Landuse change and its impact on rice productivity in Sleman Regency 2007-2017

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Abstract. Landuse change is a serious phenomenon which faced by some of the suburban areas. Sleman Regency is one of regencies that is located in suburban area or outskirts of Special Region of Yogyakarta. The imbalanced between the need or the demand and the availability of land in Special Region of Yogyakarta, trigger a city expansion to the surrounding areas, especially in Sleman Regency. The purpose of this research is to study and to examine the impact of landuse change towards to the paddy productivity in Sleman Regency. The landuse analysis was performed by comparing the RBI map of Sleman Regency in 2007 and the RBI map of Sleman Regency in 2017. The result of the research showed us that during 2007-2017 period, the decreasing areas were fields by 0.93%, shrubs by 0.12%, and rice fields by 47.5%. Landuse that experienced increase in area were buildings by 2.89%, plantations by 12.62%, and settlements by 34.26%. The decreasing area of paddy fields did not significantly reduce the productivity of the rice. Rice production from 2007-2017 period is stable and tends to be increase. That is because the area of harvested land from 2007-2017 has also increase due to the agriculture diversification program in Sleman Regency. This research shows us the projection of paddy productivity until 10 years later from 2017.

1. Introduction
Land use has continued to change over time. Land use change in line with population growth. In addition, the number of residents resulted in the need for land also increased, while land area never increased. The need for land availability caused unavoidable land use change, which is the change of agricultural land to non-agricultural land. Paddy fields become the most vulnerable agricultural land in land change because: (1) The rice field Agroecosystem generally has a higher population density than dry land agroecosystems; (2) Rice fields are generally located close to the city; (3) Infrastructure around the field is better because of previous development; and (4) the paddy fields are generally in the flat topography, so the development becomes easier [1].

Based on the reasons above, the region that is most vulnerable to land use changes is the region in the suburbs. It is in accordance that the development of the city of Dehrandum from 2004-2014 has resulted in the change of regional structures and patterns in the suburbs [2]. Sleman Regency is a regency that directly borders the city of Yogyakarta, which is significantly affected by the development of Yogyakarta [3]. Land use change is also influenced by population growth. Increase in population density caused by development acceleration in suburban areas. High demographic growth
resulted in the change of forest land use to develop more intensive land and the rural center is developing very quickly [4].

In Sleman Regency from 2007 to 2017 it has been increased by a population of 151,561 people with a population growth rate of 1.13% per year [5]. The increase in population is always accompanied by increasing land demand for settlements. Land needs for settlements that continue to increase, leading to the function of agricultural land into non-agricultural land. Consequently, the increase in the population of pressure on agricultural land increased [6]. The impact of land use change can also cause a permanent food problem that will even though there is no change in land use but the impact will still be felt in a long period [7].

Agricultural land pressure will impact agricultural productivity results. The higher population pressure in a region then the value of agricultural productivity is decreasing [8]. Meanwhile, the increase in population resulting in rice needs also increased [7]. Thus, the purpose of this research is to examine the impact of land use change and its factors on rice productivity in Sleman regency.

2. Methods and Materials
The first step that must be done is to choose an area as an object. The selected area is Sleman Regency. Sleman Regency is a regency that located in the Special Province of Yogyakarta. This district has a fairly high population due to high migration rates. This will increase pressure on land and the environment then causes changes in land use. That land use change will probably has an impact in decreased agricultural productivity in the local area.

This research was conducted with quantitative descriptive analysis method using secondary data consisting of harvested area data of Sleman Regency in 2007-2017, production of paddy data in Sleman Regency 2007-2017, and total settlement area data in Sleman Regency 2007-2017. The overall data was obtained from the official website of the Indonesia’s Central Bureau of Statistics. Those data then processed into a graph to understand the fluctuation of harvested area and rice production in Sleman Regency from 2007 to 2017. The data is also processed into the Sleman Regency land use map in 2007 and the Sleman Regency land use map in 2017 helped by software ArcGIS. The purpose of making this land use map of Sleman Regency 2007 and 2017 is to know the distribution and differences in land use in Sleman Regency in 2007 and 2017.

Data on harvested area and the amount of rice production are then processed again into land productivity data by calculating the amount of paddy production with harvested area of paddy from 2007 to 2017. The formula to calculate paddy productivity in Sleman Regency is:

\[ \text{Productivity of Paddy} = \frac{(\text{Production of Paddy})}{(\text{Harvested Area of Paddy})} \]  

The purpose of calculating land productivity from year to year is to know the fluctuations about productivity in paddy in Sleman Regency. Then, the results of the productivity calculation are later projected until 2027 to find out whether it will increase productivity in the future. This projection of Productivity was using formula below:

\[ P_t = P_0 \times (1 + rxn) \]  

\( P_t \) = Productivity at t-year
\( P_0 \) = Productivity at early year
\( R \) = \((1/n) \times \ln(P_t/P_0)\)
\( N \) = deviation of year

This research was using arithmetic projection, because this projection assumed that the level of productivity in Sleman Regency every year is the same. Basically, these methods shows in this flowchart:
3. Result and Discussion

Most of the Land conversion in Sleman Regency, Yogyakarta are changed from agricultural land to non-agricultural especially in the form of settlement [9]. The urbanization flow is the cause of the land conversion which where the land availability for settlements are in low level while the population is increasing [10]. Agricultural area especially paddy field in Sleman Regency are the indication of the partially changed Sleman Regency’s morphology area that switched from rural area to urban area.

There is a significant agricultural area size transformation based on the Indonesia Topographic Map (RBI map) of Sleman Regency in the year of 2007 and 2017. The paddy field had decreased by 47.75%, while the size of settlement area had increased by 34.26% which will affect the production and paddy productivity level in Sleman Regency because of the decreasing of agricultural area especially paddy field in terms of size. The changing of land use that happened in Sleman Regency in the year of 2007 and 2017 can be seen in figures below:
Figure 2. Land Use Map of Sleman 2007.
The figures pointed out the significant change towards the paddy field size and settlement area size. Since 2011, most of the DIY region including Sleman Regency had increased in terms of size in land use installation such as road, services, trades, and settlement area as the biggest one, while the paddy field and forest area size decreased [10]. The paddy field size had been decreased in Sleman Regency from 2007 until 2017 which has a connection towards the productivity of rice in Sleman Regency.

Paddy field in Sleman Regency has a total of 242,795 ton with 42,450 ha area size in 2007, while in 2017 it has 289,098 ton in production with the land size of 50,392 ha. The total amount of the production and harvested area size had a fluctuating development, however there were a significant decreasing in 2011 but it was increasing in the following years. The graph of the production quantities and harvested area size, showing off a linear correlation. The quantities of the paddy production and harvested area size in Sleman Regency in 2007 until 2017 can be seen fully in the table below:

**Figure 3. Land Use Map of Sleman 2017.**

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Table 1. Production and Harvested Area of Paddy Field 2007-2017.

| Year | Production (Tons) | Harvested Area (Ha) |
|------|------------------|---------------------|
| 2007 | 242,759          | 42,450              |
| 2008 | 267,607          | 43,064              |
| 2009 | 268,075          | 44,037              |
| 2010 | 264,317          | 44,398              |
| 2011 | 231,376          | 40,641              |
| 2012 | 311,378          | 45,832              |
| 2013 | 306,201          | 48,584              |
| 2014 | 312,891          | 51,780              |
| 2015 | 326,819          | 49,870              |
| 2016 | 322,418          | 52,156              |
| 2017 | 289,070          | 50,392              |

Source: Central Bureau of Statistic (BPS Indonesia)

Figure 4. Graph of Paddy Productivity in Sleman Regency 2007-2017. Source: Central Bureau of Statistic (BPS Indonesia) (processed).
The decreasing of the quantities and harvested area size in 2011, in which the land use transformation happened significantly such as land conversion from agricultural (specifically paddy field) to settlement and built-up land [11]. Thus it makes the use of agricultural land especially paddy field decreasing significantly in the production and harvested area size. It is the impact that is directly proportional to the existing of land conversion in 2011. Although there was a decreasing in 2011, the production and the harvested area size are increasing and stable in Sleman Regency after 2012 until 2017.

The production quantities and harvested paddy area size that increased after the 2011 caused by the government program in Sleman Regency in the form of agricultural diversification. Diversification is an effort in developing farming production that depends on the condition of the area’s geophysical where the agricultural exist [12]. The geophysics condition in Sleman Regency where the soil is fertile, supports the agricultural diversification, with the result that the production of paddy field in Sleman Regency is increasing and tend to be stable.

Based on the total quantities productions and the harvested paddy field size in Sleman Regency, it can be done a projection to know the connection between the changing of land use towards the agricultural productivity. The Agricultural productivity projection is intended to know the paddy productivity in the year from 2017 to 2027, where the calculation used the arithmetic formula. The projection resulting in an increasing of paddy productivity from 5.74 ton/ha in 2017 to 5.94 ton/ha in 2028. Thus it has the same amount of the total production and harvested area size that tend to increase and stable as the result of the effort in agricultural diversification in Sleman Regency.

![Figure 5](image-url)  
**Figure 5.** Graph of Harvested Area of Paddy Field in Sleman Regency 2007-2017.  
Source: Central Bureau of Statistic (BPS Indonesia) (processed).

| Year | Production (Tons) | Harvested Area (Ha) | Productivity (Tons/Ha) |
|------|------------------|---------------------|-----------------------|
| 2017 |                  |                     | 5.74                  |
| 2018 |                  |                     | 5.80                  |
| 2019 |                  |                     | 5.85                  |
| 2020 |                  |                     | 5.90                  |
| 2021 |                  |                     | 5.95                  |
| 2022 |                  |                     | 5.99                  |
| 2023 |                  |                     | 6.03                  |
| 2024 |                  |                     | 6.07                  |
| 2025 |                  |                     | 6.12                  |
| 2026 |                  |                     | 6.17                  |
| 2027 |                  |                     | 6.22                  |

**Table 2.** Rice Productivity Projection of Sleman Regency 2017-2027.
4. Conclusions

The main cause of land transformation from agricultural area to non-agricultural area such as settlement area is the urbanisation flow that happened in Sleman Regency, Yogyakarta in 2011. In the period of time from 2007 until 2017, there is a decreasing amount of paddy field around 47.5%, while the settlement area is increasing by 34.26%. It affects the amount of the production of paddy, which where in the year of 2007 had 265,567 tons and then it went down in 2011 to 231,376 tons, and then went up again but it’s more stable this time until 2017 reaching 289,070 tons. Based on those data, it can be done a productivity projection of rice in 2017 until 2027, which where the productivity of rice in Sleman Regency is tend to be stable with productivity amount in 2017 by 5.74 tons/ha until in 2027 by 5.94 tons/ha. The quantities of rice being projected is increasing and tend to be stable caused by the diversification program in Sleman Regency, with the result of paddy productivity can be increased although the planted area size decreasing.

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