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Analysis of Green Land Changes to Building Land Using Geographic Information System (GIS) in Salatiga City from 2013 to 2019

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Abstract
The land is a crucial element in human life as space and resource. The development of a region will not be neglected by the use of land. Data from BPS Salatiga 2013 to 2019 shows an average increase in population reaching 1.45%. 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. The research was conducted in Salatiga and the time of the study starts in August 2019 until January 2020. The purpose of this research is to see and analyze the extent of each transformation of the land use and land cover changes by utilizing Landsat 8 Satellite Imagery in 2013-2019. Data processing in this study uses spatial analysis overlay technique that combined with unsupervised classification and confusion matrix method through SAGA GIS software. The results of data processing will afford new maps and land use change tables then explained descriptively. Based on the analysis that has been done, In 2013, the land use in Salatiga was dominated by green land of 3.031,29 ha which was then followed by land use for built-up land reaching 2.033,91 ha. And in 2019, land use was still dominated by green land of 2.499,03 ha which was then followed by the use of built-up land of 2.483,64 ha. The final result of the area of Salatiga in 2013 - 2019 which experiencing land change from a green land to be built up land is 755,91 hectares.

Keywords: Land Change, Landsat 8 Satellite Imagery, Overlay, Confusion Matix, GIS

1. Introduction

Salatiga is a small town in Central Java province with an area of approximately 5400 ha. This town has 4 sub-districts with a total of 22 villages, 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 Salatiga is quite high which increased the growth of the population.

Data from (BPS, 2014), shows that Salatiga Data from (BPS, 2014), shows that Salatiga reached 178,594 inhabitants in 2013. Each year based on population data from BPS 2013 to 2019 shows an average increase in population reaching 1.45% and is expected to continue to increase every year. Likewise with the land use for built-up land, from 2013 to 2019 based on these data noted changes in land use.

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. The land is the whole environment that provides opportunities for humans to live their lives (Rahayu, 2007). Based on this understanding, it can be interpreted that land is an important element in human life as both space and resources. The development of a city will continue to increase every time, both in the physical and non-physical sectors. And the land use has experienced rapid development during the last six years from 2013-2019. It was originally a green land and nowadays it has been transformed to be a development area. Therefore, according to the mandate of Law No. 26 of 2007, RT (neighborhood) and RW (hamlet) for 2010-2030 was made. It is stipulated as a reference for land use management, and to monitor changes.

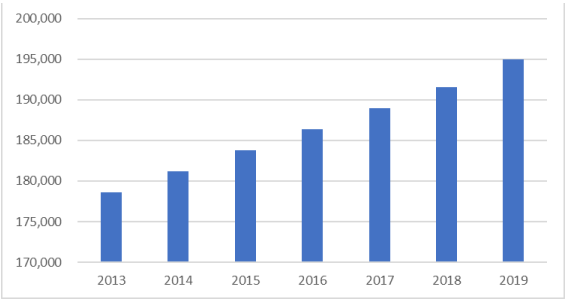

Figure 1. Graph of Population in Salatiga 2013-2019
(Source: BPS Kota Salatiga Tahun 2013-2019)

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).

In calculating and analyzing land changes, landsat 8 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, and also have a role to assist in the calculation process because they are able to present qualitative and accurate information about the changed land and its distribution. The identification process is carried out using the OBIA (Object Base Image Analysis) – Unsupervised Classification and Confusion Matrix (Two Grids) method, which in turn will produce new information, such as a map of land changes and a table of land changes from green land to built-up land (Sutanto, 1989).

Based on the above background, the formulation of the problem for this paper is to find out how extensive is the land change in Salatiga between 2013 to 2019 from the processing of Landsat satellite imagery and wants to prove that GIS can be used to determine the extent changes in Salatiga. Whereas for the purpose of this study is to calculate and analyze land-use changes in Salatiga from 2013 to 2019 using Landsat Satellite Imagery. The scope of this research is to analyze, calculating, and mapping changes in green land into a built-up area in Salatiga. And the benefits of this research are as information from local government on land changes that occur in the Salatiga area and as a reference for the local government for regional development.

2. Literature Reviews

Previous Researches

Research related to land changes has been carried out before, one of them was Blora District has experienced a change in the conversion of agricultural and forest land to non-agricultural land that does not pay attention to the requirements for soil and water conservation, which causes land crisis. The most critical land is in Bogorejo Sub-district with an area of 181,53 Ha, and potential critical land is in Todanan Sub-district with an area of 13.245,71 Ha. Vegetation density plays a major role in the level of critical land on the function of protected areas outside the forest area, while the level of land productivity has a major influence on agricultural cultivation areas and production forests (2015).

Research on land use change in the Salatiga City has been conducted in 2003-2013. Based on the analysis that has been done in getting the results that in 2003, the use of land reaching 3.573,967 ha of green land and 2.009,049 for building land. Then in 2008, covering an area of 3.449,469 ha of land used for green land and 2.134,062 building land. And finally in 2013 to reach the green land 3.266,270 and 2.384,892 ha not used as green land (2015).

Another research is Sirimau District, Ambon city showing that there was a very big change in size of land use for settlements, which was 1036,1. Meanwhile, it was only 966,9 Ha on the previous year. Changes in land use in Ambon are dominated by changes in forest land and dry agricultural land that have turned into residential land. This is due to the high rate of population growth which achieves rate of 5.54%.The way chapter titles and other headings are displayed in these instructions, is meant to be followed in your manuscript (2017).

Land

According to (Purwowidodo, 1983) the definition of land is: “A physical environment that includes climate, soil relief, hydrology, and plants, in which to a certain extent will affect the ability of land use”.

Land can also be interpreted as “land surface with solid, liquid and even gas” (Rafi'i, 1990).

According to FAO (1995) in (Rayes, 2007) land has several functions, such as a production function, a biotic environmental function, a climate regulating function, a hydrological function, a storage function, a waste and pollution control function, a living space function, a relic function and storage, and a spatial liaison function.

Land Use

Land use is any form of human intervention on land in order to meet their needs both material and spiritual. Land use is divided into two major groups, such as land use for agriculture and land use for non-agriculture (Arsyad, 1989).

In the land use to help the needs of human life, we need a policy or rules about land use to reduce the risk of damage.

Changes in Land Use

Changes in land use can be interpreted as changes in land functions from previous functions to be other functions that are able to have a negative impact on the environment and the ability of the land itself. In this study, changes in land use in Salatiga include changes in green land and built up land between 2013 and 2019.

According to Trisasongko et al (2009), there are two major approaches in analyzing land use change by utilizing remote sensing data or satellite imagery. The first approach is the comparison of thematic maps. Various classification methods can be utilized in this approach. The step used in this approach is to compare two or more thematic data in an analysis process, commonly known as a Land Use/Cover Change (LUCC) analysis. The second approach does not involve classification procedures, so no thematic data is generated as intermediary data. Some

statistical procedures can be used in this approach, including Multivariate Alteration Detection (MAD), and the second is Change Detection.

Landsat Satellite Imagery 8

Landsat 8 satellite imagery was successfully launched by NASA (11 February 2013). It will orbit every 99 minutes and take images of the entire earth every 16 days. The characteristics of Landsat 8 imagery are such as using the Operational Land Manager (OLI) and Thermal Infrared Sensor (TIRS) with 11 channels. There are 9 channels (bands 1-9) on the OLI and 2 others channles (bands 10 and 11) are on the TIRS.

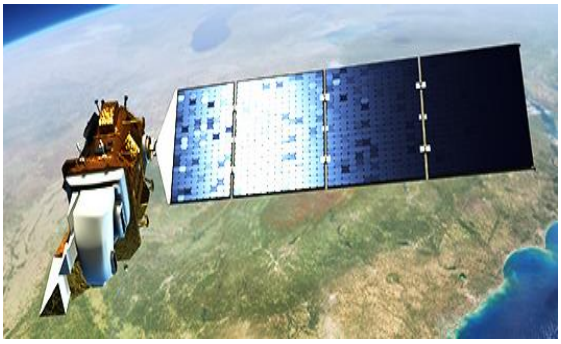

Figure 2. Landsat Satellite 8
(Ardiansyah, 2017)

Landsat 8 satellite imagery has several advantages regarding both the specifications of the bands it has and the long range of the electromagnetic wave spectrum captured. Having a resolution of 30m and 12bit pixels will further distinguish the appearance of objects on the surface of the earth thereby reducing the occurrence of misinterpretation. The image display becomes smoother, both in multispectral and panchromatic bands.

Overlay Maps

According to ESRI Technology in the (ESRI, n.d.), the definition of overlay is a process of overlapping layers of geographic data that cover the same area to study the relationships between them.

There is another definition of Overlay such as a general method for analyzing geographical phenomena that occur simultaneously. In GIS the overlay process has been developed into an analytical tool where various forms of descriptive, deductive, and inductive analysis can be carried out at the data layer. Important applications of overlay analysis include change analysis, assessment of spatial data accuracy, and various forms of multi-criteria evaluation (Ahlqvist, 2009).

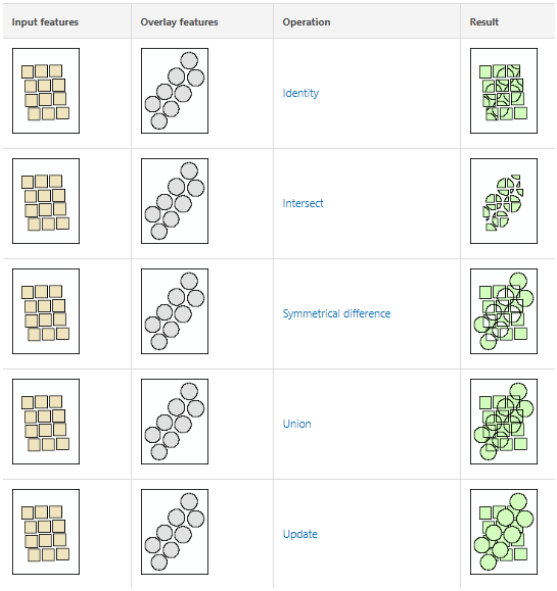

Figure 3. Application of overlay operations in ArcGIS
(Source: https://desktop.arcgis.com)

Remote Sensing

Definition of Remote Sensing by (Lillesand & Kiefer, 1987) is the science and art to obtain information about objects, regions, or symptoms by analyzing data obtained using tools without direct contact with the object, area, or phenomenon being studied.

There are 2 types of data obtained from remote sensing such as Manual data, obtained through image interpretation. And numeric data (digital), obtained through the use of remote sensing software specifically applied to computers.

Geographic Information System (GIS)

GIS is a system that organizes hardware, software, and data and can utilize a storage system, processing, and data analysis simultaneously, therefore information related to spatial aspects can be obtained (Aronoff, 1989).

GIS can be used to make information in the form of thematic maps and zoning for residential areas, green land, and school buildings. Many software can be used to maximize the processing of GIS data, including ArcGIS, MapInfo, Quantum GIS, and others. However, from some of the software above, ArcGIS is the most commonly used because it has complete facilities.

3. Research Method

Table 1. Satellite Used and Research Tool

No	Satellite	Periode	Band Used	Research Tool
1	Salatiga Satellite Imagery Landsat 8	2013-06-24	4,5,6	SAGA GIS software version 6.4.0 used for data processing and map creation
2	Salatiga Satellite Imagery Landsat 8	2019-06-25	4,5,6	

Research stages can be seen in **Figure 4**.

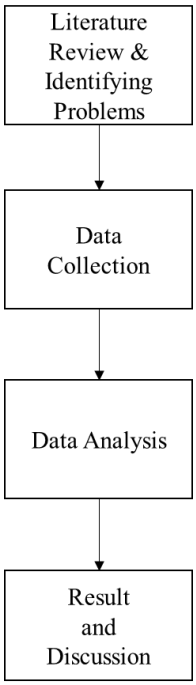

Figure 4. Research Stages
(Source: Author, 2019)

The research was conducted in Salatiga and the time of the study starts in August 2019 until January 2020 with the equipment used in this study are computers and software, such as GIS data processing software (SAGA GIS).

The first step in this research is to review the books, articles, or journals related to the research as reference materials for identifying problems in Salatiga and determine the research topic. After the problem has been identified, the next step is to collect data with a mixed method. A planned and structured quantitative method is used to collect some digital data. Meanwhile, a discussion on problems and solutions using a qualitative approach is done with the Regional Planning, Research, and Development Agency (Bappeda) Salatiga, because this method is a method that emphasizes on the aspect of in-depth understanding of the problem.

The data used are primary data and secondary data. The primary data in this study includes RT (neighborhood) and RW (hamlet) in Salatiga year 2010-2030 and the Salatiga Existing Land Use Map obtained from field observations and the Salatiga Regional Planning, Research and Development Agency (Bappeda). For secondary data, it includes Landsat 8 Satellite Imagery year 2013 (June) and year 2019 (June) from the USGS website (https://earthexplorer.usgs.gov/).

After all, data is completed, then analyzed using spatial analysis techniques to describe land-use changes that occur in Salatiga. Spatial analysis with classification and overlay will be applied in this study, the results of which will be in the form of new maps and explained in the description.

The first step to the classification and overlay process or overlapping map is to make sure that the projection and datum system between the satellite images and the vector data used as cutters is the same. After the satellite images have been successfully cut off, the next step is the classification process using unsupervised classification methods in which there will be 4 classes and will produce land cover area calculations for each year. To find out the land-use changes in Salatiga between 2013 - 2019, the Confusion Matrix method can be conducted..

4. Results and Discussion

Based on research that has been done, the method used in this study and previous research is different, where in the study using the supervised classification method to classify land use. Although the methods used are different, the results of data processing using supervised and unsupervised classification methods are not much different.

At the same location, Salatiga City, but years of research and study period are different, where the results of the land use for each of these two studies is different, but still produce a flow of changes in land use are the same, namely a decrease in the use of green land and increasing land use non-green or built up land.

From 2013 to 2019, the land use in Salatiga has been grouped into 4 parts, such as green land, built-up land, neither green land nor built up land, and unidentified area.

Green land includes rice fields, plantations, and other green areas. Whereas the built up land covers residential areas, and public facilities. For non-green land and built up land includes water areas, vacant land areas, and road areas. For unidentified classes, it covers areas that cannot be identified by Landsat 8 imagery.

In 2013, the land use **Table 2 and Figure 6** in Salatiga was dominated by green land of 3.031,29 ha which was then followed by land use for built up land reaching 2.033,91 ha. Neither green land nor built up land reached 192,51 ha and unidentified area was 7,47 ha.

Table 2. Area of Land Use in Salatiga Year 2013

No	Category of Land Use	Land Use Area (ha)
1	Green Land	3,031.29
2	Built Up Land	2,033.91
3	Neither Green Land nor Built Up Land	192.51
4	Unidentified	7.47
	Total	5,265.18

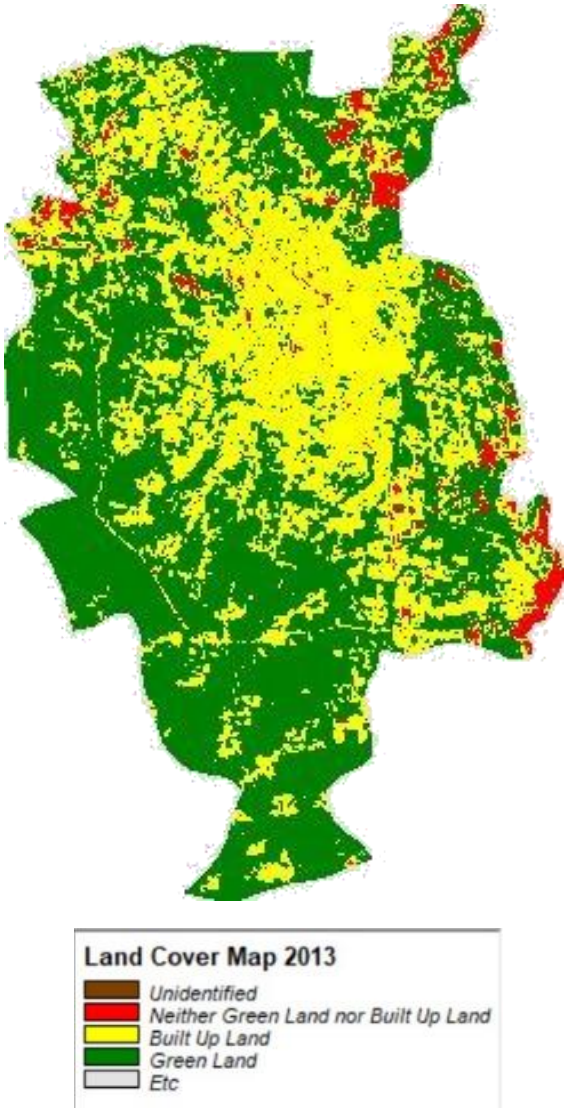

Figure 6. Map of Land Use in Salatiga 2013 (Source: Landsat Image Overlay Result 8 - Author, 2019)

Table 3 and **Figure 7** illustrate the land use condition in Salatiga year 2019 which has experienced changes in each land use. As in 2013, land use was still dominated by green land of 2.499,03 ha with a difference of 15,39 ha which was then followed by the use of built-up land of 2.483,64 ha. Furthermore, neither green land nor developed land is 269,01 ha and the unidentified area is 13,5 ha.

Table 3. Area of Land Use in Salatiga Year 2019

No	Category of Land Use	Land Use Area (ha)
1	Green Land	2,499.03
2	Built Up Land	2,483.64
3	Neither Green Land nor Built Up Land	269.01
4	Unidentified	13.5
	Total	5,265.18

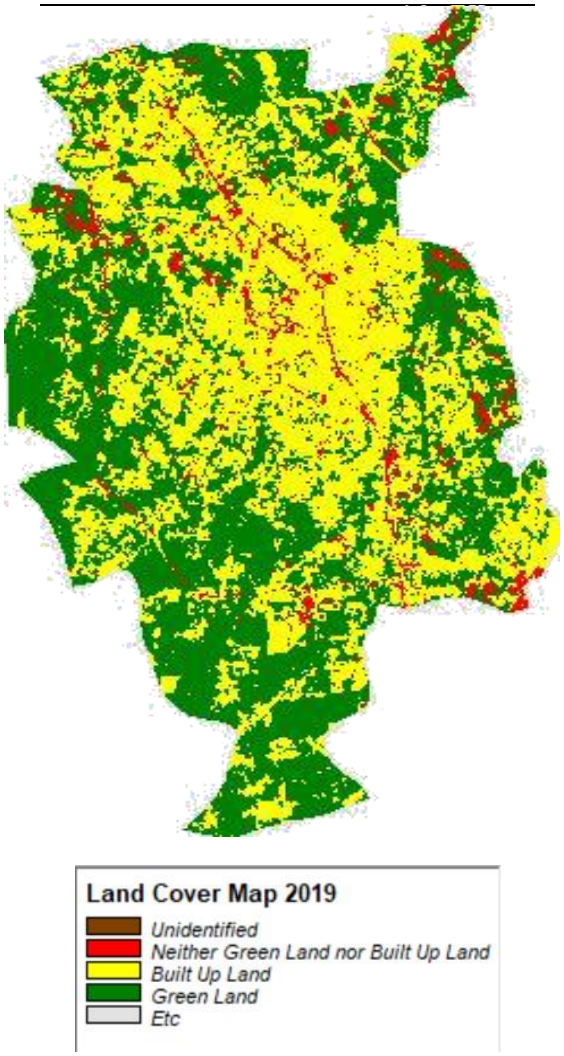

Figure 7. Map of Land Use in Salatiga 2019 (Source: Landsat Image Overlay Result 8 - Author, 2019)

The development of an area and the increasing population causes a bigger need for residential areas and other facilities. This is one of the factors that cause green land in Salatiga to change its function to be built-up land. Land-use changes that occur in

Salatiga are not only caused by indigenous people, but also by migrants.

Overlay Result Analysis

The area in this research is 5,265 ha. In this paragraph, the results obtained from the confusion matrix process and in square meters unit then converted to hectares with Field Calculator.

In 2013, the green land changed into Built-Up Land was 755.91 ha. As for the Built-Up Land in 2013 and 2019 in this calculation is 1,516.14 ha. Neither Green Land nor Built-Up Land that was developed in 2013 which experienced a change to Built-Up Land in 2019 was 64.98 ha. Lastly is the land that is Unidentified in 2013 changed as much as 1.98 ha to Built-Up Land in 2019. With a total land changes from the year, 2013 to 2019 amounted to 2,337.03 ha.

5. Conclusion

Based on the research on land cover change analysis using the Landsat image interpretation method, it proves that GIS can be used to calculate the rate of land change in Salatiga. And the area of green land cover that has changed into built-up land in Salatiga is 755,91 ha. The change is caused by several factors, one of which is the level of regional and population development.

6. Acknowledgements

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7. References

Ahlqvist, O. (2009). Overlay (in GIS). Dalam *International Encyclopedia of Human Geography* (hal. 48-55). Oxford: Elsevier.

Ardiansyah, T. (2017, April 2). Diambil kembali dari Forester Act: https://foresteract.com/landsat-8-oli/

Aronoff. (1989). *Geographic Information Sistem : A Management Perpective.* Ottawa, Canada: WDL Publication.

Arsyad, S. (1989). Konservasi Tanah dan Air. Bogor: Institut Pertanian Bogor.

BPS. (2014). *Salatiga Dalam Angka 2014.* Salatiga: Badan Pusat Statistik Kota Salatiga.

ESRI. (t.thn.). Diambil kembali dari Esri Support GIS Dictionary: https://support.esri.com/en/other-resources/gis-dictionary/search/

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

Laka, B. M., Sideng, U., & Amal. (2017). Perubahan Penggunaan Lahan di Kecamatan Sirimau Kota Ambon. *Jurnal Geocelebes*, 43-52.

Leunupun , P., & Papilaya, F. S. (2019). 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). *JOURNAL OF APPLIED GEOSPATIAL INFORMATION*, 195-203.

Lillesand, & Kiefer. (1987). *Remote Sensing and Image Interpretation, Second Edition.* New York : John Willey and Sons.

Noviana, B., Subiyanto, S., & Sasmito, B. (2015). Analisi Kesesuaian Perubahan Penggunaan Tanah Terhadap Rencana Tata Ruang Wilayah (RTRW) Di Kota Salatiga Tahun 2003,2008, Dan 2013. *Jurnal Geodesi Undip*, 62-72.

Purwowidodo. (1983). *Teknologi Mulsa.* Jakarta: Dewaruci Press.

Rafi'i, S. (1990). *Ilmu Tanah.* Bandung: Angkasa.

Ramayanti, L. A., Yuwono, B. D., & Awaluddin, M. (2015). Pemetaan Tingkat Lahan Kritis Dengan Menggunakan Penginderaan Jauh dan Sistem Informasi Geografis (Studi Kasus : Kabupaten Blora). *Jurnal Geodesi Undip*.

Rayes, M. L. (2007). *Metode Investarisasi Sumber Daya Alam.* Yogyakarta: Andi.

Sutanto. (1989). *Penginderaan Jauh Jilid I.* Yogyakarta: Gajah Mada University Press.