Assessment of spatial changes of LULC dynamics, using multi temporal landsat data (case study: Lesti Sub Watershed, Malang Regency, Indonesia)

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Abstract. The research background is to present certain important observations about land change as one of the basis for decision making for water resources management in the sub-urban environment, taking into account field data and classification of satellite imagery to understand natural spatial change patterns. The Lesti sub-watershed, an area upstream of the Brantas River related to multi-functional activities, continues to develop in terms of infrastructure management, especially the river water discharge that enters the Sengguruh Reservoir which causes increased pressure on water and human needs for housing. The method is utilizing Landsat satellite imagery for the last 20 years is used to obtain an analysis of land use/land cover (called: LULC) changes to see the rate of change over the last 20 years. The land use classes used are agricultural land, surface vegetation, built-up areas, open land, and water bodies. Landsat satellite imagery data are classified and used to obtain LULC analysis in the area, to estimate and understand the rate of change over the last 20 years. The results showed that for 20 years, vegetation and open land experienced a considerable decline, while the value of built-up land increased from 0.79% to 13.26%.

keywords: land use classes, land use land cover (LULC), satellite imagery

1. Introduction

Population growth and the development of an area are one of the factors of land use change. LULC changes in sub urban areas cause many problems such as changes in water quantity and quality, loss of agricultural land, and urban environmental problems [1], [2].

In general, water resources in Indonesia face long-term problems related to management that affect the country's economic development, causing reduced food security, public health and environmental damage. In addition, of course, it also affects the availability of clean water [3]. As in several other countries, in order to overcome the problem of damage to watersheds and water resources in Indonesia, integrated watershed management actions are needed [4].

Factors that determine changes in hydrological behavior in a watershed can be influenced by several factors, such as changes in climate and land use change [5]. The results of observations of rainfall data from 1955 to 2005 show very significant changes related to changes in existing hydrological phenomena
Cities developing rapidly must pay attention to the dynamics of land use change to formulate effective planning strategies and policies [6]. The study of water resources is used to manage, assess and simulate this important natural resource. Based on the arrangement of the watershed according to its designation, of course, that goes hand in hand with an analysis of land cover and land use. Each watershed has its hydrological characteristics. This can be observed from several parameters such as soil type, land use, topography, or slope and slope length [7].

Environmental damage in the Lesti sub watershed which is increasingly widespread due to significant forest and land damage has caused a decrease in the carrying capacity of the watershed so that there is a need for optimal watershed management [8]. This is also reinforced by the existence of several studies that there has been a change in land use in the Lesti sub watershed [9]. The important thing components in the hydrological cycle and hydrological analysis is the rain parameter. During the last ten years, flood disasters in the territory of Indonesia as a result of damage to land and watersheds have occurred in succession, with the intensity, frequency, and distribution or areas affected by disasters increasing and expanding.

Watershed is a land area that is topographically limited by mountain ridges that collect and store rainwater to channel it through the main river then to the sea. The land area is a water catchment area, an ecosystem with the main elements of human resources as beneficiaries and natural resources, including land, water, and plants. [10].

The process of rain becoming a flow is a natural occurrence, where when the soil is saturated with water, the rain that falls will accumulate into a flow on the surface of the ground. This complex process is caused by two things, namely the watershed system variables and the input characters which have space and time variables. So as a solution to these problems, modeling with rain, land use, and evapotranspiration parameters can be used to estimate the potential discharge that occurs. Analysis of rain into discharge can be used, one of which is the FJ Mock method by assuming the value of land use in the study area, where the research that has been conducted is divided into 5 (five) classes, namely vegetation, water bodies, agriculture land, built up area, and open land [11], [1], [12], [13].

Recent developments also show that LULC changes due to development programs, to assess LULC and the extent of geomorphological changes in the Lesti sub watershed, a study of LULC changes is required. In analyzing the morphological behavior of the environment in the study location related to LULC change, remote sensing data is needed which is important information to assess the historical and current conditions of the Lesti sub watershed area. By conducting multi-images and multi-temporal analysis of a watershed, a result of an analysis of trends in land use change in the study area will be achieved. This paper presents the results of observations of LULC changes from 2000 to 2020 in the Lesti sub watershed, Malang Regency, Indonesia.

2. Materials and Method

2.1. Study area
This study is mainly based on supporting data collected for selected watersheds in Malang Regency, especially in the upstream areas of the Brantas river basin. We limited the point of interest to the Lesti sub watershed region being studied. The location of this study is part of the south area of Malang Regency. The selection is based on a location that allows a lot of land change due to population growth and the form of distribution of a population. The data collected is used to further analyze the processes or factors that influence LULC changes using a multi-image and multi-temporal approach. It is also useful for better analysis so that it can explain LULC change in the Lesti sub watershed. Lesti Sub Watershed is one of the watershed in Malang Regency, East Java Province, Indonesia. Geographically the Lesti Sub Watershed is located between 704°00' - 705°55'00" LS South Latitude and 112°10'00" - 112°25'00" BT East Longitude. Lesti sub watershed is included in 7 (seven) sub-districts, including Poncokusumo, Ampelgading, Wajak, Tirtoyudo, Turen, Dampit and Sumbermanjing Wetan. Lesti sub watershed as the study location is shown in Figure 1.
2.2. Image classification and processing

The data used from various sources include primary data, information from the service and the surrounding community, as well as satellite imagery. The secondary data used are topographic maps and several other supporting tools such as compasses, cameras, and other measuring tools used to collect data at the location. On April 15, 1999 a Delta II rocket launched Landsat 7 from Vandenberg Air Force Base in California, the Enhanced Thematic Mapper (ETM+) sensor carried by the satellite. Since June 2003, the sensor has been acquiring and transmitting data for analysis via Scan Line Corrector (SLC).

On February 11, 2013, Landsat 8 (also known as Landsat Data Continuity Mission, LDCM) was officially launched from Vandenberg Air Force Base California, aboard an Atlas-V rocket. Where Landsat 8 is the most recently launched satellite carrying the Thermal Infrared Sensor (TIRS) and Operational Land Imager (OLI) instruments.

This study uses a qualitative descriptive analysis method to interpret multitemporal satellite imagery maps for satellite image data in 2000, 2005, 2010, 2015, and 2020. We used Landsat 7 imagery to analyze LULC 2000, 2005, and 2010, then Landsat 8 imagery to analyze LULC 2015 and 2020 in the area study. In order to avoid problems related to spatial resolution, check for example on the type of soil and correct the geometry factor in the analyzed image. In addition, sharpening, image registration, land class classification, and the overlay process for each area are also carried out.

Image data is also sharpened for easy analysis, then enlarged to distinguish slopes and hills. It is then digitized using the polyline method to determine the boundaries of the watershed under study. The overlaid images were from citra Landsat 7, and citra Landsat 8. Classification of land classes is carried out properly and carefully so that there is no possibility of errors in distinguishing LULC in the study area. So in brief, the methodology we use is:

1. Input stage
   - Satellite Imagery from Landsat-7 and Landsat-8 (2000 until 2020)
2. Process stage
   - Geo Rectification of Topography sheets
   - Un Supervised Classification
   - Field visit (for Ground Truth Check)
   - Supervised Classification
   - Authentication with Handbook
   - Finalizing the Classes
   - Delineation of Watershed Boundaries
   - Land class analysis from 2000 to 2020
3. Output stage
   - LULC classes
   - Change Analysis

   First, a classification without land use analysis was carried out to obtain all the valuable information about the different land use classes. After that, a field survey is carried out. This data is used to determine the classification of the assigned land class for a better analysis of the existing land cover according to the specified class. Next, the analysis results are determined for changes based on five classes of LULC according to the year of analysis, namely 2000 to 2020.

2.3. Watershed boundary interpretation

The results of interpretation and overlaying of multitemporal satellite imagery data will be obtained the watershed boundaries of the study area. Landsat 8 OLI / TIRS satellite imagery is one of the resource satellites commonly used in agriculture, rectification errors, pixels, and digitization are three sources of problems to consider when calculating watershed boundaries [14], [15]. From the Landsat and SPOT image data at a scale of 1:50,000, digitization can be done using the polyline method so that the watershed's boundaries are obtained. The overlay map can limit the change in LULC in 2000, 2005, 2010, 2015, and 2020 observation years. We did not consider tectonic formations especially to determine the formation of the Lesti sub-watershed in Malang Regency because this area is part of East Java Province, and requires separate analysis to analyze the geomorphology of the area separately.

OLI (Operational Land Imager) captures data with enhanced radiometric precision over a 12-bit dynamic range, which improves the overall signal to noise and noise ratio. This raises a potential 4096 gray levels, compared to only 256 gray levels on Landsat 1-7 8-bit instruments. Improved signal to noise performance enables improved characterization of land cover state and condition. The 12-bit data are scaled to 16-bit integers and delivered in the Level-1 data products. Products are scaled to 55,000 grey levels, and can be rescaled to the Top of Atmosphere (TOA) reflectance and/or radiance using radiometric rescaling coefficients provided in the product metadata file (MTL file). Enhanced Thematic Operational Land Imager (OLI) - Built by Ball Aerospace & Technologies Corporation, give nine spectral bands, including a pan bands they are:
1. Visible with wave 0.43 – 0.45 μm at 30 m by Band 1.
2. Visible with wave 0.450 – 0.51 μm at 30 m by Band 2.
3. Visible with wave 0.53 – 0.59 μm at 30 m by Band 3.
4. Red with wave 0.64 – 0.67 μm at 30 m by Band 4.
5. Near-Infrared with wave 0.85 – 0.88 μm at 30 m by Band 5.
6. SWIR 1 with wave 1.57 – 1.65 μm at 30 m by Band 6.
7. SWIR 2 with wave 2.11 – 2.29 μm at 30 m by Band 7.
8. Panchromatic (PAN) with wave 0.50 – 0.68 μm at 15 m by Band 8.
9. Cirrus with wave 1.36 – 1.38 μm at 30 m by Band 9.

Thermal Infrared Sensor (TIRS) - Built by NASA Goddard Space Flight Center give two spectral bands they are:
1. TIRS 1 with wave 10.6 – 11.19 μm at 100 m by Band 10.
2. TIRS 2 with wave 11.5 – 12.51 μm at 100 m by Band 11.
3. Results and Discussion
The LULC Lesti Sub Watershed area of Malang Regency in 2000, 2005, 2010, 2015, and 2020 changed across several types of LULC, as shown in Table 1. LULC change of Lesti Sub Watershed area from 2000 to 2020 is dominated by land use for open land, vegetation, and water body. Results also show that land cover types changed, primarily to agriculture land, built-up area and a open land, which varies in total area for different years of image, analyzed. Open land has changed considerably from 2000 to 2020, accounting for a 6423.93 (56%) hectare increase, and between 2005 and 2015 vegetation reduced by -2013.93 (10%). Open land increased 16% from 2005 to 2015 and down to 50% to 2020.

Based on the above summary, it can be concluded that the rapid increase and expansion of the urban area, especially of the built-up land, can be a major factor for loss of agriculture, surface and groundwater resources, increased surface runoff, reducing natural groundwater recharge and many other environmental. Based on the observations from the present work, it is clearly indicated that the use of satellite data for land use mapping and change assessment is an important aspect of sustainable land, water, and environmental management [1], [16], [17]. As well as images of maps and graphs of LULC changes in the Lesti sub watershed can be seen in Figure 2 and Figure 3.

### Table 1. LULC area of Lesti sub watershed in 2000, 2005, 2010, 2015, and 2020.

| No | YEAR | 2000 (Ha) | 2005 (Ha) | 2010 (Ha) | 2015 (Ha) | 2020 (Ha) |
|----|------|-----------|-----------|-----------|-----------|-----------|
|    | LULC | %         | %         | %         | %         | %         |
| 1  | Agriculture Land | 7.180,47 | 18.84 | 9.956,8 | 26.12 | 6.243,1 | 16.38 | 9.718,9 | 25.50 | 11.783,9 | 30.91 |
| 2  | Built-Up Area | 299,59 | 0.79 | 357,7 | 0.94 | 527,2 | 1.38 | 1.034,4 | 2.71 | 1.167,7 | 3.06 |
| 3  | Open Land | 11.479,66 | 30.11 | 8.445,4 | 22.15 | 10.994,9 | 28.84 | 10.020,5 | 26.29 | 5.055,7 | 13.26 |
| 4  | Vegetation | 19.078,65 | 50.05 | 19.278,4 | 50.57 | 20.273,1 | 53.18 | 17.264,5 | 45.29 | 20.031,1 | 52.55 |
| 5  | Water Bodies | 82,28 | 0.22 | 82,3 | 0.22 | 82,3 | 0.22 | 82,3 | 0.22 | 82,3 | 0.22 |
|    | TOTAL | 38.120,65 | 100.00 | 38.120,6 | 100.00 | 38.120,7 | 100.00 | 38.120,6 | 100.00 | 38.120,6 | 100.00 |

**Figure 2.** Maps of LULC changes in the Lesti sub watershed.
Figure 3. Graphs of LULC changes in the Lesti sub watershed.

4. Conclusion
Sustainable development and population growth have affected land use and geomorphology changes along the Lesti watershed from 2000 to 2020 in Malang Regency. It can be concluded that LULC changed during 2000, 2005, 2010, 2015 and 2020. These changes mainly occurred in built-up areas or settlements, open land, and vegetation with a total area that varied in each observation year period. However, land cover of water bodies remained stable from the initial year of the selected analysis between 2000 until 2020.

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