District, Central Java) written by (Nugroho and Wijaya, 2015), this study aims to determine the extent of changes in rice fields in Boyolali Regency from 2010 to 2014, to find out the impact of the changes itself to the level of agricultural productivity, especially from the rice farming sector, and to make a GIS of rice fields in Boyolali Regency. This study uses multitemporal intermediate resolution imagery namely Landsat-TM from 2010 to 2014 with the supervised classification method. The results of this study show that the area of change of rice fields from 2010 - 2014 was quite significant, decreasing by 18,694.35 ha, which might be caused by the conversion of rice fields into public facilities and the development of private industries. But this decrease did not affect rice production in Boyolali Regency. This is due to the existence of a program from the Agriculture Service named Integrated Crop Management Field School or Sekolah Lapang – Pengelolaan Tanaman Terpadu (SL-PTT) which helps farmers improve their productivity results.

Conceptually, those studies above relate to this research, that is to determine the extent of changes in rice fields. However, this research discusses more about the changes of rice fields into built-up land. This study also uses remote sensing data, which is a compilation of several HRSIs that are processed through screens in ArcGIS software and using one of the functions of GIS analysis, namely overlay. In this study, field validation will be carried out to check the digitized map, which is not done in those studies above.

Land Conversion

Land conversion is a change of land function from its original function into another function that has a negative impact on the environment and the potential of the land itself (Utomo *et al.,* 1992) in Ridwan (2009). Agricultural land conversion is caused by high population growth which urges the availability of land, especially residential land. Irawan (2005) in his research revealed that there are three factors why rice fields become and agricultural land that has the most chance for land conversion : (1) rice field is more flat compared to dry land, making it easier to develop non-agricultural activities, (2) economic infrastructure is more available in rice fields than dry land areas due to past development focused on increasing rice production, (3) compared to dry land which is mostly found in hilly and mountainous regions, rice fields, in general, are closer to consumer areas or relatively densely populated urban areas. Every year, the rate of change in land use in the suburbs of Yogyakarta reaches 8.24%. This is due to the high population pressure on agricultural land and the construction of various facilities and also the development of urban functions in the periphery. If this continues, the conversion of agricultural land, especially rice fields, can threaten food self-sufficiency both locally and regionally (Kurniawan and Sadali, 2018).

Remote Sensing

According to Lillesand and Kiefer (1979) in Sutanto (1986), Remote Sensing (RS) is a science and art to obtain information about objects, regions, or symptoms by analyzing data obtained by using a tool without direct contact with things studied. RS data is represented by various types of satellite imagery raster (Irwansyah, 2013). Imagery can describe objects or regions that are similar to their appearance and location on the surface of the earth. The imagery is often made with a return period so that it can be a monitoring tool for changing an object or area, such as changes in environmental quality, expansion of arable land, etc. (Sutanto, 1986). There are various types of satellite imageries, including Landsat, IKONOS, Quickbird, and others.

Image Interpretation

The use of satellite imagery to find out objects on earth is done through image interpretation. Image interpretation can be used to classify classes of land use or land cover. Image classification consists of digital and visual classification/interpretation. Unsupervised and supervised are examples of digital classification methods. Both visual interpretation and digital classification, especially supervised methods, require image interpretation to fulfill the objectives on earth. There are 8 elements of image interpretation that allow us to know objects on earth, they are hue and color, shape, size, texture, pattern, shadow, association and convergence of evidence which is the use of some unparalleled image interpretations for tourism objects (Sutanto, 1986). However, we don't have to use all of them if the object can already be recognized by three or four elements. The visual interpretation requires these interpretation elements to classify the object classes as a whole, with another word, this method is done manually through on-screen digitizing. Meanwhile, digital classification especially the supervised method uses image interpretation to determine the Region of Interest (ROI) of the research area. After that, the classification process is carried out by the software based on the ROI.

In general, digital classification requires the ability of GIS software to classify selected areas into several classes. In the study of Carlos Javier Puig, et al (2002), explains that digital classification provides good spatial details for land use and land cover, however, the classes are not easy to classify. Digital classification also requires more time in the editing process and reducing errors. Also, digital classification is difficult to apply in the tropical area due to a diverse pattern of land use and land cover. Another study by Samrumi (2009) in Gunawan (2011) explains that digital classification is more efficient to use in research which conducted large areas because researchers only have to determine which region that will be used as a sample. However, digital classification requires a truly clean image, such as cloud free. This classification also provides less optimal results, because the interpretation carried out by software only considers hue and color, so there will be a possibility that different objects can be classified into one class.

Visual interpretation is done manually by utilizing on-screen digitization to distinguish object classes. In contrast to digital classification, visual interpretation is considered more optimal, because the interpretation process is using other elements of interpretation such as size, texture, etc. (Samrumi, 2009 in Gunawan, 2011). Disturbance in the image does not really affect visual interpretation, as long as it is not too severe. However, visual interpretation should be done by the same person, because everyone has its own characteristics in interpreting the image, so the results can be different. Visual interpretation is recommended to overcome deficiencies of spectral differences in the imagery if the image bands are incomplete. (Puig *et al.,* 2002).

Geography Information System (GIS)

GIS is an information system that is intended to be distributed, store, manipulate, analyze, organize and display all types of geographical data. GIS components are spatial data, management data and procedure analysis, computers and software, and also people who manage. In general, GIS has two functions namely, attribute analysis and spatial analysis. Attribute analysis function is related to database basic operation (DBMS). While spatial analysis consists of classification, networking, buffering, 3D analysis, overlay and other analysis functions (Prahasta, 2001). One of the functions of spatial analysis that is often used is the overlay. The overlay combined two or more data sets that produce into one layer with a new data set (Irwansyah, 2013). The overlay's tool that will be used in this research is the intersect. Intersect calculated geometric transitions, and also join table attributes from the inputted layer.

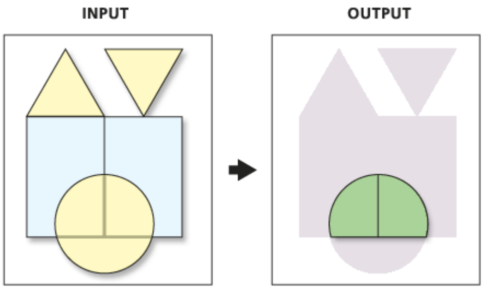


Figure 2. How intersect works (Source : desktop.arcgis.com)

GIS can be used to makes thematic maps, determining locations (for example, determining which areas are suitable for school construction in a sub-district), as a reference in the preparation of urban spatial plans, or for mapping the distribution of natural resources. There is some software that can be used for processing GIS data, including ArcGIS, MapInfo, Quantum GIS, and so on. One of them that is often used in processing GIS data because of the complete feature is ArcGIS. ArcGIS is a software developed by ESRI (Environmental System Research Institute), which has several applications with their respective functions, including ArcMap, ArcCatalog, ArcScene, and ArcGlobe.

3. Research Method

This research was conducted in 3 sub-districts in Sleman Regency, namely Depok, Ngaglik and Mlati Subdistricts starting from October 2018 - March 2019 with the equipment used in this study are computers and software, such as GIS data processing software (ArcGIS - ArcMap version 10.2), Microsoft Office, also Avenza Maps and Google Maps (My Maps) for field survey purposes. The stages of this research can be seen through the following research flowchart;

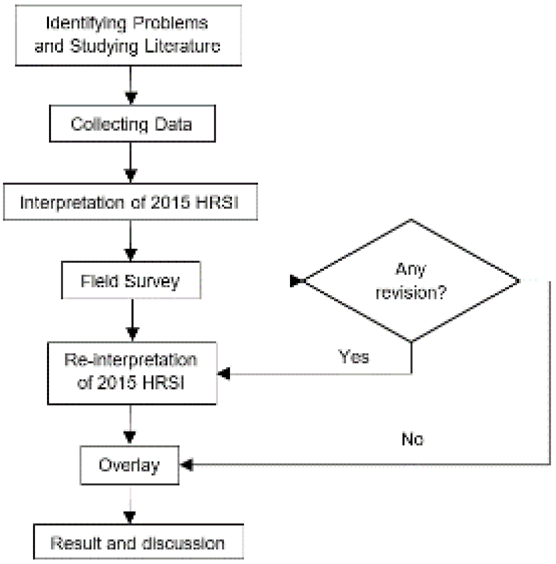


Figure 3. Research Flowchart

The first step begins with identifying problems found in Sleman Regency and studying literature. Step two is collecting the data such as, (1) Map of Rupa Bumi Indonesia (RBI) of Sleman Regency in 2000 obtained from the official national geoportal (www.tanahair.indonesia.go.id) by Geospatial Information Agency / Badan Geospasial Indonesia (BIG), and (2) Compilation of High-Resolution Satellite Imagery (HSRI) of Sleman Regency in 2015 obtained from the Department of Defense and Spatial Planning / Dinas Pertahanan dan Tata Ruang (DIPERTARU) of Sleman Regency.

After all the data is collected, the next step is image interpretation manually through on-screen digitization to classify object classes, with an analysis scale of 1: 25,000. The result of this interpretation is a Land Use Map of Depok, Ngaglik and Mlati Sub-district at Sleman Regency in 2015. The fourth step is a field survey. Before starting the survey, the author determines the study sample first. The method used to determining sample in this study is the random sampling method with the amount of samples calculated based on Slovin's formula, namely:

$$n = \frac{N}{1 + Ne^2}$$

where, n = amount of samples, N = amount of population, dan e = margin of error

The N value in this study is the total polygons which are the results of the intersect process of 2000 RBI map and 2015 imagery interpretation map, with selected polygons from the Rice Field and Built-up Land only, which totals 2575 polygons. While the margin of error (e) is 15%. This value is determined based on the image threshold accuracy of at least 85% (Sutanto, 2016). According to Slovin's formula, therefore:

$$n = \frac{2575}{1 + 2575(15\%^2)} = 43{,}6903$$

The N value or the minimum number of samples is rounded up to 44, and then divided into 4 categories, such as Rice Fields which becomes Built-up Land (R-B), Built-in Land which becomes Rice Fields (B-R), Built-up Land which is still a Built-up Land (B-B) and Rice Fields which which is still a Rice Fields (R-R), using Pivot Table with the following results:

Table 1 Research Samples

Category	Polygons	Percentage (%)	Amount of Sample	Amount of Final Sample
B-B	366	0,142	6,209	6
B-R	41	0,015	0,695	3
R-B	1902	0,738	32,271	33
R-R	266	0,103	4,513	6
TOTAL	**2575**	**1**	**43,690**	**48**

There is a category of Built-up Land becomes a Rice Field, because on the 2000 RBI map there were some lands that classified as Residential, while in 2015 interpretation map, most of the land was rice fields. This is not unusual, considering that the built-up land has a very small possibility to be converted into rice fields. So, this category is included as one of the research samples.

Then, we added one category namely 'not sure-rice field' (NR) which are land on the RBI map that was rice fields, but (1) on the HRSI is covered in clouds, and (2) on HRSI seen planted with annual plants. Points (2) are included as NR category because usually annual plants are planted alternately with rice. So, if the farmer planted the annual plants and after that they planted rice, then that land is classified as rice fields. For this reason, it needs to be used as a research sample, because it will affect the area of rice fields later. The final number of samples is in the table below:

Table 2. Research Samples Final

Category	Polygons	Percentage (%)	Amount of Sample	Amount of Final Sample
B-B	366	0,142	6,209	6
B-R	41	0,015	0,695	3
R-B	1902	0,738	32,271	33
R-R	266	0,103	4,513	6
NR	-	-	3	3
TOTAL	**2575**	**1**	**43,690**	**51**

After that, proceed with the field survey. In the field survey process, the author will take a photo of samples as a comparison to the map of imagery interpretations which already made before. If there is a discrepancy with the results of the interpretation, then it will be re-interpreted. The next step, the re-interpreted map will be overlaid with the RBI Map of Sleman Regency using one of the overlay tools namely Intersect. The result is a Map of Rice Field Conversion into Built-up Land in Depok, Ngaglik and Mlati Sub-district of Sleman Regency from 2000 - 2015.

4. Result and Discussion

This study aims to find out how much area of rice fields that are reduced due to being converted into built-up land in Sleman Regency, especially in the sub-districts adjacent to Yogyakarta City, such as Depok, Mlati and Ngaglik Subdistrict from 2000 - 2015. The result of this study is a Map of Rice Field Conversion into Built Land in Depok, Ngaglik and Mlati Sub-districts of Sleman Regency from 2000 - 2015.

Imagery Interpretation and Object Classification

In the interpretation process, the author began with classifying the land cover, and after that, the land cover separated into two different classes. Land cover such as residential buildings, non-residential buildings, and hardened land (ex: pavement) are classified as Built-up Land class. Rice field classified as the rice field class. Meanwhile, the land cover which is a 'non-built-up land and non-rice field' class, such as shrubs, grass, water bodies, tombs and so on, was not included in the research classes, because this research only prioritizes the changes of rice fields into built-up land. Details of object classification can be seen in Table 3 below:

Table 3. Classification Details

Land Cover	Class
Residential Building Non-residential Building Hardened Land	Built-up Land
Rice Field	Rice Field
Grass Vacant Land Shrubs Moor Mixed Gardens Tombs Water Body	Non-built-up land and non-rice field

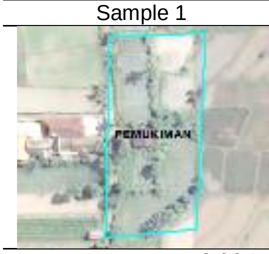
The author interpreted based on 8 elements of image interpretation mentioned in Literature Reviews of this study. Here are some examples of image interpretation by the author:

Table 4. Image Interpretation by the Author

HRSI Apparance	Interpretation	Class
	This is rice field, can be seen from its pattern which is patched, the texture of the surface is smooth and the color is green or brown (rice fields that have been harvested)	Rice Field
	This is housing, can be seen from the similiar shape, and the pattern of buildings distribution compared to ordinary settlements.	Built-up Land
	These are ponds, can be seen from its patchy pattern, the texture of its surface is smooth and the dark color indicates the presence of water. At first glance similar to rice fields, but if observed, the size of the rice field is usually similar to one another, while in the appearance of the image beside, there is a section that has a clearly different size.	Non-built-up land and non-rice field

In the 2000 RBI map there were some lands classified as residential buildings, whereas based on the 2015 HRSI appearance, most of the land are rice fields. The survey results show that the land attributed to residential buildings in the 2000 RBI map is still a rice field nowadays. Thus, the authors conclude that there may be some errors when inputting attributes in the 2000 RBI map.

Table 5. Survey Result of Bulit-up land that is a Rice Field in 2015 HRSI

HRSI Apparance	
Sample 1	Sample 2
	
Field Survey Photo	
	

Furthermore, in the field survey, the author also examined samples which appeared as annual plants in HRSI. The results of the survey and interview with local resident showed that the land proposed had always been planted with annual plants, such as sugarcane and snake fruit (salak), and had never been planted with rice. Thus, the land is not included in the rice field class.

Table 6. Survey Result of Annual Plants

HRSI Apparance

Field Survey Photo
 

Spatial Analysis (Overlay)

After completing the interpretation based on the results of the field survey, the 2000 RBI map and the 2015 land use map (HRSI interpretation map) were overlaid using one of the overlay tools namely, intersect. But before that, each map has to be dissolved first to combine polygons with the same class.

The dissolved results of the 2000 RBI map in Figure 4 shows that there are still many rice fields compared to the dissolved results of the 2015 HRSI interpretation map in Figure 5. The most striking difference is in Depok Sub-district. It appears that rice fields in 2015 have started to decrease due to being converted into built-up lands, such as residential buildings, boarding houses, hotels, restaurants, and shopping places. Likewise, it can be seen in Figure 5 that both Ngaglik and Mlati Sub-districts area which is directly adjacent to Depok Sub-district has already begun to be densely by built-up lands.

After that, the dissolved results of each map are then overlaid using intersect tools. The intersect results of the two maps can be seen in Figure 6. The yellow color is the area that was converted from rice fields into built-up land from 2000 to 2015. The percentage of the study area that was converted from rice fields to built-up land are 36.59% in Depok Sub-district, 35 .73% in Ngaglik Sub-district and 27.67% in Mlati Sub-district.

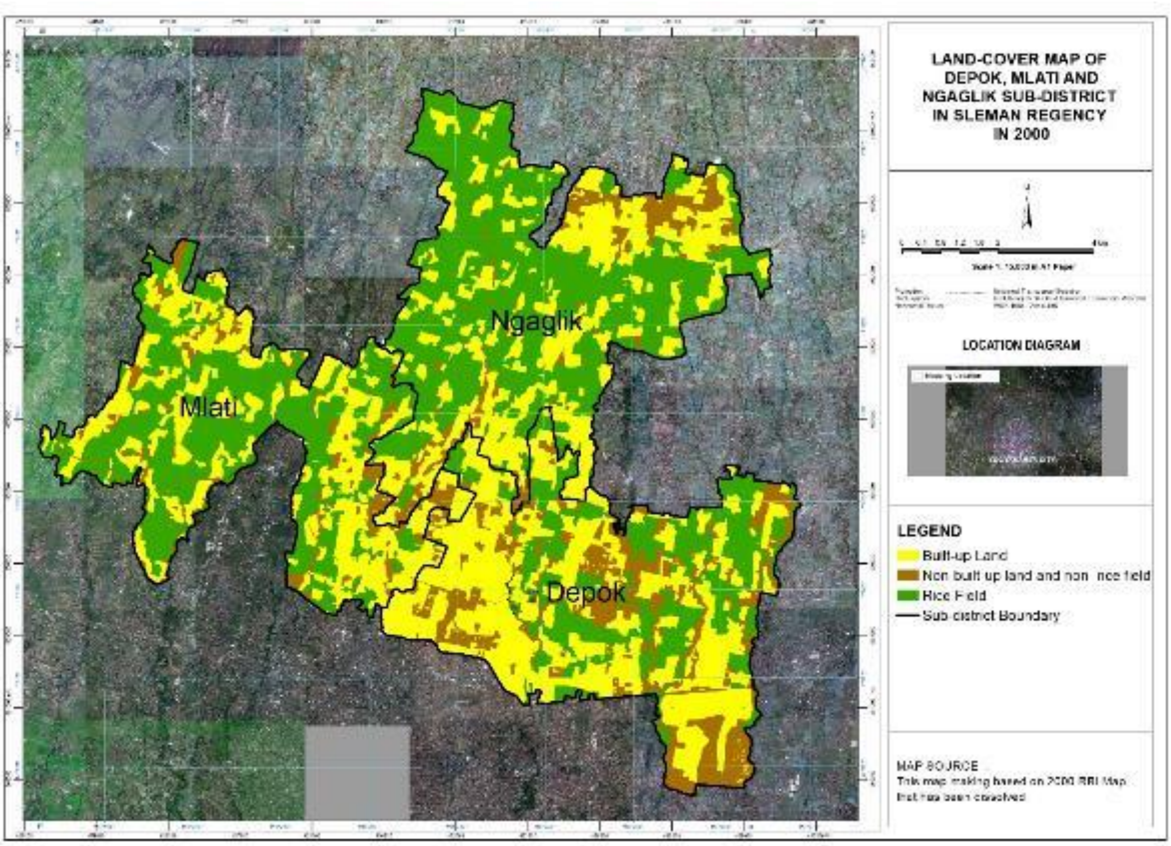


Figure 4. Land Cover Map of Research Area in 2000 After Dissolved

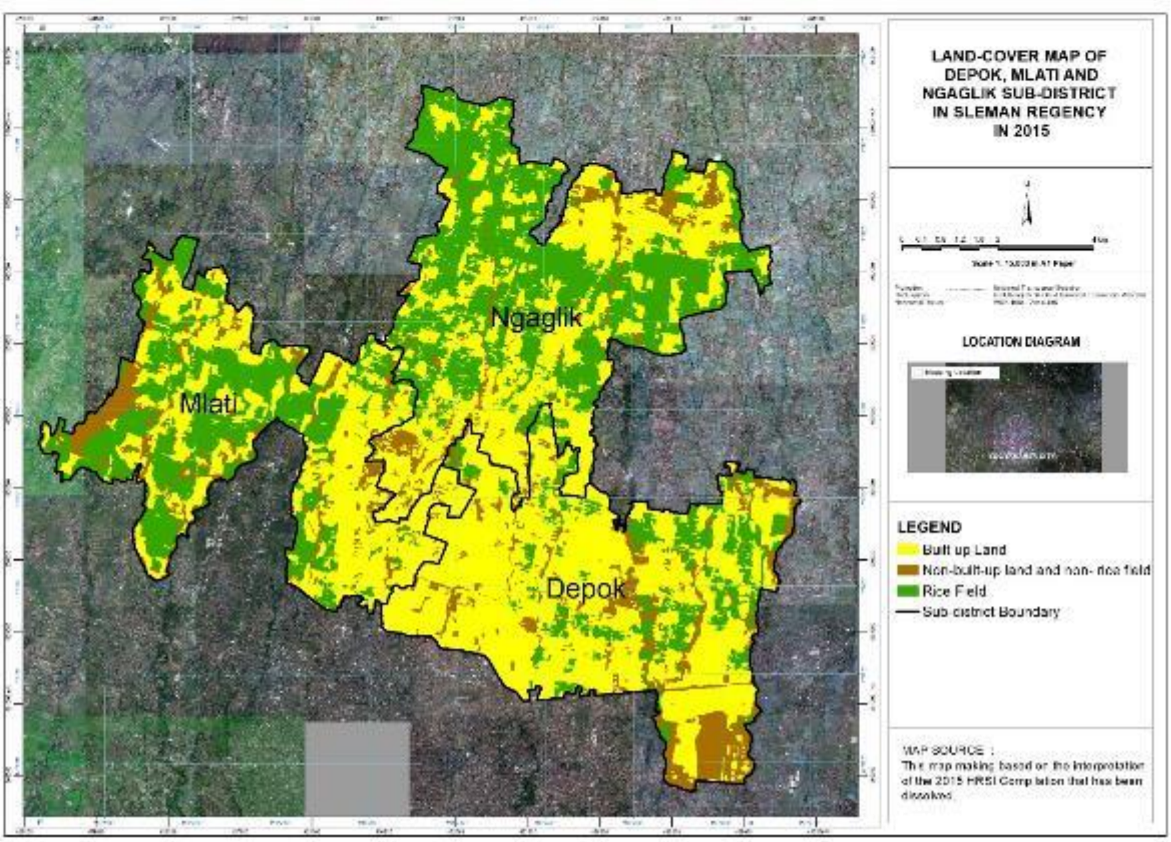


Figure 5. Land Cover Map of Research Area in 2015 After Dissolved

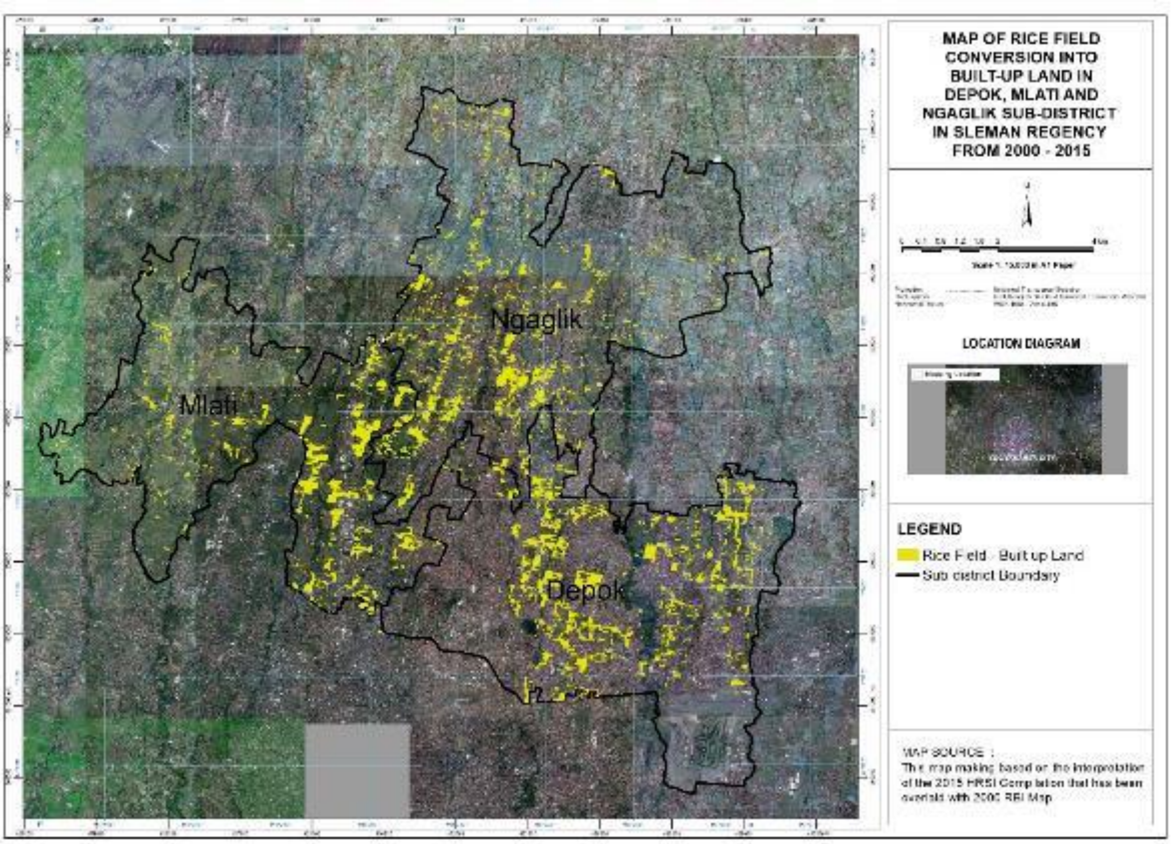


Figure 6. Map of Rice Field Conversion into Built-up Land in Research Area from 2000 to 2015 (After Intersect)

Overlay Result Analysis

Total area in this research is 10.106,877 ha with the most extensive research area is Ngaglik Sub-district with an area of 3.735,764 ha, followed by Depok Sub-district with 3.472,229 ha, and then Mlati Sub-district with 2.898,884 ha. In 2000, the sub-district with the widest rice field was Ngaglik Sub-district which was 2.138,793 ha. While the least rice field area was Depok Sub-district with an area of 935,920 ha. Comparison of the land cover area in 2000 can be seen in Table 4 below:

Table 7. Total Land Cover Area in 2000

Sub-district	Rice Field (ha)	Built-Up Land (ha)	Non-built-up land and non- rice field (ha)
Depok	935,920	1.717,114	819,195
Mlati	1.428,910	1.161,396	308,578
Ngaglik	2.138,793	1.284,754	312,217
Total	**4.503,623**	**4.163,264**	**1.439,99**

Meanwhile, based on 2015 HRSI interpretation, rice field in the research area are decrease (comparable to Table 5). Ngaglik Sub-district in 2000 had rice fields of 2.138,793 ha, but in 2015 decreased by 378,759 ha to 1.769,034 ha. Mlati Sub-district in 2000 had 1.428,910 ha of rice fields area, but in 2015 decreased by 341,948 ha to 1.086,962 ha. Likewise with Depok Sub-district, which in 2000 had a rice field area of 935,920 ha, in 2015 decreased by 414,95 ha to 520, 976 ha.

Table 8. Total Land Cover Area in 2000

Sub-district	Rice Field (ha)	Built-Up Land (ha)	Non-built-up land and non- rice field (ha)
Depok	520,976	2.415,711	799,077
Mlati	1.086,962	1.410, 509	401,413
Ngaglik	1.760,034	1.691,482	284,248
Total	**3.367,972**	**4.107,193**	**1.484,738**

The results of this study show that there was a quite extensive change of rice field into built-up land in research areas. Total of rice field in the research area in 2000 was 4.503,623 ha, while in 2015 it was reduced to 3.367,972 ha. The area of rice fields which were converted into built-up land can be seen in Table 6 below:

Table 8. Total Conversion Area from 2000-2015

Sub-district	Total of Rice Field that being Converted to Built-up Land (ha)	Percentage (%)
Depok	316,318	36,59
Mlati	239,240	27,67
Ngaglik	308,892	35,73
Total	**864,45**	**100**

Total of rice fields which were converted into built-up land in the research area is 864.45 ha. Depok Sub-district has the most extensive conversion among 3 sub-districts in this research, with a percentage of 36,59%. One of the reasons this conversion happened was because there are several universities such as Gadjah Mada University, Yogyakarta State University, Atma Jaya University, and other universities in Depok Sub-district. Therefore, the demand for a residential or boarding house increased due to students who immigrated.

5. Conclusion

The results of this research prove that GIS can be used to determine the extent of changes in a rice field at Ngaglik, Depok and Mlati sub-districts. Total of rice fields which were converted into built-up land in the research area is 864.45 ha. The widest conversion is in Depok Subdistrict with 414,95 ha and a percentage of 36.59%. Visual interpretation method still can be used to analyze an area of about 10.106,877 ha in less than 1 month, but the analysis scale must be 1: 25.000. If you want to do interpretation more details (compare to the analysis scale of 1: 25.000) and still want to use the visual interpretation method, it will take longer than 1 month.

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References

ArcGIS. (n.d.). *How Intersect Works*. Retrieved January 14, 2019, from http://desktop.arcgis.com/en/arcmap/10.3/tools/analysis-toolbox/how-intersect-analysis-works.htm.

BPS (2017). *Statistik Perumahan Provinsi Daerah Istimewa Yogyakarta 2017*. Yogyakarta: Badan Pusat Statistik Provinsi Daerah Istimewa Yogyakarta.

Gunawan, E. (2011). Penggunaan Metode Hibrida untuk Identifikasi Kerapatan Kanopi di Sebagian Kabupaten Kulonprogo. Bachelor's thesis, Gadjah Mada University, Yogyakarta.

Irawan, B. (2005). Konversi Lahan Sawah : Potensi Dampak, Pola Pemanfaatannya dan Faktor Determinan. Forum Penelitian Agro Ekonomi, vol. 23, no. 1, 15.

Irwansyah, E. (2013). *Sistem Informasi Geografis : Prinsip Dasar dan Pengembangan Aplikasi*. Yogyakarta: Digibooks.

Kurniawan, A., & Sadali, M. I. (2018). *Keistimewaan Lingkungan Daerah Istimewa Yogyakarta*. Yogyakarta: Gajah Mada University Press.

Nugroho, D., Sasmito, B., & Wijiaya, A. P. (2015). Monitoring Perubahan Area Persawahan Dengan Penginderaan Jauh Data Landsat

Multitemporal (Studi Kasus Kabupaten Boyolali, Jawa Tengah). Jurnal Geodesi Undip, vol. 4, no. 2, 224-231.

Prahasta, E. (2001). *Konsep-konsep Dasar Sistem Informasi Geografis*. Bandung: CV. Informatika.

Puig, C. J., Hyman, G., & Bolanos, S. (2002, January). Digital Classification vs. Visual Interpretation : a case study in humid tropical forest of the Peruvian Amazon. Retrieved January 13, 2019, from https://www.researchgate.net/publication/237021820_Digital_Classification_vs_Visual_Interpretation_a_case_study_in_humid_tropical_forests_of_the_Peruvian_Amazon

Septiofani, R. O., Subyianto, S., & Sukmono, A. (2016). Analisis Perubahan Luas Lahan Sawah di Kabupaten Kendal Menggunakan Citra Resolusi Tinggi (Studi Kasus : Kec. Kaliwungu, Kec. Brangsong, dan Kec. Kota Kendal). Jurnal Geodesi Undip, vol. 5, no. 1, 98-106.

Sutanto (1986). *Penginderaan Jauh Jilid I*. Yogyakarta: Gajah Mada University Press.

Sutanto (2016). *Metode Penelitian Penginderaan Jauh*. Yogyakarta: Penerbit Ombak.