Monitoring of land use land cover change using google earth engine in urban area: Kendari city 2000-2021

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Abstract. The physical development of an area causes Land Use Land Cover (LULC) changes due to land requirement increases. Kendari City is the capital city of Southeast Sulawesi Province with extensive urbanization and extensive LULC changes. This study aims to analyze LULC changes in Kendari City (2000-2021) using multi-temporal Landsat imageries data. Landsat-5, Landsat-7, and Landsat-8 imageries spanning 20 years obtained from the Google Earth Engine (GEE) database. LULC classification based on machine learning using random forest method. The pattern of LULC of 2000 - 2010 spread to the west and increased the settlements in Kadia District. In 2010 - 2021 settlement developments to the west and south, namely in Kadia and Wua-wua Districts. An increase in built-up land or settlements in Kendari City has occurred about two times over the last 20 years has led to agricultural land. The increase in built-up land or settlements in Kendari City reached 1,920.44 Ha, and at the same time, there was a decrease in agricultural land in rice fields by 1,866.86 ha in the last 20 years.

1. Introduction
The physical development of cities followed by environmental degradation in water, air, and land is a challenge facing all regions today [1-3]. According to [4] changes in Land Use Land Cover (LULC) are a factor in the decline in environmental quality due to population growth and increased need for built-up land. To meet the needs, vacant land or agriculture turns into sectors needed by the community, such as the goods and services industry or even settlements. The dynamics of LULC change is strongly influenced by human factors such as population growth (amount and distribution), economic growth, and is also influenced by physical factors such as topography and soil type. The demand for space for LULC increases with the increase in population and economic growth, while the availability of land does not increase or can be said to be constant [5].

The development of remote sensing technology is used for monitoring changes in LULC is currently in the use of cloud computing systems. One of the platforms, Google Earth Engine (GEE), has a database of various images that can be used for temporal monitoring. [6] using GEE can be for monitoring changes in LULC using Support Vector Machine (SVM) and Random Forest (RF) methods. The results of his research indicate that population increase and urbanization are the main contributors to changes
in LULC in Somalia. [7] also uses GEE for monitoring six cities in the US, especially for air conditions through the Urban Heat Island. His research stated that changes in LULC caused an increase in Urban Heat Island in 6 US cities.

In Indonesia, research related to LULC change are mostly carried out in almost all regions, including Jakarta [8]-[11], Surabaya [12-14], Makassar [15-17], Yogyakarta [18, 19]. Kendari city, as the capital city of Southeast Sulawesi Province, has higher economic growth than other areas in Southeast Sulawesi is the attraction of urbanization which causes an increase in population and will simultaneously demand changes in LULC in the Kendari City area to meet community needs [20]. However, there has been no study of LULC change using GEE in the Kendari area so that it can be carried out quickly. This study aims to determine changes in LULC in Kendari City in 2000-2021 using GEE.

2. Data and Methods

2.1. Study Area

The study is conducted in Kendari City, Southeast Sulawesi, which is located in 122°26’00” – 122°38’30” E and 3°64’00”– 4°5’00” S. Kendari has ten subdistricts i.e., Mandonga, West Kendari, Kendari, Puuwatu, Kadia, Wua-wua, Kambu, Baruga, Poasia, and Abeli. Based on Statistic Agency of Indonesia (BPS), in 2020, there are 340,796 populations over Kendari City. The highest population density located in Kadia with 5,874 per km² then followed by Wua-wua with 2,958 per km². Kendari city around the Kendari bay. Figure 1 shows the map of the study area.

![Figure 1. Map of the study area](image)

2.2. Data and Material

Monitoring of LULC change in Kendari City uses remote sensing data i.e., Landsat image data and shapefile (shp) data i.e., main and local roads in Kendari City from the Map of Rupa Bumi Indonesia (RBI). Temporal Landsat imagery used in monitoring LULC changes has a time span of 2000-2021. Each year uses a different kind of Landsat-8 imagery due to the availability of the data. For the year 2000 using Landsat 7, 2010 using Landsat-5, and 2021 using Landsat-8. Landsat image data is processed using a cloud-based geospatial platform, namely Google Earth Engine.
2.3. Methods
The pre-processing stage is carried out to obtain corrected pixel and mosaic radiometric values from several recording times to obtain a clean image of cloud cover. LULC classification uses the machine learning RF method by taking training samples for each land cover class. The LULC classification process using RF was carried out to extract land cover types in the monitoring area. Classification obtained from this method there are five classes i.e., waterbody, built-up land or settlement, vegetation, open land, and agricultural field. The results of the RF classification of each Landsat image are LULC data for each year which will be used for the analysis of LULC change and LULC maps. The main roads of Kendari City are arterial and collector roads. This data is obtained from RBI maps in shapefile (shp) format. The main road shp data is used to analyze a distance of 500 m with the buffering method. This analysis is carried out to find or make a map of the distance to the main road as the driving factors for the development of built-up land. Figure 2 shows the flow chart of this research.

3. Result and Discussion
LULC classification based on 2000, 2010 and 2021 multitemporal Landsat imagery. The Landsat-7 ETM image mosaic records the LULC of the City of Kendari in 2000 from January - December. For 2010 the availability of Landsat data, namely Landsat-5 TM mosaic from January-December because the Landsat-7 image has been damaged by stripping. Meanwhile, for 2021 the availability of data in the form of Landsat-8 OLI mosaics for January - March. Although using different sensors, the three images have the same pixel size, which is 30 m. The appearance of the actual color image for Kendari City can be seen in Figure 2. The best image quality is in 2021, where it only has a little cloud cover, while the 2000 and 2010 images have quite a lot of cloud cover so that there are black spots on the visual appearance. This affects the results of LULC classification based on pixel values. The results of LULC classification in Kendari City on a regional scale (1:100,000) can be seen in Figure 3. This study is an initial study on a medium scale, for further analysis, it is necessary to test the accuracy of digital interpretation results.
Figure 3. RGB image of Kendari city (a) Landsat-7 (2000), (b) Landsat-5 (2010), (c) Landsat-8 (2021)

LULC classes in Kendari City that can be interpreted from Landsat images are bodies of water, settlement, vegetation, open land, and agricultural fields. Kendari City, which is a coastal city, in 2010 the development of the town in the form of built-up land/settlement is mostly found in the Districts of West Kendari and Kadia around Kendari Bay or the central part. In the north, south, and west, Kendari City is surrounded by vegetation in the form of high-density vegetation or the form of agricultural fields. This vegetation covers residential areas, including agricultural fields and open land.

The development pattern of Kendari City LULC from 2000 - 2010 to the west is the addition of settlements in The Kadia District. Figure 4 shows a map of Kendari city's LULC from 2000 - 2021. Based on this map, city's development starts from the center and extends towards the surroundings. In 2010 - 2021, settlement developments to the west and south were in the Districts of Kadia and Wuawua.
Figure 4. LULC of Kendari City (a) 2000 (b) 2010 dan (c) 2021

Table 1. Area of each LULC class in 2000, 2010, and 2021

| No | LULC class     | Area of 2000 (Ha) | Area of 2010 (Ha) | Area of 2021 (Ha) |
|----|----------------|-------------------|-------------------|-------------------|
| 1  | Waterbody      | 22,21             | 48,92             | 214,28            |
| 2  | Settlement     | 1421,23           | 2447,50           | 3341,67           |
| 3  | Vegetation     | 16806,63          | 16861,87          | 16049,38          |
| 4  | Open area      | 1809,30           | 835,95            | 2188,70           |
| 5  | Agricultural field | 2560,59         | 2426,26           | 693,73            |

Based on Figure 3 and Table 1, the use of built-up land/settlement has expanded approximately 2 times in the last 20 years. The expansion of built-up land generally leads to agricultural lands in the form.
of rice fields. The increase in settlement in Kendari City reached 1,920.44 ha and simultaneously, there was a decrease in agricultural land into rice fields/fields of 1,866.86 ha in the last 20 years. The development of built-up land/settlement land in Kendari City is generally carried out by converting agricultural land in the form of agricultural fields so that it needs the attention of stakeholders. The shrinking of agricultural land, especially land that produces food, will cause new problems in the future related to meeting food needs, especially in Kendari City.

Table 2. The area of land built-up land/settlement by each sub-district in Kendari City in 2000, 2010, and 2021

| No | Sub-district   | Area of built-up/settlement (Ha) |
|----|----------------|----------------------------------|
|    |                | 2000    | 2010    | 2021    |
| 1  | Abeli          | 77.06   | 137.31  | 133.80  |
| 2  | Baruga         | 51.88   | 192.57  | 334.84  |
| 3  | Kadia          | 240.31  | 370.01  | 499.57  |
| 4  | Kambu          | 76.07   | 269.60  | 370.85  |
| 5  | Kendari        | 128.33  | 193.63  | 125.85  |
| 6  | Kendari Barat  | 295.62  | 331.61  | 353.37  |
| 7  | Mandonga       | 248.38  | 319.41  | 357.32  |
| 8  | Poasia         | 77.90   | 164.97  | 398.20  |
| 9  | Puuwatu        | 98.86   | 201.78  | 402.81  |
| 10 | Wua-Wua        | 126.84  | 266.62  | 365.04  |

Table 3. Area of agricultural fields for each sub-district in Kendari City in 2000, 2010, and 2021

| No | Sub-district   | Area of agricultural field |
|----|----------------|----------------------------|
|    |                | 2000    | 2010    | 2021    |
| 1  | Abeli          | 214.12  | 137.88  | 12.72   |
| 2  | Baruga         | 285.33  | 469.29  | 260.41  |
| 3  | Kadia          | 180.91  | 158.31  | 32.62   |
| 4  | Kambu          | 485.05  | 471.65  | 144.63  |
| 5  | Kendari        | 114.99  | 62.15   | 0.00    |
| 6  | Kendari Barat  | 73.14   | 85.82   | 2.11    |
| 7  | Mandonga       | 168.77  | 120.34  | 7.61    |
| 8  | Poasia         | 426.16  | 356.13  | 119.71  |
| 9  | Puuwatu        | 497.37  | 473.50  | 88.32   |
| 10 | Wua-Wua        | 114.74  | 91.19   | 25.61   |

Based on Table 2 and Table 3, the highest rate of land conversion occurred in four sub-districts, namely Baruga, Kambu, Poasia, and Puuwatu, with an expansion rate of about 5 (five) times for 20 years. This data shows that the expansion of built-up land in Kendari City generally occurs in suburban areas and areas with relatively wider agricultural land. Along with the expansion of built-up land/settlement, in these four sub-districts there has also been a decline in agricultural land in the form of rice fields/fields about 5 times in the last 20 years.

The Kendari City area, which had urban characteristics since 2000, has not experienced the expansion of built-up land/settlement land as fast as Baruga, Kambu, Poasia, and Puuwatu. However, in these relatively urban areas, such as Kendari, West Kendari, and Mandonga sub-districts, there has been a change in LULC in the form of a significant reduction in agricultural fields. Although the area is not as large as agricultural land in Baruga, Kambu, Poasia, and Puuwatu sub-districts, the percentage of area in 2000 compared to 2021 is very high. Based on table 3, in the districts of Kendari, West Kendari, and Mandonga, the remaining agricultural land is less than 4%. In other words, since 2000 until now more
than 96% of agricultural land in the form of rice fields/fields has been converted into other types of LULC.

![Figure 5. Distance of 500 m from the main road in Kendari City in (a) 2000 (b) 2010 and (c) 2021](image)

Table 4. Area of LULC at 500m from the main road in Kendari city

| No | LULC class       | Area of LULC at 500m from the main road (Ha) |
|----|------------------|--------------------------------------------|
| 1  | Waterbody        | 11.82                                      |
| 2  | Settlement       | 1259.71                                    |
| 3  | Vegetation       | 4126.28                                    |
| 4  | Open area        | 1079.57                                    |
| 5  | Agricultural field | 1348.50                                    |
|    |                  | 2000                                       |
| 2  | Settlement       | 2062.28                                    |
| 3  | Vegetation       | 3913.19                                    |
| 4  | Open area        | 516.64                                     |
| 5  | Agricultural field | 1299.91                                    |
|    |                  | 2010                                       |
| 2  | Settlement       | 2628.30                                    |
| 3  | Vegetation       | 3536.11                                    |
| 4  | Open area        | 1300.41                                    |
| 5  | Agricultural field | 290.83                                     |
The pattern of LULC change is also influenced by the structure of the city, particularly the main road network. Based on table 3, the rapid expansion of built-up land generally occurs in the main road corridor of Kendari City. On the other hand, the shrinkage of agricultural land in the form of agricultural fields in Kendari City also tends to occur in the City's main road corridors or within a 500-meter radius of the Kendari City main road network.

4. Conclusion
LULC is defined as human activities on land are influenced by human factors (number and distribution of the population) and physical factors (topography, soil type and others). Classification of Land Use Land Cover in Kendari City from 2000, 2010 and 2021 is classified into 5 classes, namely water body, settlements, vegetation, open land and agricultural field. Over 10 sub-districts, the settlement area tends to increase, except for the Abeli sub-district and the Kendari sub-district which tend to be varied. In 2000, the largest area of built-up land/settlement land was in West Kendari District. In 2010 and 2021, the most built-up land/settlement land area was in Kadia sub-district. Kadia District and West Kendari District are districts with a high number of slum settlements.

The LULC of water bodies and built-up land/settlement land tends to increase, while the use of vegetated land, open land, and agricultural fields varies. The increase in water bodies is caused by the silting of the bay due to erosion, sedimentation and infrastructure development, trade, and services around the bay. The increase in built-up land is caused by a surge in population and migration which indirectly encourages a decrease in vegetation for land clearing as residential areas, shops, hotels, services, trade, and industry. The distance from the main road has an influence on LULC patterns in the City of Kendari. The pattern of development tends to follow the road (linear) due to the flat and hilly topography of the City of Kendari. Residents tend to build in flat areas and avoid building in hilly areas on the north side of Kendari City.

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